A Comparative Analysis of Speed: AI-Driven Tool vs. Pen-and-Paper Method in Matrix Multiplication

Sonia Sakthi S[1,*]

[1] University College of Engineering, BIT Campus, Anna University

*Corresponding Author: soniasundarhere@gmail.com

Abstract

The use of artificial intelligence (AI) in mathematical research is revolutionizing problem-solving approaches. However, the comparison of AI-based math tools with the traditional pen-and-paper problem-solving approach in terms of effectiveness remains underexplored. This study investigates the speed differences between AI-driven tools and the manual pen-and-paper problem-solving method when addressing complex matrix multiplication. Two groups of college students were formed: one group used the AI tool Wolfram Alpha, while the other employed the traditional manual calculation method. A set of benchmark matrix multiplication problems was chosen to assess computational challenges. Quantitative data on the speed of solutions were collected and analyzed. Preliminary findings indicate that AI-assisted methods significantly reduce computation time and excel in handling calculation-heavy tasks. The results suggest that AI's computational capabilities offer a considerable advantage in terms of speed, showcasing its potential as a faster and more efficient tool for mathematical problem-solving.

Keywords: Artificial Intelligence, Matrix Multiplication, Wolfram Alpha.

Introduction

The integration of artificial intelligence (AI) in various fields has gained significant attention, and its application in mathematical research is no exception (Thomson and Lee, 2023). AI tools, such as Wolfram Alpha, have demonstrated remarkable potential in solving mathematical problems, promising faster, more efficient solutions compared to the traditional pen-and-paper method (Wolfram Research, 2023). The comparative effectiveness of AI-driven tools versus the manual approach to solving problems using pen and paper, especially in terms of computational speed, is significant (Engelbrecht and Borba,2024). AI can process vast amounts of data and perform calculations at remarkable speeds (Zhang, 2023).

This study examines the differences in speed between AI-based tool and manual problem-solving technique when addressing complex mathematical tasks. To conduct the research, college students were divided into two groups: one utilized the AI tool Wolfram Alpha, while the other relied on the pen-and-paper calculation method. The participants were tasked with solving a set of benchmark matrix multiplication problems using their respective methods. By collecting quantitative data on the time taken to arrive at solutions, the study offers valuable insights into the advantages of AI in accelerating mathematical computations.

The results suggest that AI-assisted methods significantly outperform manual calculations in terms of speed. This research highlights the potential of AI as a transformative tool in mathematical problem-solving, offering a promising alternative for those seeking faster, more efficient ways to tackle complex mathematical challenges.

Objective and Hypothesis of the Study

The objective is to determine whether there is a significant difference in the average problem-solving performance between the manual pen-and-paper method and the AI math tool. The hypothesis for this study is that there will be a significant difference in the mean scores of problem-solving performances between Wolfram Alpha and the manual pen-and-paper method.

Methodology: AI-Assisted vs. Traditional Pen-and-Paper Approach

For this study, two distinct student groups were formed to compare the use of the AI-assisted method with the traditional pen-and-paper technique.

- The first group consisted of students utilizing the advanced AI-based mathematical tool, Wolfram Alpha. This group may include professionals experienced in working with AI tools, such as computer science students or mathematicians with a background in computational methods.

- The second group consisted of graduate students well-versed in the traditional mathematical pen-and-paper approach. These participants relied on manual calculations and were expected to approach problems analytically, using a step-by-step problem-solving method.

A diverse set of 50 matrices with varying sizes (e.g., 2×2, 3×3, 4×4, etc.) was used to account for the complexity of matrix multiplication. The same set of matrices was used for both methods (i.e., Wolfram Alpha and pen-and-paper).

- The first group had 50 students who started a stopwatch when they began solving the problem in Wolfram Alpha, stopped it when they finished, and recorded the time taken.

- The same set of problems was then solved manually using pen and paper by the second group, which also consisted of 50 students. The students from the first group recorded the time taken by the second group using a stopwatch.

The results were documented for each method and matrix multiplication problem, and the data were comparatively analyzed in terms of time. The collected data were analyzed using preliminary tests and significance tests for differences between means to determine whether to accept or reject the hypothesis.

Experimental Design

The experimental design of this study follows a controlled approach to evaluate and compare the performance of the traditional method and AI-assisted method in solving mathematical problems. Figure 1 illustrates the various distinct stages of the experiment.

