If You Can't Beat It, Join It!
Teaching and Learning Mathematics with
ChatGPT and Key Prompts to Stimulate Self-Learning

By Philip Slobodsky*, Mariana Durcheva ± & Leonid Kugel°

In this study, we examine mathematics students' use of ChatGPT and address issues related to AI-generated errors and editing of prompts containing formulas. We're introducing Chat-Mat™, an integrated suite of tools designed to enhance the learning experience. This set of tools includes a math Prompts Editor, an Algebraic Calculator, a Graph Plotter, and sets of themed Key Prompts. Our approach allows students to effectively communicate with ChatGPT, check its answers, and use advanced mathematical tools for deeper exploration. By providing detailed instructions for quick editing and selecting Key Prompts, we support a variety of learning objectives, including problem solving, understanding mathematical concepts, and engagement with the broader historical and practical context of mathematics. By providing students with suggested prompts, we develop the ability to construct their own questions while also enriching their learning experience with additional contextual information. To assess the impact of Chat-Mat™ on learning outcomes, we conducted a survey among students. The results indicate a positive correlation between the use of our artificial intelligence tools and student exam performance, suggesting that Chat-Mat™ significantly improves the effectiveness of self-paced math learning.

Keywords: ChatGPT, prompts, mathematics, self-learning, algebraic calculator

Introduction

Artificial intelligence programs such as ChatGPT, Co-Pilot, Bard, Claude and others allow you to answer math questions in general, as well as solve equations and perform algebraic operations in particular. Students use this ability to solve problems assigned for homework, assignments, etc. However, these attempts face two technical problems in writing prompts that involve mathematical expressions. The first problem is writing expressions in LaTeX format, which is unfamiliar to most users (students). In addition, the result appears as long and complex lines of text that are difficult to edit even for those who know the syntax.

The second issue currently being discussed in the scientific and pedagogical discourse on the use of ChatGPT in teaching and learning mathematics is the frequent errors in calculations (Remoto, 2024).

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Both problems limit the use of these programs by mathematics (and physics) students. In addition, the illiterate use of incorrect solutions can cause confusion among students and conflicts between them and exercise examiners.

Another conceptual issue that has been present in the discourse of mathematics education in recent decades is: whether students are allowed/encouraged to use automatic calculation tools (calculator, computer software) to solve homework problems?

After unsuccessful attempts to ban the use of various computing tools, the consensus among many involved in mathematics education today is that if banning them is not possible, it is advisable to make use of the effort and time students spend using these tools and transform so-called "forbidden" activities into opportunities that deepen and diversify learning, enhancing students' curiosity and critical thinking.

The new additions to the Halomda learning and e-assessment system are a set of tools that provide answers to all of the above questions:

a. Quick access to ChatGPT;
b. Technical solution for inserting mathematical expressions into prompts;
c. Checking and exploring the responses received from the bot;
d. Help in compiling prompts and lists of recommended prompts for the subjects being studied.

The above-mentioned set of tools, known as Chat-Mat, enables effective use of AI tools in learning mathematics, encourages students to explore mathematical problems in more depth, and complements the course content by introducing various key issues.

The research questions we posed in this work can be summarized as follows:

Q1: To what extent did the use of the Halomda platform's Learn, Train and Test modes enhance student learning outcomes?
Q2: To what extent can the use of ChatGPT stimulate students' interest and desire for self-learning?
Q3: To what extent can the use of the AI toolkit integrated into the Halomda platform improve student learning performance?

Literature Review

On the one hand, the integration of technology into the educational process is not a new idea and has always been a topic of discussion. Moreover, it is an accreditation requirement for most teacher preparation programs (Meisner & McKenzie, 2023). According to the constructivist teaching and learning paradigm, active student participation is desirable because knowledge acquired through active learning methods "tends to be of higher quality, characterized by understanding, applicability, and persistence" (Bardorfer, 2024). In addition, performance-based learning "helps students understand their strengths so they can improve and identify weaknesses that need improvement" (Tashtush, Shirawia, & Rasheed, 2025). On the other hand, the education sector is undergoing significant changes due to rapid technological advancement. These changes affect various aspects of education,

requiring teachers to adapt and integrate new developments into their teaching practice. A revolutionary technology innovation that is gaining global attention is artificial intelligence (AI) systems such as ChatGPT.

Since the public launch of ChatGPT in October 2022, numerous papers have been published on the potential applications and initial results of AI bots in education in general (Alali & Wardat, 2024), and mathematics education in particular (Wardat, Tashtoush, Alali, & Jarrah, 2023). Topics related to mathematics include various issues such as the computing capabilities of various bots (Green, 2024; Botana & Recio, 2024; Rane, 2023), research writing (Bringula, 2023), mathematical research (King, 2023), plagiarism detection (Eager & Brunton, 2023), and related fields such as physics (Liang, Zou, Xie, & Wang, 2023).

