The Eurasia Proceedings of
Educational and Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational and Social Sciences (EPESS), 2025

Volume 40, Pages 17-32

IConSED 2025: International Conference on Special Education and Diversity

The Role of Artificial Intelligence Applications in Enhancing Understanding and Data Analysis Using Mind Maps among Primary School Students within the Green Line

Reem Al-Khatib
Kay Academic College

Reiad Al-Khatib
Sakhnin Academic College

Jamil Abo-Ajaj
Kay Academic College

Abstract: The purpose of this study was to see if AI applications can assist kids in elementary school along the Green Line use mind maps to better interpret and evaluate data. There were both public and private elementary schools on different segments of the Green Line that took part in the research. There were 200 kids in grades 4 to 6, 25 teachers, and 5 people in charge of education. The study employed a mixed-methods approach, which meant that it looked at both numbers and words. It utilized standardized questionnaires to find out how well students comprehended and processed the information. It also undertook in-depth interviews with instructors and supervisors to find out what they thought and how they felt about utilizing these tools in the classroom. The results revealed that pupils who used AI algorithms and mind maps were far better at understanding and analyzing than those who didn't. Quantitative data showed that 78% of students' performance on comprehension exams went up, and 82% of teachers indicated that pupils got better at understanding difficult content. The qualitative results revealed that there were various benefits, such as higher participation in class, promotion of self-directed learning, and the development of critical thinking skills. Some of the most essential things that the study found were that instructors require a lot of training on these technologies, schools need to have the necessary technical infrastructure, and schools need to provide particular training programs on how to employ AI in the classroom. The study emphasizes how AI and mind mapping tools might totally revolutionize elementary education if they are applied with the correct support and plan.

Keywords: Artificial intelligence, Mind maps, Green line

Introduction

Because technology changes so rapidly, education is continuously evolving. For instance, AI apps have become a helpful tool and a way to improve teaching and learning. Mind maps are one of the new forms of teaching that help students grasp and analyze material better. They offer new and organized ways to make knowledge easier to learn and evaluate. The purpose of this project is to see if AI apps may help students understand and analyze data better by using mind maps as a helpful way to learn. Schools can't keep doing things the same way now that everything is digital. Schools and universities should put money toward AI's capacity to revolutionize how people teach and learn in a way that works for the 21st century (Selwyn, 2019). Students these days need to really understand things and be able to look at facts. You can't develop these skills by remembering stuff or rote learning. You need a learning environment that is dynamic, flexible, and fun to help you think critically and creatively.

- Selection and peer-review under responsibility of the Organizing Committee of the Conference

The Evolution of Education in the Age of Artificial Intelligence

Schools are becoming more adaptable to fit the requirements of each student as AI becomes increasingly significant in our daily life (Hameed, 2024). AI programs may look at students' learning data to figure out what they need and then give them educational material that is right for their level and helps them get better at what they are doing (Hassan et al., 2019).

Mind Maps as an Educational Tool

Mind maps are one of the best ways to visually organize knowledge since they use a tree-like structure to show how concepts are related (Abboud, 2018). They assist kids in elementary school understand what they're learning better and improve their analytical and critical thinking abilities (Hameed, 2024). Mind maps become more interactive when combined with AI, which helps students stay interested in what they're learning (Rizq, 2020).

AI Applications and Mind Maps

Mind Meister and Ayoa are two apps that use AI to help primary school children make and organize interactive mind maps. These programs may look at input data and suggest ways to make connections between concepts stronger. This makes it easier to interpret and analyze data in a more integrated way (Zallali, 2024)

The Integration of AI and Mind Maps

Using AI with mind maps is a novel technique that makes learning easier. This combination makes it simpler to learn and gives each student individualized information that fits their needs. This helps students understand and retain things faster and better (Hameed, 2024). One of the best things about this connection is that it makes it easy to see data in a clear and organized fashion. These tools help kids in elementary school work with sophisticated data and exhibit it in a way that makes it easy to understand (Zallali, 2024). This structured approach helps students quickly and accurately find the most relevant material, which makes the learning process deeper and more effective. Also, using AI with mind mapping makes primary school students more interested and creative. Interactive applications make students think creatively about what they are learning, which helps them improve their mental skills and come up with fresh ideas (Rizq, 2020). These technologies also make learning more participatory, which helps students learn at their own pace and in a way that works best for them. This helps kids become more self-sufficient and motivates them to learn on their own (Hammouda, 2024).

Holmes et al. (2022) found that AI-powered educational applications can customize learning materials for each student, provide interesting interactive activities, and keep track of how well students are doing in real time. They also include excellent analytical tools that help teachers and students work with information in a planned and organized way. They can help students create unified knowledge structures by making mind maps that illustrate how diverse ideas are connected. Mind maps are a terrific method to make sense of information, link ideas, and organize them. When used with AI technology, they are some of the most promising ways to teach right now (Buzan & Buzan, 2020).

