



## HUMAN MATHEMATICAL REASONING IN THE AI ERA : A COMPARATIVE ANALYSIS OF SKILL DEVELOPMENT AND COGNITIVE DEPENDENCY

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### Abstract:

Artificial Intelligence (AI) has become an integral component of contemporary mathematics education, offering tools that support problem-solving, feedback, and conceptual understanding. This study investigates the influence of AI on human mathematical reasoning, with particular emphasis on skill development and cognitive dependency. Data were collected from 173 undergraduate students using a structured questionnaire based on a five-point Likert scale. The study examines relationships between AI usage, mathematical reasoning ability, comparative reasoning performance, and cognitive dependency.

The findings reveal a strong positive correlation between AI usage and mathematical reasoning skills ( $r = 0.65$ ), as well as comparative reasoning performance ( $r = 0.60$ ), indicating that AI-assisted learning enhances accuracy, efficiency, and the ability to evaluate multiple solution strategies. However, results also show a moderate positive correlation between AI usage and cognitive dependency ( $r = 0.48$ ), suggesting that excessive reliance on AI tools may reduce independent problem-solving and critical thinking. Survey responses further indicate that many students prefer manual problem-solving for better conceptual retention and deeper understanding.

The study concludes that AI is most effective when used as a supportive learning aid rather than a replacement for human reasoning. Balanced and guided integration of AI can enhance mathematical learning outcomes while preserving essential cognitive and analytical skills.

**Keywords:** Mathematical Reasoning, Undergraduate Students, Mathematics Education, Problem Solving, Critical Thinking, AI-Assisted Learning

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### Introduction:

Artificial Intelligence (AI) is rapidly reshaping educational practices, particularly in mathematics, where intelligent systems are being used to support personalized instruction, adaptive feedback, and targeted problem solving guidance. A growing body of research demonstrates that AI tools can enrich learners' conceptual understanding and engagement in mathematics by offering tailored explanations and immediate feedback, which traditional methods may not always provide. Systematic reviews also highlight

the expanding role of AI in mathematics classrooms, noting its capacity to personalize learning experiences and scaffold difficult concepts through technologies such as virtual tutors, intelligent tutoring systems, and game-based environments. Empirical evidence suggests that AI integration can improve student performance and consistency in mathematics achievement when compared with conventional instruction, although outcomes vary depending on the specific technology and pedagogical integration used. However, alongside these benefits, recent studies

have raised concerns about learners' over-reliance on AI, which may negatively affect independent reasoning, critical thinking, and problem-solving capacities if not balanced with active cognitive engagement.

This dual potential invites critical exploration of whether AI supports skill development or fosters cognitive dependency in mathematics learning. Motivated by this ongoing debate, the present study investigates undergraduate students' perceptions of AI integration in mathematics education. It examines how AI usage relates to fundamental mathematical skills—such as logical reasoning, conceptual understanding, analytical thinking, and independent problem-solving -- and evaluates whether AI enhances learning or promotes dependency. Using a survey of 173 undergraduate students, this research contributes to a nuanced understanding of AI's educational impact in the mathematics domain.

#### Objective :

- To examine the impact of AI tools on human mathematical reasoning.
- To compare mathematical skill development with and without AI assistance.
- To assess cognitive dependency on AI in mathematical problem-solving.
- To evaluate whether AI enhances or replaces conceptual understanding.
- To identify strategies for balanced use of AI in mathematics learning.

#### Problem Definition :

- How has AI affected your mathematical reasoning ability?
- Does AI improve learning or creates dependency?
- Which method helps you remember solutions better?
- How should AI be used in mathematics learning?

#### Literature Review:

##### ● AI in Mathematics Education

Recent studies indicate that AI tools can enhance mathematics learning by providing step-by-step problem-solving guidance, adaptive feedback, and visualization of complex concepts. Researchers have found that AI-supported learning environments improve **conceptual understanding, accuracy, and learner confidence** (Smith & Jones, 2020; Kumar et al., 2021). These tools are particularly effective for scaffolding difficult concepts and allowing students to explore multiple solution strategies.

##### ● Human Reasoning and Skill Development

Mathematical reasoning involves logical thinking, analytical problem-solving, and independent cognitive engagement. Prior research emphasizes that **active problem-solving** is critical for skill retention and deeper understanding (Brown & Larson, 2019). While AI can support reasoning, excessive reliance may reduce mental effort, leading to weaker problem-solving abilities over time.

##### ● Cognitive Dependency on AI

Several studies have highlighted the risk of **cognitive dependency**, where students become over-reliant on AI-generated solutions and fail to engage actively with underlying concepts (Chen et al., 2021; Lee, 2022). Balanced integration of AI is necessary to prevent such dependency while maximizing learning benefits.

##### ● Perceptions of Students

Surveys and empirical research indicate that most students view AI as a helpful **supplementary tool** rather than a replacement for reasoning (García et al., 2020). The findings of this study align with this view: over **58% of respondents** reported that AI improved their reasoning ability, yet a significant



proportion still preferred manual problem-solving for retention and understanding.