Recent studies have examined the impact of ChatGPT on students' learning motivation and interest. Research shows that incorporating ChatGPT into teaching can increase students' interest in learning by providing varied and targeted learning modes, improving knowledge acquisition, and promoting independent learning (Hui, Qian, & Zheng, 2023). ChatGPT-generated dialogues in language learning materials have been shown to significantly improve student motivation, especially in the areas of self-regulation, intrinsic values, and test anxiety (Aydın Yıldız, 2023); improve understanding and academic performance (Afkarin & Candra, 2024). Supporting students' autonomy, competence, and relatedness can improve their learning motivation and performance, as well as enhance their interest and academic performance (Zhou & Li, 2023). These results provide valuable information for educational reforms and new pedagogical approaches in the era of artificial intelligence.

Given that our research focuses on the use of ChatGPT by mathematics students, we focused on reviewing relevant papers on this topic here. The challenges associated with the use of ChatGPT by mathematics students are both technical and didactic in nature. One technical issue discussed in Remoto (2024), involves inserting math formulas into prompts: "In math, you'll come across a lot of math symbols that you can't type into ChatGPT. This is its limitation, since it is not designed specifically for mathematics".

While most of the published papers describe and discuss the rapidly growing ability of AI bots to correctly solve math problems in various areas of mathematics, some also delve into the potential benefits of AI tools for students. For example, in Güler, Yıldız, Boran, and Dertli (2024) are offered recommendations for future research on integrating ChatGPT into mathematics education contexts: "ChatGPT provides a useful tool for students who may be hesitant to ask questions in class, allowing them to find answers to their questions or submit queries without hesitation; it serves as a valuable tool for students to explore concept definitions using ChatGPT while preparing for lessons." In addition, the authors believe that "students can get instant feedback by checking the solutions to basic-level questions using ChatGPT," and with effective ChatGPT, they "can directly access answers to basic-level questions covering basic concepts and operations."

Various aspects of the didactic benefits and potential applications of ChatGPT in student learning are discussed in Nitin (2023), where the author states that "ChatGPT and similar LLMs can serve as interactive tutors, guiding students through complex problem-solving processes by providing step-by-step explanations, generating real-

time examples, and offering tailored feedback". However, it is important to note that "balancing the use of LLMs as educational aids while encouraging independent thinking is a delicate challenge that educators must facilitate interactive learning enabling it to "act as a personalized tutor", since it "caters to individual learning styles", all of which "leads to a deeper understanding".

It should be considered that despite the benefits associated with the education revolution, the integration of AI models into classroom work may have serious ethical implications, such as dependence on AI and reduction of human interaction, authenticity and originality of student work, privacy and data security, and the presence of unconscious bias in AI-generated content (El-Seoud, Shehab, Nagaty, & Karam, 2023). If data is biased, AI models reinforce that bias, thereby "exacerbating existing discrimination in education systems" (Verma, 2019). Additionally, the lack of accountability and transparency when using AI models in the classroom raises various questions, such as who is responsible for the accuracy of educational decisions made by AI models and how these decisions are made (Tang & Su, 2024). Naidu and Sevnarayan (2023) are concerned about a potential crisis of academic integrity due to the use of ChatGPT for online assessment in distance education. In conclusion, ChatGPT helps the learning process by helping students understand proofs, theorems, and mathematical reasoning. However, educators should be aware of potential ethical issues.

General Structure of the Halomda Train and Assessment Platform

The system of teaching and e-assessment in mathematics and physics was first announced in 2001 (Kornstein, 2001). The system is based on web technologies and is supported by both its own LMS and Moodle. It presents 3 main modes of operation - Learn, Train and Test (Figure. 1).

Figure 1. Modes of Operation

The system includes a graphical mathematical expression editor that allows users to write intuitively without the need for special syntax. It is supported by special Computer Algebra (CA) software designed to evaluate the answers and compare them with the correct ones. The platform also includes research tools—software for building and exploring graphs of functions and an Algebraic Calculator that performs symbolic operations in 10 areas, including basic algebra, equations, trigonometry, calculus, linear algebra, statistics.

The graphical task editor does not require knowledge of any programming language; with its help, about 5,000 exercises in mathematics and physics have been developed for primary, middle and high school students, as well as university students.

The course provides students with a comprehensive set of basic problems covering the curriculum. Typically, this set includes from 50 to 150 tasks grouped into weekly tasks (Slobodsky & Durcheva, 2023).

The Learn and Train modes present students with a series of tasks, each with random parameters to ensure that different trials produce different sets of exercises. Students have the opportunity to ask help, which is provided at three levels: general help, which describes a solution method, common to all problems in a particular subject; a list of steps to solve the problem with a description of each step; and the final result of all solution steps.

In Test mode, students are presented with multiple answer options without assistance and are required to complete a series of tasks that simulate the conditions of a classroom test.

This unique yet simple structure provides feedback and control throughout the learning process.