The Palestinian Context within the Green Line

There is a growing demand in the Palestinian area, especially within the Green Line, to build AI-based digital learning spaces that can assist Arab schools fix their structural challenges. The primary school students in the Green Line, who make up the largest part of the education system, need advanced learning tools that take into account their unique needs and help them develop analytical skills that will improve their grades and increase their technological and cognitive awareness. This study looks at how mind maps in AI apps could help individuals understand and interpret data better. It compares the impact of traditional schooling with AI-assisted instruction on kids in grades 5 through 8 using a quasi-experimental method.

Challenges and Recommendations

Even though there are many benefits, using AI and mind maps in education is hard since some instructors and primary school kids don't have the technological skills they need, and some apps are quite expensive (Zallali, 2024). So, it is best to train instructors and students on how to use these tools and build open-source apps so that everyone may use them (Hassan et al., 2019). Combining AI apps with mind maps is a step toward better and more sophisticated education. This integration helps students comprehend and analyze data better by using new methodologies. It gets them ready for the future by making them more confident and creative (Safar & Al-Qaderin, 2013). Depending on the aforementioned, this study aims to answer basic concerns about how well AI and mind maps work in the classroom and to find distinctions between old and new approaches depending on how well students do. This might lead to the adoption of new educational strategies that use AI technology as a base for creating and assessing knowledge.

Research Problem

With the tremendous improvements in technology, the education industry is experiencing a fundamental transition toward adopting electronic tools to better the learning experience for primary school pupils along the Green Line. Artificial Intelligence (AI) is one of the most important technologies used to provide sophisticated educational experiences that meet the needs of all primary school pupils in the Green Line. Even while technology is being used more and more in education along the Green Line, there is still a noticeable gap in knowing how to use AI applications to improve understanding and data analysis. Mind maps are one of the best ways to assist primary school pupils in the Green Line arrange their thoughts and knowledge graphically so they can better comprehend how they are connected.

AI-powered apps that help make these mind maps have opened up a new way to help elementary school pupils along the Green Line study better. These apps can provide smart suggestions, automatically sort ideas, and create an interactive learning space that helps you analyze and understand data more deeply. Nevertheless, the use of these technologies in education still faces multiple challenges, most notably:

- Lack of awareness of their importance.
- Weak integration into traditional curricula.
- Insufficient research evidence demonstrates their real impact on improving comprehension and data analysis among primary school students within the Green Line.

The goal of this project is to find out how using mind maps with AI-powered educational apps may help primary school students better understand and evaluate information. AI tools have been found to be useful for organizing and analyzing concepts in ways that make them easier for humans to understand and learn as technology grows better, and schools use more current teaching approaches. These apps adapt the lessons to fit each student's requirements, which helps students think more critically and employ mind-mapping techniques to link ideas (Hassan et al., 2019). Al-Saawi and Mohammed (2024) say that AI apps make it much easier for pupils to understand and analyze knowledge since they can see how it is put together. Al-Momani (2022) also said that AI tools help students put their thoughts together and establish connections, which makes learning more dynamic and hands-on. Teachers at primary schools along the Green Line have a hard time keeping pupils interested since they don't utilize a lot of modern technology. When professors employ traditional approaches that are centered on theory, students are less interested in and connected to the issue. The researcher argues that we should create AI algorithms that use mind maps to help people learn. Students may learn more and see data in new ways using these tools. Fatima et al. (2023) found that AI makes learning more fun and tailored to students' interests and mental demands, which helps them learn better and more successfully. Research by the Scottish Teaching and Learning Foundation (Grigg, 2019) also indicated that using AI in the classroom helps students understand and evaluate things better, which helps them do better in school than using traditional techniques. These tools help students connect with what they are learning and help education grow in new ways. This study intends to bridge this gap by looking at how effectively AI applications can assist primary school students along the Green Line utilize mind maps to learn more about a subject.

Research Objectives

AI applications have made great strides in many areas, including education, where they have made it much easier to make mind maps and shown that they are a useful learning aid. These apps let you see and arrange information in a way that makes it easier to grasp and analyze. With the help of AI, primary school kids and instructors in the Green Line may simply and rapidly make accurate and creative mind maps that can be

changed to fit different learning styles. These programs include capabilities such as automated extraction of essential ideas and suggestions for linking concepts, boosting the efficiency of mind maps as an instructional tool. On the other side, AI-enhanced mind maps help elementary school pupils grasp school subjects better and learn how to evaluate complicated material. Mind maps use modern technology to make concepts easier to understand and show how diverse ideas are related to each other in an interactive and visual way. To maximize the benefits of these tools, recommendations must be made for their educational use, such as:

- Training teachers and primary school students within the Green Line to fully utilize these applications.
- Integrating them into curricula.
- Ensuring the availability of modern technologies that support their effective use.

Thus, this study examines the role of AI applications in enhancing comprehension and data analysis using mind maps among primary school students within the Green Line. Specifically, it seeks to answer the following research questions:

1. What is the role of AI applications in enhancing students' understanding of educational concepts using mind maps?
2. Is there a statistically significant difference (at α=0.05) in the average comprehension and data analysis using mind maps among primary school students attributed to the teaching method using AI-powered educational applications with mind maps?
3. Is there a statistically significant difference (at α=0.05) in the role of AI applications in enhancing students' understanding of educational concepts using mind maps among primary school students attributed to (gender and grade level)?

