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Mind Meets Machine: A Scientometric Exploration of the Cognitive Frontier in Generative AI

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ABSTRACT
This study explores how generative artificial intelligence (GenAI) affects users' thinking and learning by analyzing research trends from 2016 to 2025 using bibliometric methods. Based on 302 academic papers, it shows how early research focused on technical aspects like deep learning and chatbots, while recent studies (especially in 2025) highlight more human-centered topics such as creativity, decision-making, and language understanding. The findings group the research into four main themes: AI in education, medical training, cognitive science, and decision-making. The study concludes that GenAI is becoming more connected to how people think, learn, and use language, offering guidance for future research and educational practices.

Keywords: Generative AI, Cognitive Knowledge, AI in Education, Human-AI Interaction, Research Trends

1. INTRODUCTION

This study examines the interplay between generative artificial intelligence (GenAI) and users' cognitive knowledge through a bibliometric investigation that aims to synthesize emerging research trends and examine how GenAI technologies affect cognitive processes. The advent of GenAI has not only accelerated innovations in education and human–computer interaction but also challenged traditional conceptualizations of cognition by providing novel tools for both knowledge construction and deconstruction (Ahmed et al., 2024; Bozkurt, 2023). In recent years, researchers have increasingly turned their attention to the cognitive repercussions of deploying language models and conversational agents across diverse domains. For instance, while GenAI's capabilities are touted for enhancing problem-solving and creative thinking (Gonsalves, 2024), concerns have emerged regarding potential over-reliance and the ensuing metacognitive laziness among users (Fan et al., 2024; Zhai et al., 2024).

A bibliometric approach is ideally suited to capture these multifaceted influences, offering a macroscopic view into the evolution of GenAI literature and its impact on users' cognitive knowledge. Similar investigations in educational praxis have shown that systematically mapping the literature can unveil not only emerging trends but also critical gaps in the understanding of how cognitive skills are fostered or undermined by GenAI interventions (Bozkurt, 2023; . The present study, therefore, integrates diverse strands of inquiry—from empirical analyses of GenAI-assisted cognitive interventions to theoretical debates on AI-induced shifts in knowledge paradigms—to provide a comprehensive picture of current research trajectories. By leveraging bibliometric methods, the study aims to delineate patterns related to disciplinary intersections, temporal trends, and contextual adaptations, thereby contributing to a more nuanced understanding of how GenAI redefines cognitive epistemologies in modern settings (Bozkurt, 2023; , Fan et al., 2024).

Moreover, early evidence suggests that the transformative potential of GenAI is accompanied by critical challenges, necessitating a re-examination of cognitive frameworks in light of automated knowledge generation and retrieval (Gonsalves, 2024). Such paradigmatic shifts call for further exploration of the balance between cognitive augmentation and the risk of cognitive offloading, underscoring the importance of rigorous bibliometric analysis in synthesizing the heterogeneous literature in this rapidly evolving field (Zhai et al., 2024). This investigation, therefore, aims to serve as a foundation for future studies, fostering interdisciplinary dialogue on the integration of GenAI and the enhancement of cognitive knowledge across varied user populations.

2. METHODS

The methodology employed for the bibliometric investigation of "Generative AI and Users' Cognitive Knowledge" utilized the Scopus database as the primary source for literature retrieval. This approach was chosen due to Scopus's extensive coverage of peer-reviewed publications across multiple disciplines, particularly those relevant to technology

and education (Zamrudi, 2023; Goncalves et al., 2024). A systematic search strategy was implemented, utilizing keywords such as "generative artificial intelligence," "cognitive knowledge,". To ensure the data rigidity, we conduct a metadata review from initial identification process resulting about 906 records and refined to be 302 data as indicated in Figure 1.