Combination of ChatGPT and Math Software in the Chat-Mat™ Communication Toolkit

The latest version of the Halomda platform includes access to ChatGPT, as part of the Chat-Mat package. Integrated programs: ChatGPT and recommended prompts (Key Prompts), Graph-Man (a software for constructing and analyzing graphs), and Algebraic Calculator (solves equations and performs symbolic operations in 10 areas of mathematics) (Figure 2).

*Figure 2*. Chat-Mat kit, Algebraic Calculator, Graph-Man
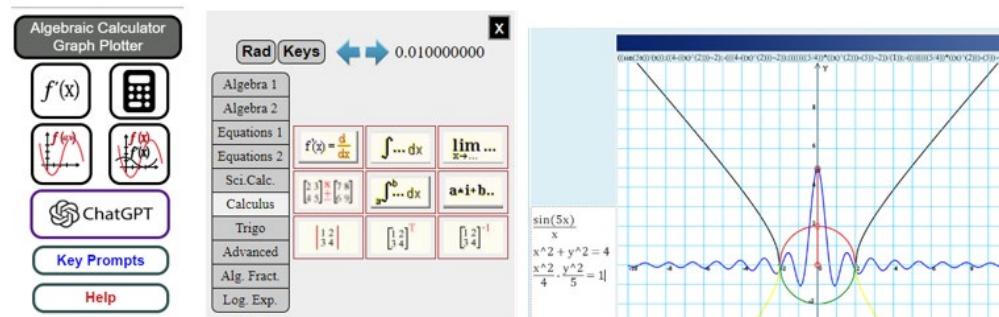
In addition to the ChatGPT integration, Halomda has developed a graphical editor for mathematical expressions and their representation in the LaTeX format required by ChatGPT.

For example, to submit a prompt that includes limit calculation:

$$\lim_{x \to 0} \left(\frac{\sin x}{x/\pi} \right)$$ one should type: \lim_{x\rightarrow0}{(\frac{sinx}{x/\pi

,))

The graphic editor allows you to enter a limit using the appropriate templates (Figure 3). Subsequently, to create a prompt that includes text and a math expression, users can simply copy and paste it into the ChatGPT message window.

Figure 3. Math Templates
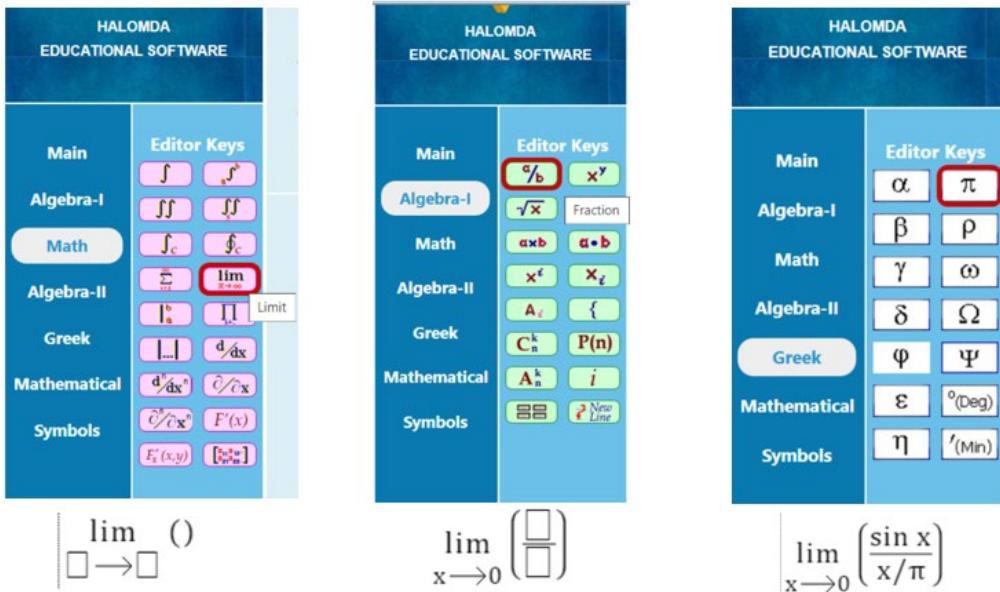
This feature allows students to chat with the bot about math topics. The main didactic issues mentioned in the research regarding the use of ChatGPT in mathematics education (Wardat, Tashtoush, Alali & Jarrah, 2023; Zhao, Shen, & Qi, 2023; Nitin, 2023) are as follows:

a) How to solve the problem of incorrect responses received from ChatGPT?
b) How should students use ChatGPT as a reliable guide beyond direct problem solving, given the frequent incorrect solutions?

The Chat-Mat kit, integrated into the Halomda learning system, is based on the following educational concept: a student's knowledge in any mathematical subject is closely related to the time spent studying the subject and the variety of different approaches that he has mastered. The more diverse activities students engage in, the greater the expected success! The following scenario describes what students do when solving problems:

a) contacting ChatGPT with a request to solve the problem.