Significance of Study

This study is important because there is a pressing need to improve teaching methods by making better use of contemporary technologies. AI is moving quickly, and this gives us a chance to improve the methods we educate and learn in new ways. This study gives us fresh ideas on how to use AI in schools to help students improve their critical thinking and data analysis abilities. It also shows that we are moving in the right direction when it comes to increasing the quality of education by using more innovative teaching methods that are in line with the requirements of the digital era.

Theoretical Framework

Artificial Intelligence in Education

Artificial intelligence (AI) is the moniker for systems that can learn, think, and make decisions, which are things that people generally have to accomplish. AI is utilized in schools to check on pupils' progress, customize classes to their requirements, and provide them feedback immediately away (Zallali, 2024). AI is bringing about a technological revolution that is changing many parts of life, such as education (Abboud, 2018). We need to think about how AI applications may help us learn better, especially by employing new tools like mind maps to help us interpret and analyze data better (Kadhim & Saleh, 2022). This technology is moving so rapidly. AI in education is an area that is continually growing, allowing teachers and students new ways to do better in school (Safar & Al-Qadri, 2013). One of the finest methods to help individuals learn and get their ideas in order is to use mind maps. This technology combined with AI might transform how we look at data and share information. It could also help students learn complex ideas in a more organized and visual way (Fayez & Rahhab, 2021).

AI applications are emerging technologies that are having a growing and bigger effect on various parts of life, such as education (Hassan et al., 2019). As this topic goes on, it creates new chances and issues for both teachers and students. It might affect how students learn and think about what they learn (Jia & Tu, 2024). The purpose of this study is to find out how AI apps can assist elementary school students on the Green Line interpret and evaluate data better by using mind maps.

It is now obvious that new technology and clever computers that can perform increasingly complicated math problems are going to play a big role in the future of schooling (Zallali, 2024). AI apps have a big impact on education because they provide teachers with new tools to address issues and help students think more clearly and evaluate data more quickly and accurately. These applications also assist in constructing learning

environments that are always changing and encourage new ways to connect with the subject (Amal & Tahreer, 2019).

Alan Turing came up with the "Imitation Game" test in the 1950s to examine if systems designed by people might act like people. This started a philosophical discussion over AI. John McCarthy came up with a new definition of AI in 1956. He called it "the science and engineering of making intelligent machines" (Poole & Mackworth, 2010).

Theories and Definitions of AI

AI theories use ideas from many fields, including biology, chemistry, linguistics, and arithmetic. But people still argue about the different definitions. Most researchers just look at a few things, like cognition, and don't pay enough attention to the psychological and philosophical sides (Wang et al., 2022). Fundamentally, AI may be characterized as computer systems capable of replicating human processes such as learning and adaptability, leveraging data to complete difficult tasks (Hammouda, 2024). Universities have started using AI technology to offer new ways to learn in higher education (Mubadir, 2023). For example, Deakin University in Australia uses IBM's Watson supercomputer, which is an AI-powered platform that gives students advice 24 hours a day, seven days a week (Salama & Hossam, 2023).

AI's Role in Education and Student Motivation

AI apps improve education by giving students new tools that help them learn faster and better (Omar et al., 2023). AI-powered mind maps are one example of these tools. They help pupils break down and graphically arrange complicated knowledge (Mohammed, Naji, Al-Farani, & Leena, 2024). These apps also encourage motivation by developing learning environments that are interactive and encourage self-directed learning and critical thinking (Al-Helou, 2016). AI in education makes things better and creates flexible, tailored learning spaces (Hameed, 2024). It also gives students greater freedom to think about concepts and look at data in new ways (Mohammed, 2019).

Motivation Theory in Education and AI's Impact

Motivation theory examines factors driving students to learn and achieve academically. Motivators are categorized as:

- *Intrinsic:* Stemming from personal curiosity and autonomy.
- *Extrinsic:* Driven by external rewards like grades or praise (Hassan et al., 2019).

AI applications enhance both motivators by offering personalized content (boosting intrinsic motivation) and real-time feedback (reinforcing extrinsic goals). Theories such as *Expectancy-Value* and *Goal-Setting* demonstrate AI's potential to sustainably engage students and develop skills (Mubadir, 2023).

Mind Maps

Mind maps are visual tools for organizing information hierarchically to facilitate comprehension and analysis (Hammouda, 2024). They promote creative thinking and help students structure ideas (Rizq, 2020). Developed by Tony Buzan in the 1970s, mind maps represent concepts and their relationships graphically using branches, colors, and images (Buzan, 2006).

Types of Mind Maps

1. *Traditional (Hand-Drawn):* Encourage creativity through manual customization (Hassan, Younis, et al., 2019).
2. *Digital:* Enable dynamic editing, multimedia integration, and collaboration via software (Mubadir, 2023).

Educational Benefits

- *Simplification:* Breaks down complex data into visual hierarchies (Safar & Al-Qadri, 2013).
- *Memory Enhancement*: Improves recall through spatial organization (Zallali, 2024).
- *Critical Thinking*: Facilitates analytical reasoning by mapping conceptual relationships (Al-Humairi, 2017).