Table 1. Search String Design

Context	Search String
Human Cognitive Knowledge	"human cognit*" OR "cognitive skill*" OR "cognitive knowledg*" OR "cognitive abilit*" OR "mental process*" OR "executive function*" OR metacognit* OR "conceptual knowledg*" OR "factual knowledge*" OR "procedural knowledg*" OR "cognitive develop*" OR "cognitive learn*" OR "cognitive psycholog*" OR "thinking skill*" OR "problem-solving skill*" OR "reasoning skill*"
Generative AI	"generative AI" OR "generative artificial intelligence" OR "large language model*" OR "LLM*"

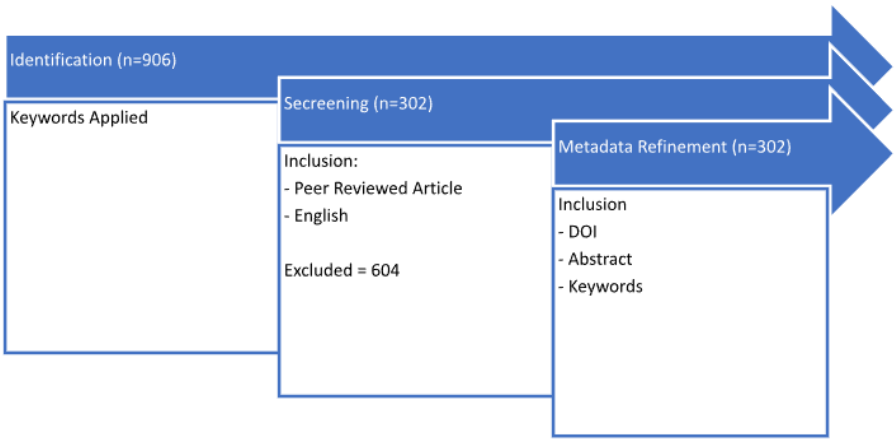


Figure 1. Bibliometric Metadata Refinement

Data analysis for the bibliometric study was conducted using VOSviewer and Bibliometrix, two powerful tools for visualizing and analyzing bibliometric data. VOSviewer was utilized to create thematic maps, which visually represent the relationships among keywords in the literature, elucidating the research themes and their interconnections (Zamrudi et al., 2024; Zamrudi, 2023). This visual approach allowed for the identification of major domains in the context of generative AI, providing insights into how various themes have evolved over time. Bibliometrix complemented this analysis by providing rich statistical metrics, such as publication trends and citation analysis, which are crucial for understanding the impact and reach of the findings within the academic community.

Through thematic mapping, we were able to capture the dominant research themes concerning generative AI and cognitive knowledge, revealing key areas of focus such as AI-driven learning enhancements, users' cognitive adaptations, and the social and ethical implications of AI integration in educational settings. These themes were further analyzed in detail to understand their compound effects and relationships, allowing for a nuanced depiction of how research in this field interrelates and progresses.

3. RESULTS AND DISCUSSION

3.1. Thematic Map

The general finding from the thematic maps using co-occurrence network, indicates that most of the study is conducted in health science related. The thematic map from this study indicates 4 main cluster indicated in Figure 2. First, cluster 1 (red) consist of 32 terms, cluster 2 (green) consist of 29 terms, cluster 29 (blue) contain 18 terms, and last but not least the cluster 4 (yellow) contain of 17. From this cluster, we do synthesize theme related to specific topics for each cluster, which in results all of four clusters having 5 theme each, and finally we summarize the bigger theme for each clusters as shown in Table 2.

As shown in Figure 2, the biggest nodes is shown by the artificial intelligence related terms, such as ai, large language model, Chat Gpt, chat bots, generative ai, as it is the backbone of the topics investigated.

3.1.1. Transformative Integration of AI in Learning and Education Systems

The integration of Artificial Intelligence (AI) in education is transforming learning through five key aspects: technology adoption, cognitive skill development, contextual outcomes, user perspectives, and infrastructure support. AI tools like chatbots and large language models (LLMs) enhance personalized learning and critical thinking (Khlaif et al., 2024; Imran et al., 2024; Gao et al., 2023; Fan et al., 2024; Namboothiri et al., 2024). They also improve students' creativity and argumentation skills (Gonsalves, 2024; Zhou et al., 2024; Nusivera et al., 2025), though implementation varies by institutional readiness and raises concerns around assessment validity and academic integrity (Kaldaras et al., 2024; Rahman & Watanobe, 2023). Successful adoption depends on user acceptance, professional development, and robust infrastructure supported by ongoing research to ensure ethical and effective use (Rojas et al., 2024; G & Nair, 2024; Zhai et al., 2024).