The way to communicate with ChatGPT is through the prompt. The learning environment allows students to create a prompt that includes math expressions and send it to a smart bot. For example, using the formula editor, a student writes the following question, consisting of two sections:
Find the domain of the function:

$$f(x)=3\backslash\log\_2\{(x+4)\}-1+\backslash\log\_2\{(x-2)\}$$
and solve the equation: $3\backslash\log\_2\{(x+4)\}=1-\backslash\log\_2\{(x-2)\}$

ChatGPT correctly solves the first section, including the verbal explanation (Figure 4), but could not solve the equation (giving wrong reasons and miscalculated) (Figures 5-6).

Figure 4. A Typical Prompt and a Correct Answer from the Bot

Figure 5. Section 2 of the Prompt, an Error During the Solution

HA You

solve equation: 3log2(x+4) = 1- log2(x-2)

ChatGPT

To solve the equation $3 \log_2 (x + 4) = 1 - \log_2 (x - 2)$, let's follow these steps:

1. Apply logarithmic properties to condense the equation.
2. Solve for x algebraically.

Let's start:

Step 1: Apply the logarithmic properties.

Use the logarithmic property: $n \log_b (x) = \log_b (x^n)$.

So, the equation becomes:

$\log_2 (x + 4)^3 = \log_2 \frac{1}{(x-2)}$ **?**

Step 2: Remove the logarithm by equating the expressions inside the logarithms:

$(x + 4)^3 = \frac{1}{x-2}$

Now, we solve this equation for x.

*Figure 6*. Calculation Error and Wrong Answer of ChatGPT

$$(x + 4)^3 = \frac{1}{x-2}$$ **?**

$$(x^2 + 8x + 16)(x + 4) = 1$$

•••••••••••••••••••••••••••••••

$$x^3 + 12x^2 + 48x + 63 = 0$$ **?**

Now, this is a cubic equation. While there isn't a general form
is for quadratics, we can still find solutions using numerical
case, we can see that $x = -3$ is a solution.

Therefore, the solution to the equation is $x = -3$.

b) Even if students do not recognize the mistakes, they are aware of the possibility and, following the instructions, can check the answers using two math programs included in the Chat-Mat kit: graphing a function using Graph-Man (Figure 7) and solving equations using Algebraic Calculator (Figure 8).

Figure 7. Graphical Solution by "Graph-Man"
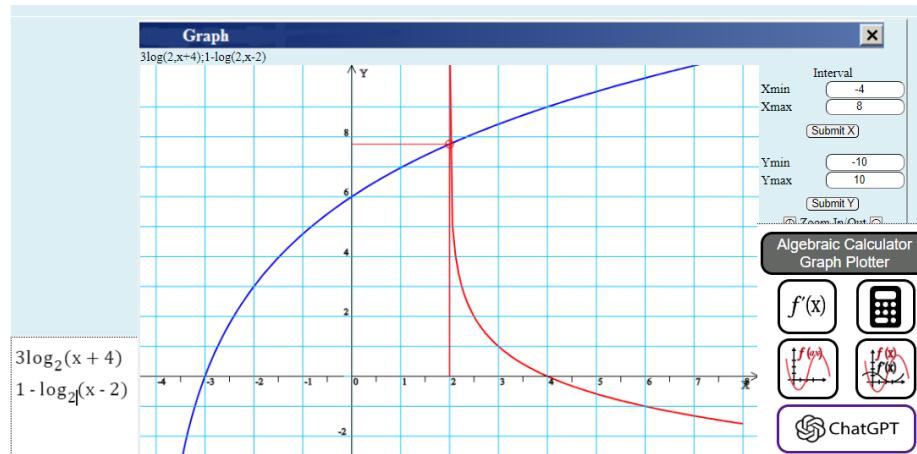
The graph of the function shows the intersection of the two branches of the equation, indicating that the equation has a solution. The same solution can be obtained using the algebraic calculator.

Figure 8. Solution by Algebraic Calculator

$$3\log_2(x+4) = 1 - \log_2(x-2)$$

$$\begin{cases} x+4>0 \\ x-2>0 \end{cases}$$

$$x \in (2 ; \infty)$$
Domain

$$\log_2\left((x+4)^3\right) = \log_2\left(\frac{2^1}{x-2}\right)$$

$$\frac{x^4 + 10x^3 + 24x^2 - 32x - 130}{x-2} = 0$$

$$x^4 + 10x^3 + 24x^2 - 32x - 130 = 0$$

$$x - 2 \neq 0$$

$$x^4 + 10x^3 + 24x^2 - 32x - 130 = 0$$

$$x_1 = -4.67$$

$$x_2 = 2.01$$

$$x_1 - 2 = -6.67 \neq 0$$

$$x_2 - 2 = 0.0092 \neq 0$$

$$x_1 = -4.67$$
Outside of domain. False root!