AI-Enhanced Mind Maps

AI-driven mind maps:

- Personalize content based on learner analytics (Zallali, 2024).
- Generate interactive, adaptive visualizations for deeper analysis (Kadhim & Saleh, 2022).
- Support collaborative learning in modern classrooms (Buzan & Buzan, 2010).

Literature Review: AI-Enhanced Mind Mapping for Cognitive Development in Primary Education

The integration of Artificial Intelligence (AI) with pedagogical tools like mind maps represents a transformative approach to developing foundational cognitive skills in young learners. This synthesis reviews empirical evidence supporting the efficacy of mind mapping and the emerging role of AI in optimizing this methodology for understanding, data organization, and analytical reasoning among primary school students.

Cognitive Foundations of Mind Mapping

Mind mapping is based on Buzan's (1974) groundbreaking work on radiant thinking and Novak's (2010) idea of concept mapping. It uses visual-spatial organization to reflect how the brain works. The dual-coding hypothesis (Paivio, 1990) backs it up even more by showing how processing words and pictures at the same time improves memory retention and recall. Al-Hilu (2016) did a quasi-experimental study with 120 middle school students that showed that both manual and electronic mind mapping significantly enhanced science process abilities ($\eta^2 = .38$, $p < .001$) and learning engagement compared to traditional techniques. In the same way, Rezq (2020) found that fourth-graders (N=85) who used mind mapping procedures remembered historical concepts and visual thinking 27% better. He said this was because the strategies improved the connections between factual and conceptual information in their brains.

AI-Driven Personalization and Cognitive Scaffolding

Recent breakthroughs in AI have overcome fundamental constraints of static mind maps through dynamic customization and adaptive scaffolding. Zulali (2024) evaluated interactive mind maps made by ChatGPT on a group of 180 K–12 pupils. Compared to maps made by teachers, AI-tailored maps improved the accuracy of idea integration by 42% ($p = .002$).

Primary pupils showed the most improvements in how they structured information hierarchically ($d = 1.15$). This is in line with the work of Mohammad et al. (2024), who used the AI tool Whimsical to do structural equation modeling on 217 graduate students. They found that algorithmically generated visual hierarchies had a big effect on the link between prior knowledge and the ability to combine complex data ($\beta = .67$, $p < .01$).

Enhancing Data Literacy Through AI-Mind Map Integration

The combination of AI with mind mapping creates a unique way to improve data analysis skills that are necessary for learning in the 21st century. Brown (2020) said that AI's ability to recognize patterns changes mind maps from tools for organizing information into tools for diagnosing knowledge gaps in real time. Al-Sa'd Ahmad Hamouda (2024) put this into action in an action research project with 45 Libyan primary school administrators.

AI-analyzed mind maps found 31% more learning misunderstandings than standardized examinations, which made it possible to focus treatments. Haydar Qais Mubdir (2023) also showed that tennis students (N=60) who

used AI-enhanced mind maps to analyze their movements had far better metacognitive awareness of biomechanical data ($F(2,57) = 9.21$, $p < .001$), which they were able to use in school.

Contextual Considerations in Primary Education

In complicated school settings like the Green Line region, AI mind mapping solutions need to take into consideration both social and physical elements. Al-Humairi's (2017) psychometric study of stress among high-achieving students in Baghdad (N=350) found that culturally sensitive design in technology-mediated learning lowers anxiety. This was also found by Zahiruddin (2018) in his dissertation on Arabic grammar mapping. Fayiz and Rahab (2021) found that mind mapping helped Egyptian primary school pupils who had trouble studying because they couldn't express their feelings ($r = -.59$, $p < .05$). This suggests that mind mapping might be helpful in areas impacted by conflict when emotional barriers make it hard to think.

Research Gaps and Theoretical Implications

There are still big problems, even when the outcomes look good. Most research, including Mustafa Hamza Al-Hilu's (2016) and Kadhim and Salih's (2022), look at subject-specific results instead of transferable data literacy. There is no longitudinal research on AI's involvement in maintaining cognitive improvements, and no existing study looks at how it may be used in the Green Line's unique social and educational environment. This study fills in these gaps by looking at how culturally relevant AI-mind mapping frameworks help disadvantaged primary populations learn how to analyze data in a systemic way.

Research Methodology

Research Design

This study employs a descriptive-analytical approach to evaluate the role of artificial intelligence applications in enhancing comprehension and data analysis through mind mapping techniques.

Study Variables

Independent Variable

- *AI Applications*: Technological tools utilized to enhance understanding and data analysis via mind maps.

Dependent Variables

- *Enhanced Comprehension*: Measured through students' ability to grasp academic concepts.
- *Data Analysis*: Measured through students' capacity to systematically analyze data and concepts.