- **AI Dependency and Critical Thinking** A recent psychological study found that higher AI dependence is associated with lower levels of critical thinking, especially when students rely on AI for cognitive tasks(2025).

### Literature Gaps:

While AI's positive effects on mathematical skill development are well-documented, there is limited research examining **student perceptions of dependency alongside reasoning improvement**. This study addresses this gap by combining self-reported experiences with structured Likert-scale responses, providing a comprehensive view of AI's dual role in mathematics education.

### Findings and Analysis:

#### 1. Descriptive Analysis of AI Usage and Mathematical Reasoning

**Table 1: Distribution of Responses on AI Usage and Mathematical Reasoning**

Response Category	AI Usage in Mathematics Learning	Mathematical Reasoning Skill Development	Cognitive Dependency on AI	Comparative Reasoning Performance
Strongly Disagree	19	8	8	7
Disagree	28	19	20	15
Neutral	53	57	57	51
Agree	41	57	57	48
Strongly Agree	32	31	31	42

**Table 2: Perceived Impact of AI on Mathematical Reasoning Ability (%)**

Response Category	Percentage (%)
Greatly improved reasoning ability	23.1
Somewhat improved reasoning ability	35.3
No significant change	27.2
Somewhat reduced reasoning ability	12.1
Greatly reduced reasoning ability	2.3

**Table 3: AI and Learning vs Dependency (%)**

Response Category	Percentage (%)
Mostly improves learning	21.4
Improves learning more than it creates dependency	16.8
Improves learning and creates dependency equally	38.7
Creates dependency more than it improves learning	13.3
Mostly creates dependency	9.8

**Table 4: Methods for Remembering Solutions (%)**

Method	Percentage (%)
Solving problems manually	42.2
Solving with AI help	6.9
Both equally	29.5
Depends on the topic	19.7
Not sure	1.7

**Table 5: Preferred Use of AI in Mathematics (%)**

Method of Use	Percentage (%)
As a learning support tool	35.3
As a problem-solving assistant	20.2
Only for practice and revision	29.5
With strict limits	11.6
It should not be used	3.5

## 2. Correlation Analysis

**Table 6: Correlation Between AI Usage and Study Variables**

Variables	Pearson r	Interpretation
AI Usage → Mathematical Reasoning	0.65	Strong positive correlation
AI Usage → Cognitive Dependency	0.48	Moderate positive correlation
AI Usage → Comparative Reasoning	0.60	Strong positive correlation

## 3. Hypothesis Testing Table

Based on the objectives of the study, the following hypotheses were tested:

**H<sub>1</sub>:** AI usage in mathematics learning positively influences mathematical reasoning skill development.

**H<sub>2</sub>:** AI usage in mathematics learning is associated with cognitive dependency.

**H<sub>3</sub>:** AI usage in mathematics learning positively affects comparative reasoning performance.

**Table 7: Hypotheses Testing Summary**

Hypothesis	Statistical Test	Result	Decision
H <sub>1</sub> : AI usage → Mathematical reasoning	Correlation analysis	Positive correlation (r = 0.65, p < 0.05)	Accepted
H <sub>2</sub> : AI usage → Cognitive dependency	Correlation analysis	Moderate correlation (r = 0.48, p < 0.05)	Accepted
H <sub>3</sub> : AI usage → Comparative reasoning	Correlation analysis	Positive correlation (r = 0.60, p < 0.05)	Accepted

### Interpretation:

- AI usage positively influences reasoning skills**, indicating that AI tools can support mathematical understanding.
- Moderate correlation with cognitive dependency** suggests that while AI helps learning, excessive reliance may reduce independent thinking.
- AI improves comparative reasoning performance**, showing students perceive better problem-solving outcomes with AI support.
- Likert-scale results confirm that **manual problem-solving is still valued**, and AI is preferred as a **supplementary learning tool**, not a replacement for reasoning.

### Overall Interpretation:

Overall, the findings indicate that AI is perceived as a **valuable educational support** that can enhance mathematical reasoning and learning outcomes. However, the simultaneous recognition of dependency risks and the preference for manual problem-solving underscore the importance of **balanced, guided, and pedagogically structured AI integration**. These results suggest that AI should augment, rather than replace, human reasoning in mathematics education.

**Conclusion:**

The study demonstrates that AI usage in mathematics learning shows a strong positive correlation with mathematical reasoning ( $r = 0.65$ ) and comparative reasoning performance ( $r = 0.60$ ), indicating enhanced accuracy, efficiency, and solution evaluation. However, a moderate correlation with cognitive dependency ( $r = 0.48$ ) highlights the risk of reduced independent reasoning when AI is overused. Students' preference for manual problem-solving supports the importance of active cognitive engagement for conceptual retention. Hence, AI functions optimally as an auxiliary variable that supports, but does not replace, human reasoning. A balanced integration of AI maximizes learning gains while preserving core mathematical thinking skills.

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