$$x_2 = 2.01$$
The root of equation
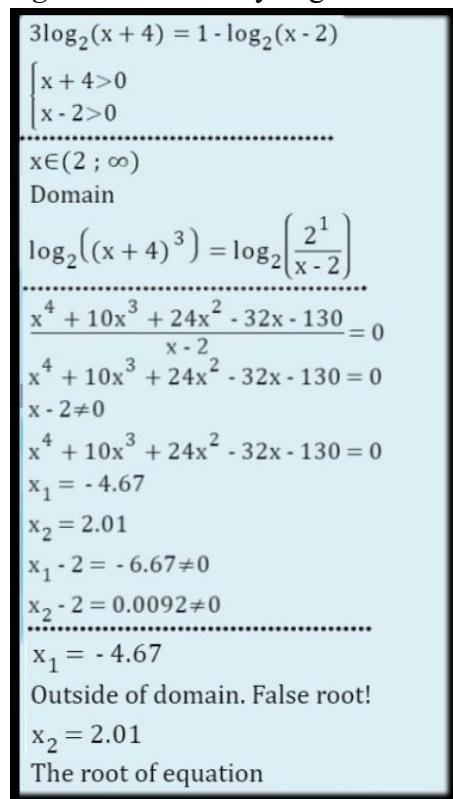
These results contradict the answers given by ChatGPT, and this contradiction can arouse students' curiosity, prompting them to contact the bot for clarification and identify the source of errors (Figure 9).

Figure 9. Correspondence with ChatGPT

HA You
Wrong: in the first step it should be 1=log_2 of 2 and not of 1

ChatGPT
You're correct. Let's correct that.

Given the equation $3 \log_2 (x + 4) = 1 - \log_2 (x - 2)$, we start by condensing the logarithms:

$$3 \log_2 (x + 4) + \log_2 (x - 2) = 1$$

$$\log_2 (x + 4)^3 + \log_2 (x - 2) = 1$$

$$\log_2 [(x + 4)^3 \cdot (x - 2)] = 1$$

Now, applying the property of logarithms $\log_b M = N$ can be rewritten as $b^N = M$, we have:

$$2^1 = (x + 4)^3 \cdot (x - 2)$$

$$2 = (x + 4)^3 \cdot (x - 2)$$

$$2 = (x + 4)(x + 4)(x + 4) \cdot (x - 2)$$

$$2 = (x^2 + 8x + 16)(x - 2) \ ?$$

Using additional math tools in the Chat-Mat package, such as the LaTeX formula editor, Graph-Man (graph drawing), and Algebraic Calculator, can significantly improve student's understanding of the problem, even if the ChatGPT's solution is accurate.

This is especially important for algebraic problems, where a graphical representation of the solution is indispensable. Since the current free version of ChatGPT lacks graphical capabilities, using these tools becomes even more invaluable.

For example, when calculating a limit $\lim_{x \to 0} \left(\frac{\sin x}{x/\pi} \right)$ and checking the result, a student can perform the following actions:

a) Calculate the limit manually.
b) Confirm the result using ChatGPT. To do this, the expression for the limit must be written in the appropriate format; the problem is solved using one of the ChatMat tools - the Formula Editor. The student can then create a prompt using the included instructions from the toolkit and send it to ChatGPT.

Figure 10 shows the output generated by the bot, allowing the student to compare it with the manual output.

Figure 10. Response Generated by ChatGPT

please solve: \lim_{x\rightarrow0}{(\frac{sinx}{x/\pi })}

To solve the limit $\lim_{x\to0}\left(\frac{\sin x}{x/\pi}\right)$, let's break it down step by step.

First, rewrite the expression inside the limit:

$$\frac{\sin x}{x/\pi} = \frac{\sin x}{x} \cdot \pi$$

Now the limit becomes:

$$\lim_{x\to0}\left(\frac{\sin x}{x} \cdot \pi\right)$$

We can separate the limit into two parts:

$$\lim_{x\to0}\left(\frac{\sin x}{x}\right) \cdot \lim_{x\to0}(\pi)$$

We know that π is a constant, so:

$$\lim_{x\to0}(\pi) = \pi$$

Next, we use the well-known limit:

$$\lim_{x\to0}\left(\frac{\sin x}{x}\right) = 1$$

Combining these results:

$$\lim_{x\to0}\left(\frac{\sin x}{x} \cdot \pi\right) = \left(\lim_{x\to0}\left(\frac{\sin x}{x}\right)\right) \cdot \left(\lim_{x\to0}(\pi)\right) = 1 \cdot \pi = \pi$$

Thus, the limit is:

$$\boxed{\pi}$$

If the results of both methods match, the student can review all solution steps and contextual explanations. However, if there is a discrepancy between the results, the student can use an algebraic calculator (as shown in Figure 11) to calculate the limit. Additionally, he can visualize the graph of the corresponding function using Graph-Man (as shown in Figure 12).

These additional tools provide a comprehensive understanding of the problem and help resolve any inconsistencies in the resulting solutions.