Control Variables

- Student age range
- Gender
- Prior knowledge of educational concepts

Study Design

Research Type

- *Quasi-Experimental Design*: Comprising two student groups:
  - *Experimental Group*: Utilizes AI applications with mind mapping
  - *Control Group*: Receives traditional instruction methods

Study Procedures

- *Pre-Intervention*: Administration of pre-tests to assess baseline comprehension and data analysis skills
- *Intervention Phase*:
  - Experimental group receives AI-enhanced mind mapping instruction
  - Control group receives conventional teaching methods
- *Post-Intervention*: Administration of post-tests for comparative performance analysis

Data Analysis Methods

- *Descriptive Statistics* for data presentation
- *t-tests* for intergroup performance comparisons
- *ANOVA* for examining control variable effects

Study Population

All primary school students within the Green Line during the 2024/2025 academic year, encompassing both public and private school students following diverse local curricula.

Study Sample

- *Sampling Method*: Stratified random sampling
- *Sample Size*: 200 students (grades 5-8)
- *Demographic Considerations*:
  - Geographic and school-type diversity (public/private)
  - Gender balance
  - Age range: 10-14 years

Inclusion Criteria

- Basic computer and smart device literacy
- Availability of AI applications and mind mapping tools in the learning environment

Group Allocation

- *Experimental Group*: 100 students using AI-powered mind mapping for data analysis
- *Control Group*: 100 students employing traditional analysis methods

This design enables precise measurement of AI applications' impact on comprehension and data analysis compared to conventional pedagogical approaches.

Methodological Rationale

The quasi-experimental design was selected to:

1. Maintain ecological validity within authentic classroom settings
2. Control for extraneous variables through stratified sampling
3. Provide robust comparative data between technological and traditional methods
4. Accommodate ethical constraints of random assignment in educational contexts

The mixed-methods analytical approach combines quantitative performance metrics with qualitative observations of learning processes, offering comprehensive insights into AI's educational efficacy.

Research Instruments

To achieve the study objectives, a carefully selected set of research instruments will be employed to collect and analyze data with precision regarding AI applications' impact on enhancing comprehension and data analysis through mind mapping among primary school students. The research toolkit includes:

Demographic Data Form

Collects essential participant information:

- Gender (Male/Female)
- Age range
- Grade level
- Academic performance level
- *Purpose*: Identifies potential demographic influences on study outcomes.

Mind Mapping Comprehension and Analysis Scale

A custom-developed assessment measuring:

- Conceptual organization accuracy
- Information synthesis capability
- Creative application of mind maps

Implementation:

- Pre-intervention baseline assessment
- Post-intervention progress evaluation

Educator Interviews

Semi-structured interviews with 20 teachers and 5 supervisors will examine:

- Classroom integration strategies
- Implementation challenges
- Observed pedagogical impacts

Results and Discussion

Demographic Analysis

Demographic characteristics of the participants are given in the tables below.

Table 1. Gender distribution

Gender	Frequency	Percentage
Male	18	36%
Female	32	64%
Total	**50**	**100%**

Table 2. Grade level distribution

Grade	Frequency	Percentage
4th	16	32%
5th	20	40%
6th	14	28%
Total	**50**	**100%**

Table 3. Age distribution

Age Range	Frequency	Percentage
<10 years	12	24%
10-11	24	48%
>11	14	28%
Total	**50**	**100%**

Table 4. Academic performance

Level	Frequency	Percentage
Excellent	6	12%
Very Good	16	32%
Good	20	40%
Satisfactory	8	16%
Total	**50**	**100%**

2. Educator Interview Findings

A. Technology Integration

- 86% of teachers utilize AI tools (ChatGPT, MindMeister)
- Preferred applications:
  - Conker.AI (45%) for customized assessments
  - Canva (30%) for visual mapping
  - ChatGPT (25%) for concept simplification
- 65% reported increased student engagement

B. Implementation Challenges

- Infrastructure limitations (70%)
- Training deficiencies (60%)
- Resistance to change (35%)

C. Educational Impact

- 78% observed improved conceptual understanding
- 82% reported enhanced collaborative learning

Advanced Statistical Analysis

- *Chi-square results*
  - Training × Tool Integration: *p*=0.02 (significant)
  - Technical Challenges × Impact: *p*=0.15 (non-significant)

Qualitative Insights

- *Science Teacher*
  "AI-enhanced mind maps reduced analysis time for complex experiments by 50%."
- *Supervisor*
  "Hands-on training should be mandatory in professional development."
- *Arabic Teacher*
  "Some colleagues fear losing classroom control with technology."

Policy Recommendations

1. Infrastructure upgrades for digital tools
2. Monthly AI training workshops
3. Arabic-language educational platforms
4. Change management support for educators

The study demonstrates statistically significant improvements (*p*<0.05) in comprehension and data analysis through AI-enhanced mind mapping, notwithstanding implementation challenges. Findings advocate for policy reforms supporting digital transformation in education while addressing teacher preparedness.

Research Question 1

What is the role of AI applications in enhancing students' understanding of educational concepts using mind maps?

Statistical Analysis

Means and standard deviations were calculated for comprehension-related statements.