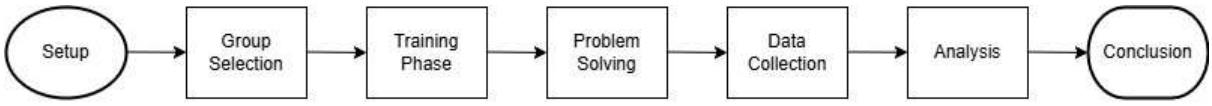

Figure (i) Structure of the Experiment

Results and Discussions

Comparison of Mean Scores of Time Taken (Seconds) in Problem-Solving Matrix Multiplication Problems Using Pen and Paper vs. Wolfram Alpha

The investigation revealed that college students' mean scores on the time taken to solve matrix multiplication problems using Wolfram Alpha and the pen-and-paper method varied. For this reason, a two-tailed test was conducted to analyze the significance of the difference between means and to evaluate college students' mathematical problem-solving abilities using both traditional (pen and paper) and AI-based mathematical tools (Wolfram Alpha).

The **Sample Statistics** reveal that the mean time for the pen-and-paper method is **860.98 seconds**, with a standard deviation of **189.62 seconds**, indicating considerable variation in the time taken by participants. In contrast, the mean time for the Wolfram Alpha method is significantly lower at **9.49 seconds**, with a standard deviation of **1.52 seconds**, suggesting that the times were highly consistent across participants. Table 1 illustrates these findings.

Samples Statistics			
Method	Mean (Time in seconds)	Number of Samples	Standard Deviation
Pen and Paper (time in seconds)	860.98	50	189.62
WolframAlpha(time in seconds)	9.49	50	1.52

Table 1

The correlation between the times taken using the pen-and-paper method and Wolfram Alpha is **0.918**, indicating a very strong positive relationship between the two methods. This suggests that participants who took longer using one method generally took longer using the other as well. Additionally, the **p-value of 0.000**, which is less than the significance level of **0.05**, confirms that the correlation is statistically significant. Table 2 presents the correlation results.

Comparison	Number of Samples	Correlation	Significance (p-value)
Pen and Paper (time in seconds) and WolframAlpha(time in seconds)	50	0.918	0.00

Table 2

The mean difference in time taken between the pen-and-paper method and Wolfram Alpha is **851.49 seconds**, indicating that, on average, the pen-and-paper method took **851.49 seconds longer** than Wolfram Alpha. The standard deviation of the differences is **188.23 seconds**, reflecting the variability in the differences between the two methods. The **t-statistic (Critical Factor) is 31.99**, which is extremely high, suggesting a significant and meaningful difference between the two methods. The degrees of freedom is **49**, which corresponds to the number of participants minus one (**50 - 1 = 49**). The **p-value of 0.000** (less than **0.05**) confirms that the difference in time between the two methods is statistically significant. Table 3 presents the t-test results for the difference in time taken between the two methods.

Differences	Mean	Standard Deviation	Critical Ratio(t-statistic)
Pen and Paper (time in seconds) – WolframAlpha(time in seconds)	851.49	188.23	31.99

Table 3

The critical ratio for the time taken to solve matrix multiplication problems using the traditional pen-and-paper method and Wolfram Alpha is **31.99**, as seen in Table 3. This value is significantly higher than the **2.58** table value required for significance at the **0.01 level**. This demonstrates that the time taken to solve matrix multiplication problems using the pen-and-paper method and the AI-based tool Wolfram Alpha differs significantly.

The significantly lower time taken to solve matrix multiplication problems using Wolfram Alpha is associated with the high mean scores of this method. This indicates that college students who used Wolfram Alpha were considerably faster at problem-solving than those who used the pen-and-paper method.

Conclusion

The results of this study demonstrate the superior speed and efficiency of the Wolfram Alpha AI tool compared to the traditional pen-and-paper method in solving complex matrix multiplication problems. AI-driven methods significantly reduce computation time, highlighting their potential as valuable tools for enhancing mathematical problem-solving efficiency. The AI method also exhibited greater consistency and reliability across participants. Furthermore, the statistical analysis confirmed that the differences in time between the two methods were large and meaningful. These findings suggest that integrating AI tools into mathematical problem-solving tasks can provide a considerable advantage in speed and consistency, making them a promising alternative for students, researchers, and professionals in the field of mathematics.

Conflict of Interest

The authors confirm that this research was carried out without any commercial or financial affiliations that could be interpreted as potential conflicts of interest.

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