Figure 11. Result Obtained Using the Algebraic Calculator

Figure 12. Utilizing Graph-Man
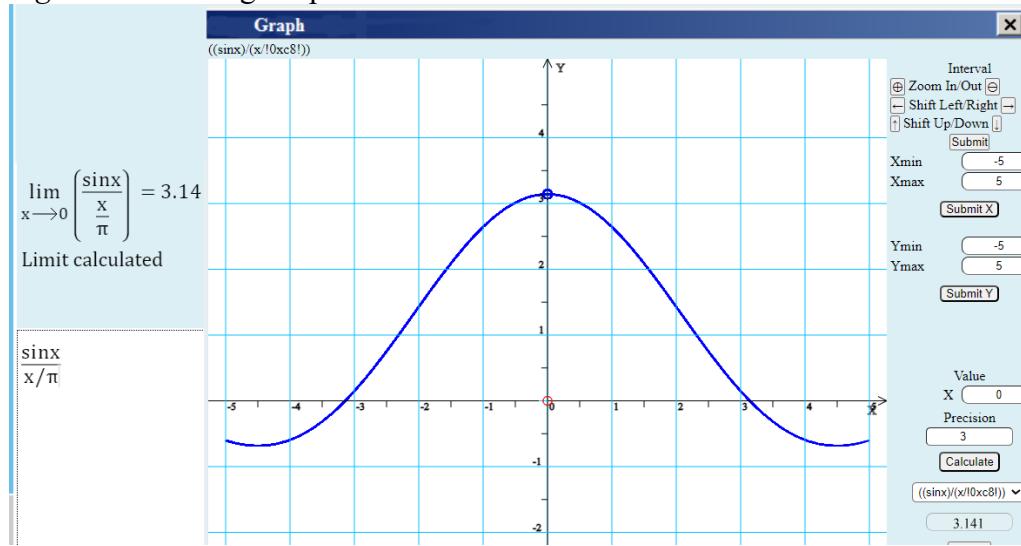
"One Who Knows"? Key Prompts as a New-Old Method of Self-Study

Once students become aware of the possibility that ChatGPT can make mistakes while solving a problem, they become more cautious, critical, and attentive to the information it provides. This situation can help educators offer an effective and meaningful learning experience with the help of a smart bot. Chat-Mat contains a prompt writing tutorial aimed at encouraging students to write their own prompts.

The idea of learning through asking questions and discussing different opinions is not new in teaching; it has its origins in Jewish tradition. Questioning is a Jewish religious concept that describes the philosophical principle of asking questions as part of the process of learning and understanding.

Today, students from various professions are studying prompt engineering. Educational publications also address this topic (Bringula, 2023). Guidance on this topic is provided in the Chat-Mat help file (Figure 13).

In addition to instructions for composing prompts that help students create them and send them to the bot, the Chat-Mat kit includes lists of recommended prompts. Each exercise that appears in the Learn and Train modes of the Halomda learning system provides access to ChatGPT and a list of typical prompts related to the subject of the exercise.

Figure 13. Access to Built-In Instructions and Key Prompts
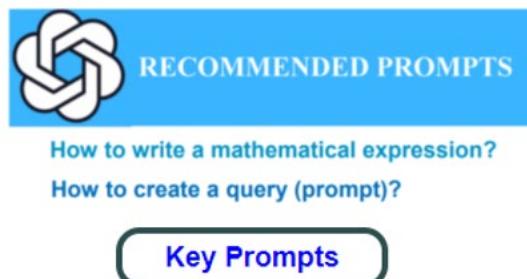
The role of recommended prompts (Key Prompts) is twofold: first, to demonstrate to students how to most effectively formulate math prompts, and second, to increase students' motivation and curiosity by providing examples of three key questions related to the topic. These key issues are:

1. Solve equations and common problems in the subject, including calculating integrals and derivatives, simplifying expressions, and questions from previous tests.
2. Refreshing definitions, theorems and proofs.
3. General facts from math history, different applications, questions for understanding, fun, paradoxes, etc.

Key Prompts lists have been included in a variety of math and physics assignments, covering topics such as: *Complex Functions*, *Limits and Derivatives*, *Probability and Statistics*, *Quantum Mechanics,* and more. For example, Figure 14 presents some recommended prompts for statistics.

Figure 14. Recommended Prompts on Probability and Statistics

1. What is the difference between mean, median, and mode?
2. What is the interquartile range and how is it calculated from a dataset?
3. How is the standard deviation (dispersion) of a dataset calculated?
4. When do we use a pie chart representation and when do we use bar/column representation?
5. How to achieve a high score in a statistics exam in 10th grade?
6. What is the purpose of studying statistics?
7. Will knowledge of probability formulas help in winning the lottery?
8. What is the probability of an impossible event?
9. What is the difference between probability and odds?
10. What is the likelihood of rain tomorrow?