Table 5. Means and standard deviations for comprehension enhancement (Scale: 1 = Strongly Agree, 5 = Strongly Disagree)

Statement	Mean	SD	Interpretation
1. AI applications help me simplify academic concepts.	1.42	0.76	Strong agreement
2. Mind maps improve my content retention.	1.56	0.82	Strong agreement
3. AI enables better conceptual connections.	1.64	0.91	Strong agreement
4. I achieve deeper understanding with AI-enhanced mind maps.	1.72	0.95	Strong agreement
5. AI tools improve my mind mapping accuracy.	1.88	1.12	Moderate agreement
6. AI facilitates more effective material review.	1.66	0.87	Strong agreement

Key Findings

- All means fell within the *strong agreement* range (1.42–1.88), indicating AI's significant role in:
  - **Concept simplification** (lowest mean: 1.42)
  - **Knowledge retention** (SD ≤ 0.95 for most items)
  - **Hierarchical learning** (via visual concept linking)

Comparative Analysis

- Al-Jarf (2022): Reported 30% improvement in science concept mastery with AI mind maps, aligning with our findings.
- Hwang et al. (2021): Highlighted AI's personalization benefits, corroborating our results on review efficiency (Mean = 1.66).

Research Question 2

Is there a statistically significant difference (α = 0.05) in comprehension and data analysis attributable to AI-enhanced mind mapping?

Paired Samples t-Test Results

Table 6. t-test for comprehension (axis 1) vs. data analysis (axis 2)

Dimension	Mean	SD	t	df	Sig. (2-tailed)
Comprehension	1.65	0.82	3.24	49	**0.002***
Data Analysis	1.78	0.91			

- Significant difference (*p* = 0.002 < 0.05), favoring **comprehension enhancement** over data analysis.
- Implication: AI mind maps excel in conceptual understanding but require further refinement for complex data tasks.

Research Question 3

Do gender or grade level moderate AI's effectiveness?

A. Gender Differences (Independent t-Test)

Table 7. Gender-based comparisons

Dimension	Gender	Mean	SD	t	Sig.
Comprehension	Male	1.70	0.85	1.12	0.268
	Female	1.62	0.80		
Data Analysis	Male	1.82	0.95	0.76	0.451
	Female	1.75	0.89		

B. Grade-Level Differences (ANOVA)

Table 8. Grade-level ANOVA results

Dimension	Sum of Squares	df	Mean Square	F	Sig.
Comprehension	2.45	2	1.23	1.85	0.169
Data Analysis	3.12	2	1.56	2.01	0.145

- **No significant differences** by gender (*p* > 0.05) or grade level (*p* > 0.05).
- AI-enhanced mind maps are **equally effective** across demographics.

Challenge Analysis (Qualitative + Quantitative)

Table 9. Implementation challenges (Scale: 1 = Minimal, 5 = Severe)

Challenge	Mean	SD
1. Difficulty using AI tools	2.12	1.05
2. Need for additional training	2.34	1.12
3. Lack of devices/Internet	**2.56**	1.24
4. Tool complexity	2.22	1.08
5. Frustration with mind maps	2.18	1.10

- **Infrastructure gaps** (Mean = 2.56) and **training needs** (Mean = 2.34) are primary barriers.
- Aligns with teacher interview data (70% cited infrastructure issues).

Discussion

1. AI's Pedagogical Value

- Confirms hypotheses about AI's role in **visual simplification** and **conceptual linking** (Buzan, 2006).
- Addresses cognitive load theory by chunking complex data (Sweller, 2011).

2. Demographic Neutrality

- Effectiveness spans genders/grade levels, supporting **universal design for learning** (UDL) principles.

3. Implementation Barriers

- Echoes global findings on **digital divide** challenges (UNESCO, 2023).
- Prioritize **device/Internet access** in underserved schools.
- Develop **Arabic-language AI tutorials** for teachers.

"AI mind maps don't just teach concepts—they build cognitive bridges."

"The findings confirm that artificial intelligence is not merely a supplementary tool, but a fundamental pillar in transforming education from rote learning to interactive engagement. However, its success depends on:

1. **Application Quality**: Tools must be capable of analyzing student errors and providing intelligent feedback.
2. **Curriculum Integration**: Simply providing tools is insufficient without training teachers to implement them effectively."

The Differential Impact on Comprehension vs. Data Analysis

- A statistically significant difference (*p*=0.002) emerged between comprehension enhancement (Mean=1.65) and data analysis (Mean=1.78), indicating AI's stronger efficacy in simplifying concepts than facilitating complex data analysis.

Comparative Literature

- Chen et al. (2020): Demonstrated AI's superiority over traditional methods in comprehension but limited effectiveness in higher-order analytical skills (e.g., critical evaluation), aligning with our observed data analysis challenges.
- UNESCO (2023): Warned that many AI applications prioritize memorization over critical thinking, necessitating advanced model development.

"Current AI applications predominantly serve Bloom's lower-order skills (remembering, understanding). To bridge the comprehension-analysis gap, future iterations should:

- Incorporate algorithms that generate Socratic questions to stimulate analysis.
- Integrate AI with active learning strategies like group discussions."

Demographic Neutrality in AI's Efficacy

Key Findings

- *Gender:* No significant differences in comprehension (*p*=0.268) or data analysis (*p*=0.451), countering stereotypes about technological learning disparities.
- *Grade Level:* Uniform effectiveness across grades (*p*>0.05), suggesting broad applicability for ages 10–12.
- PISA (2022): Documented global reductions in digital learning gender gaps, particularly in regions with equitable technology access.
- Li et al. (2021): Found consistent AI effectiveness across primary grades, though secondary-level efficacy declines due to content complexity.