Methodology

A college semester lasts 13 weeks. For the Differential Equations course, each week included 2 hours of traditional classroom and 2 hours of distance learning (using the Halomda system). During distance learning, students were required to complete 5 mandatory laboratory works, 3 of which covered 2 academic topics each. Students were given 15 ChatGPT questions to help them find solutions to specific test problems. Additionally, each student had to create 5-6 of their own prompts related to the topics being studied. Assessments were given using the Halomda system, with a bonus of up to 5 points added in Moodle, depending on the quality of independently compiled prompts.

We would like to emphasize that one of the problems of traditional classroom teaching is the different levels of preparedness of students. The teacher faces the difficult task of conveying the material so that it reaches all students. The goal of encouraging students to create their own prompts is to provide them with explanations tailored to their level of understanding. For example, many problems involving Bernoulli's method require the use of the method of integrating coefficients as part of the solution. When working on these problems, a less-prepared student might (and experience shows that many do) ask ChatGPT to explain how the two methods for solving differential equations are related.

The primary purpose of our online survey conducted in 2024 was to answer the above research questions. We sought to examine the impact of the integrated artificial intelligence tools (including context Key Prompts) of the Halomda platform on the assessment of student performance in a Differential Equations course.

To achieve this goal, we asked 22 students to answer 13 questions. Finally, we looked for recommendations that could improve our system. Likert scale prompts were used to measure students' opinions (see Table 1).

Table 1. Responses About the Impact of the Usage of the Halomda's Integrated Tools

Question	Percent of Response
1. Did you use the Halomda platform for your assignments in Statistics?	
Yes	86%
No	14%
2. What is the average grade of all the works you submitted (1-100)?	
Above 80	90%
Below 80	5%
I did not submit	5%
3. What grade did you get on the final exam? (1-100)	
90-100	45%
80-89	30%
70-79	10%
60-69	5%
Below 60	10%
4. What are the modes of operation that you used?	

Test mode	33%
Train mode	50%
Learn mode	13%
I didn't use the platform	4%
5. What of the tools that the software offers (graph sketcher, algebraic calculator, ChatGPT, key prompts) did you use?	
Graph sketcher	8%
Algebraic calculator	28%
ChatGPT integrated in the Halomda	20%
Key prompts	44%
6. Have you tried to get solution to the problems through ChatGPT?	
Yes	40%
No	60%
7. Do you agree that we can trust the solutions provided by ChatGPT?	
Strongly agree	20%
Agree	10%
Neutral	20%
Disagree	20%
Strongly disagree	30%
8. What means did you use to verify the solution suggested by ChatGPT?	
Algebraic calculator	35%
Graph sketcher	15%
I asked ChatGPT to check the solutions steps again	15%
I did not check the solution	35%
9. Have you extensively used ChatGPT to get answers on general topics such as the history of mathematics or the use of statistics in different branches of mathematics?	
Strongly agree	10%
Agree	5%
Neutral	20%
Disagree	30%
Strongly disagree	35%
10. Do you agree that it was difficult for you to compose prompts in mathematics subjects?	
Strongly agree	35%
Agree	30%
Neutral	25%
Disagree	5%
Strongly disagree	5%
11. Did you use the recommended prompts, or created them yourself?	
I used only the recommended prompts	30%
I created them myself	22%

I used both recommended prompts and ones I created myself	48%
12. Do you agree that the system (Halomda) helped you in preparing for the exam?	
Strongly agree	50%
Agree	30%
Neutral	10%
Disagree	5%
Strongly disagree	5%
13. Do you agree that the usage of the system was clear and convenient?	
Strongly agree	55%
Agree	20%
Neutral	10%
Disagree	5%
Strongly disagree	10%

Participants

The study population included regularly enrolled first year students of KAY College of Education during the first semester of the 2023/2024 academic year. The study sample was selected from students specializing in "Teaching Sciences in Middle Schools" who were enrolled in the "Differential equation" course.

Results

Q1: To what extent did the use of the Halomda platform's Learn, Train and Test modes enhance student learning outcomes?

According to student responses, 86% of them used the platform to complete their weekly assignments, which corresponds to the average grade they received on assignments (90% of them received more than 80 points). At the same time, 75% of students received a score above 80 points on the final exam (45% - above 90 points). The most preferred mode for using the system is the "Train" mode (50% of students used it), followed by the "Exam" mode (33%) and the "Learn" mode (13%); only 4% of respondents did not use the system (see Table 1). Thus, the results clearly show that widespread use of the Halomda platform for teaching, learning and testing definitely improves student learning outcomes.

These results align with the findings of Slobodsky and Durcheva (2024) and Slobodsky, Durcheva, and Kugel (2024), which demonstrate that using the Halomda platform increased student interest and engagement in the subject, as well as significantly improved learning outcomes.

Q2: To what extent can the use of ChatGPT stimulate students' interest and desire for self-learning?