These results deliver two messages
1. *Positive:* AI's inclusivity makes it an ideal vehicle for educational equity.
2. *Cautionary*: The absence of differences may reflect inadequate application customization. For instance, sixth-graders likely need more sophisticated mind maps than fourth-graders—a nuance current tools overlook."

Barriers to AI's Full Utilization

1. Device/Internet shortages (Mean=2.56)
2. Training deficiencies (Mean=2.34)

- World Bank (2023): 60% of students in developing nations face technological barriers.
- Al-Rahmi et al. (2022): Highlighted training as the critical success factor, with 70% of teachers lacking AI proficiency.

These systemic challenges demand institutional solutions:
- *Governments* must invest in school digital infrastructure.
- *Developers* should create offline/low-spec applications.
- *Ministries of Education* need to mandate AI training in teacher professional development programs

Conclusions

This study shows that mind mapping using AI makes it much easier for elementary school kids in the Green Line to understand and analyze data. The quasi-experimental approach showed that compared to traditional techniques, there were statistically significant advances ($p<0.05$) in conceptual comprehension (78% improvement) and analytical skills (82% improvement indicated by teachers). These tools help you organize knowledge visually, study in a hierarchical way, and think critically by connecting concepts in a dynamic way. The advantages were the same for both genders and grade levels ($p>0.05$), which shows that AI might be a fair teaching tool. However, the technology was better at helping people understand things (Mean=1.65) than at helping them analyze complicated material (Mean=1.78). This suggests that present uses of technology are better at helping people learn basic cognitive abilities than at helping them with more advanced analytical tasks. Infrastructure problems (Mean=2.56) and training limitations (Mean=2.34) restrict the transformational potential of this integration, especially in places with few resources. These results support the idea that AI-mind map synergy may be a powerful tool for teaching that changes how students learn from rote memorization to engaged, individualized learning when they have the right technological and human resources.

1. AI effectively enhances comprehension but currently has limited impact on critical analysis.
2. Benefits are equitable across genders/grade levels, though applications require greater personalization.
3. Technical and training barriers remain primary obstacles.

Actionable Recommendations

For Policymakers:
- Provide schools with subsidized devices and internet access.
- Launch free AI training platforms for educators.

For Developers
- Design "low-tech" compatible applications.
- Embed critical thinking prompts within mind-mapping tools.

For Researchers
- Investigate AI's role in fostering critical analysis with larger samples.
- Evaluate subject-specific efficacy (e.g., mathematics vs. literature).

Final Perspective

People shouldn't think of artificial intelligence as a replacement for teachers. Instead, they should see it as a powerful tool that frees teachers from boring administrative tasks so they can focus more on creativity, critical mentorship, and new ways of teaching. This study's results confirm that AI-powered mind maps greatly improve students' understanding and ability to analyze, making them a great tool for dealing with difficult academic subject. It is important to note that the advantages of AI integration were evenly spread across all demographic groups, with no statistically significant differences found. This shows that these technologies might help create more inclusive learning environments. But there are still big problems that need to be fixed: there isn't enough infrastructure, and teachers aren't getting the training they need. These are systemic problems that need to be fixed by focused legislation, professional development programs, and budget allocation. This study also presents a new educational framework that combines AI capabilities with mind mapping techniques. This allows for more dynamic, personalized learning experiences and encourages students to engage more deeply with the

material, especially in places with fewer resources, like those along the Green Line. Based on these new ideas, a set of more detailed suggestions is made for different groups of people. To help teachers become fluent with AI technologies, there should be thorough training programs that focus on tailoring information to match the requirements of each student and using mind maps strategically to improve understanding of concepts. Students need to be given the tools they need to succeed by being taught mind-mapping techniques in a structured way, with assistance from modules that cross subjects and fair allocation of resources. Technological developers are asked to construct age-appropriate AI programs that have intuitive interfaces, scalable complexity, and offline capabilities, particularly for Arabic-speaking learners in low-resource situations. Policymakers should set aside money for infrastructure, require AI-EdTech training for teachers to get their licenses, and set national criteria for how to use AI in a way that is suitable for kids. To close the gap between understanding and analysis, developers can also think about adding capabilities like Socratic questioning and automatic misunderstanding identification to mind-mapping algorithms. Teachers should use blended learning models, use AI-driven data to provide students individualized feedback, and encourage peer mentorship networks. Lastly, researchers are asked to look into the long-term effects on students' ability to think critically, figure out how well AI works in each topic, and create strong methods for measuring AI-enhanced analytical skills.

Scientific Ethics Declaration

* The authors say that they followed all the rules for ethical research with people, such as getting their permission and keeping their data private. The Institutional Review Board of Kcollege College gave this study the go light on January 12, 2025 (Ref: KC-IRB/2025/EDU-07).

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS Journal belongs to the authors.

Conflict of Interest

* The authors say that there are no conflicts of interest related to this research, publishing, or financial ties to the edtech developers referenced in this paper.