It is worth noting that there are not many studies on the impact of ChatGPT on students' interest and desire for self-learning, especially in the field of mathematics education. To the question "Have you tried getting solutions to your questions via ChatGPT?", 40% of the respondents answered positively, and 60% answered negatively. These results are consistent with the fact that 50% of students do not trust ChatGPT solutions.

To the question: "Do you agree that we can trust the solutions provided by ChatGPT?" (Respondents could rate their answers on a 5-point Likert scale - Table 1), about 30% of the students indicated that they trusted ChatGPT solutions (20% completely agreed), and 50% did not. Moreover, about 65% of them gave a positive answer to the question "Do you agree that it was difficult for you to compose prompts in mathematics subjects?". To the question "Have you widely used ChatGPT to get answers to general topics, such as: history of mathematics, use of statistics in different branches of mathematics?", respondents could answer on a 5-point scale. The responses show that only 15% of them used ChatGPT for research purposes. The results indicate that it is "too early to say" whether utilizing ChatGPT stimulates students' interest and desire for self-learning. Simply put, half the students didn't trust it. This may be due to the fact that most students used the free version of ChatGPT 3.5, which was known to contain a number of computational errors that could dissuade students from using it.

Our results are consistent with those of other researchers who highlight that although ChatGPT has a positive effect on learning motivation, students' usage frequency and knowledge level remain relatively low, indicating the need for further training (Zhou & Li, 2023). Considering the current teaching and learning environment, some researchers believe that ChatGPT serves as a tool for requesting and supporting information rather than replacing the teacher's role (Hui, Qian, & Zheng, 2023).

Q3: To what extent can the use of the AI toolkit integrated into the Halomda platform improve student learning performance?

Answers to the question "Which of the tools that the system offers (graph plotter, algebraic calculator, access to ChatGPT, Key prompts) have you used?" showed that the most preferred tools were Key prompts (44%) and access to ChatGPT (20%). To test the solutions provided by ChatGPT, the respondents most often used algebraic calculator (35%), followed by graph plotter (15%) and ChatGPT (15%). It can be noted that 35% of students did not check the obtained solutions. These results are somewhat alarming, as they may suggest a lack of critical thinking. However, this could be due to students' lack of experience with these types of tools, which may not always provide accurate answers.

According to the answers to the question: "Did you use the recommended prompts or create them yourself?", we can conclude that the Key prompts provided by the Halomda system turned out to be a useful tool (only 22% of respondents did

not use them). The reason for this may be that students have difficulty creating (and then typing) math prompts.

The majority of students (75%) felt that using the tools offered by the Halomda system was clear and convenient. This is consistent with the responses to the last question of the survey: "What would you recommend to be improved or added to the program?" Students responded with things like, "This is a good program," indicating that they appreciated the help provided by the Halomda system. Some students noted that "the math formulas are a little difficult to type," which is a common problem for people without experience.

In conclusion, we can say that for most students, having access to a range of different AI tools does improve their academic performance. On the other hand, a study presented by El-Seoud, Shehab, Nagaty, and Karam (2023), found that approximately one-third of the teachers surveyed observed noticeable changes in student learning outcomes due to the use of ChatGPT. In our opinion, it is very important for future teachers to see and/or critically evaluate various decisions (both right and wrong), and the Halomda system provides them with this opportunity.

Discussion and Conclusions

The main goals of the survey were to better understand how to use the new capabilities provided by AI to help students in their learning (and self-learning) process. Artificial intelligence tools are rapidly integrating into our lives, forcing us as educators to decide how to turn these tools into our allies and helpers. For this, it is extremely important to know the opinions of students. Much can be learned from the student responses presented in this study.

The research responses showed that leveraging the learning, training, and testing capabilities of the Halomda platform significantly improved student learning outcomes. Feedback from respondents shows that we cannot say with certainty that ChatGPT increases students' interest and motivation for independent learning.

We suggest that one reason for this is that half of the students did not trust this method. Conversely, the data clearly shows that access to a variety of tools significantly improves student learning outcomes.

However, our study has a number of limitations that should be taken into account. The number of participants may not be sufficient to generalize the results; it was conducted with a small group of 22 students (human boundaries) during the first semester of the 2023/2024 academic year (temporal boundaries) at KAY College of Education, Israel (spatial boundaries), and it was aimed exclusively at Differential equation course (subject boundaries). However, it is important to note that in-service teachers were not included in this study.

Despite this, the teacher who conducted the study reported that using ChatGPT with students to explore questions and answers together fostered a collaborative learning environment. This approach enhances cooperation and trust between teacher and students, thereby improving teacher-student relationships. By observing students' interactions with ChatGPT and working together to explore questions and answers, a teacher can better understand student needs and areas of difficulty,

providing more targeted assistance. These results are actually consistent with the results of the study (Hui, Qian, & Zheng, 2023).

As future work, we plan to invite teachers who use the proposed methods in their classes to participate in a similar study. Their insights and experiences are valuable, and we aim to focus our subsequent research on their perspectives to enrich our understanding of the topic.

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