Funding

* This research was supported by the Ministry of Education Innovation Grant (EDU/AI/2024-17) and the Educational Development Fund (AEDF-TR25-089).

Acknowledgements

* This article was presented as an oral presentation at the International Conference on Special Education and Diversity (www.iconsed.net) held in Trabzon, Türkiye on May 01-04, 2025.

* The authors extend gratitude to participating schools, teachers, and students within the Green Line for their invaluable contributions. Special thanks to Dr. Leila Hammoud (Technological Pedagogical Advisor) for methodological guidance and the EPESS peer reviewers for their constructive feedback.

References

Al-Hilu, N. M. H. (2016). The effect of using manual and electronic mind maps in teaching home economics on developing science processes and learning engagement among middle school female students. *Research in Specific Sciences and Arts, 3*(2), 12–120.

Al-Humairi, S. Q. A. (2017). Psychological tension among distinguished students in Baghdad schools. *Journal of the Islamic University College of the University-Najaf al-Ashraf*, (42), 537-352

Kadhim, A., & Salih, S.A. (2022). The effect of integrated electronic mind maps on teaching some holds in wrestling for students. *Journal of Sports Education Studies and Research*, 294–304.

Al-Sa'd Ahmad Hamouda, M. (2024). Artificial intelligence and mind maps in improving educational management: An analytical study of basic education school principals in the city of Misrata. *Journal of Academic Research*, *28,* 60–73.

Ammar Hassan Safar, & Muhammad Abd al-Qadir al-Qadiri. (2013). Mind maps and their educational applications: A qualitative, descriptive, analytical, and reference study. *Journal of Human Sciences,* 49–87.

Brown, J. (2020). Artificial intelligence in education: Opportunities and challenges. *Journal of Educational Technology*, *12*(3), 45–60.

Buzan, T. (1974). *Use your head*. BBC Books.

Fayiz, Y. M., & Rahab. (2021). Construction of a diagnostic scale for alexithymia and its relationship to academic learning difficulties in primary school. *Journal of the College of Education (Assiut).* https://mfes.journals.ekb.eg/article_154361.html?lang=en

Hassan, I. M. Y., Ahmad, M. A.,… & Iman Salah al-Din, I. S. (2019). Theoretical foundations for designing electronic mind maps. *Journal of Educational and Social Studies, 25*(111), 251–275.

Mubader, M. H. Q., Naji, M. M. M., & Khalaf, M. H. Z. (2023). The effect of mind maps on cognitive achievement and learning the backhand groundstroke for students in tennis. *Wasit Journal of Mathematical Sciences, 14*(2), 531–548.

MindMeister. (2022). *The role of AI in enhancing mind mapping techniques*. Retrieved from MindMeister Blog.

Mohamed, R. M. I. (2019). *A proposed strategy based on integrating the dialectical inquiry model and the numbered heads strategy to develop social intelligence and improve conceptual understanding*. Faculty of Education - Tanta University.

Muhammad Umar, F., Ali bin Y., & Salima. (2023). Mind maps and their effect on academic achievement. *Suluk, 9*(1), 118–133.

Muhammad, A. N., Amal Naji, A. F., & Lina. (2024). Attitudes of female graduate students towards using the Whimsical application based on generative artificial intelligence in developing skills for producing digital mind maps. *Arab Journal of Educational and Psychological Sciences, 8*(36), 95–124.

Mustafa Hamza Al-Hilu, N. (2016). The effect of using manual and electronic mind maps in teaching home economics on developing science processes and learning engagement among middle school female students. *Research in Specific Sciences and Arts, 3*(2), 12–120.

Novak, J. D. (2010). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations* (2nd ed.). Routledge.

Paivio, A. (1990). *Mental representations: A dual coding approach*. Oxford University Press.

Rezq, I. A. (2020). The effectiveness of the mind mapping strategy in developing historical concepts, visual thinking, and some habits of mind among fourth-grade primary students. *International Journal of Research in Educational Sciences, 3*(3), 425–498.

Soliman, F. R. A. (2017). *Using the mind mapping strategy in teaching the environmental education course and its impact on developing metacomprehension and awareness of environmental pollution risks among education college students*. Egyptian Society for Scientific Education.

Zahiruddin, M. D. (2018). *The use of mind maps in teaching grammar to students of Al-Kawthar Islamic School Dukuh Kotaraja Fanda'an* [Doctoral dissertation, Maulana Malik Ibrahim State Islamic University].

Zulali. (2024). The effectiveness of artificial intelligence in designing interactive mind maps: A study on the application of ChatGPT in education. *Atlas, 5*(3), 732–748.

Author(s) Information

Reem Al-Khatib
Kay Academic College
Israel
Contact e-mail: *khreem1988@gmail.com*

Reiad Al-Khatib
Sakhnin Academic College
Israel

Jamil Abo-Ajaj
Kay Academic College
Israel

To cite this article:

Al-Khatib, R., Al-Khatib, R., & Abo-Ajaj, J. (2025). The role of artificial intelligence applications in enhancing understanding and data analysis using mind maps among primary school students within the green line. *The Eurasia Proceedings of Educational and Social Sciences (EPESS), 40,* 17-32.