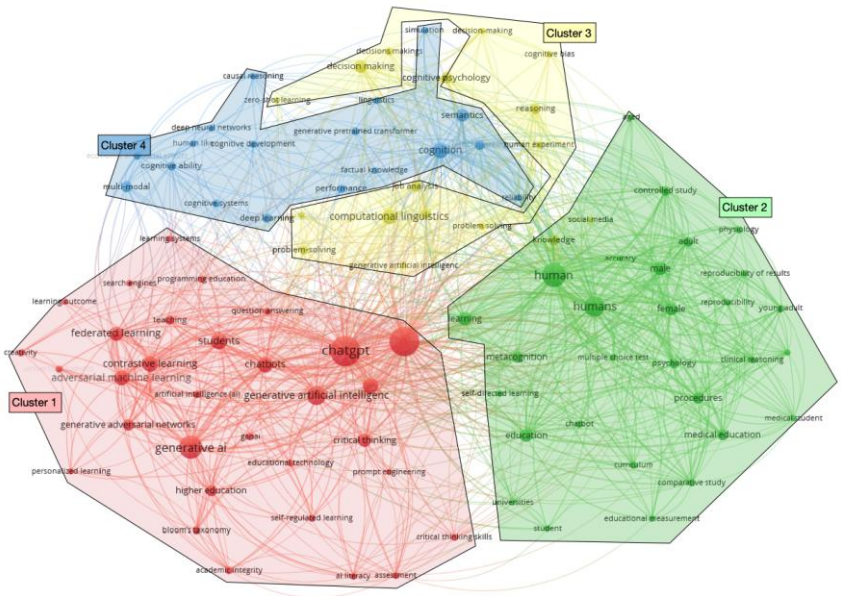


Figure 2. Keywords Co-Occurence Clustering

Table 2. Thematic Maps of Keywords Co-Occurrence Cluster

Cluster 1 (33 items)	Cluster 2 (19 items)	Cluster 3 (19 items)	Cluster 4 (19 items)
A. Artificial Intelligence and Technologies	A. Medical and Clinical Education	A. Cognitive Science and Psychology	A. Cognitive and Psychological Processes
B. Learning Strategies and Cognitive Skills	B. Educational Research and Measurement	B. Artificial Intelligence and Machine Learning	B. Decision Science and Human Behavior
C. Educational Contexts and Outcomes	C. Psychology and Human Cognition	C. Evaluation and Model Performance	C. AI and Language Technologies
D. User and Institutional Perspectives	D. Human Demographics	D. Language and Semantics	D. Learning and Support Tools
E. Infrastructure and Research Support	E. Technology in Education	E. Broader Implications	E. Media and Context
Topical Summary			
"Transformative Integration of AI in Learning and Education Systems"	"Human-Centered Evaluation and Training in Medical and Educational Contexts"	"Cognitive Modeling and Semantic Representation in AI Systems"	"Cognitive-AI Interaction in Decision Making and Knowledge Processing"

3.1.2. Human-Centered Evaluation and Training in Medical and Educational Contexts

The concept of human-centered evaluation in medical and educational contexts emphasizes personalized, inclusive, and cognitively informed approaches to improving learning outcomes. In medical training, tools like large language models (LLMs) enhance clinical reasoning and decision-making, but require rigorous evaluation to ensure reliability (Borg et al., 2024; Rojas et al., 2024; Griot et al., 2025). In education, AI fosters authentic assessments and promotes self-regulated learning, yet must align with learner needs (Abouammoh et al., 2025; Meissner et al., 2024). Cognitive and metacognitive skills shape learner-AI interactions, while demographic factors like age and background influence accessibility and effectiveness (Urban et al., 2025; Baharin, 2025). Finally, while AI personalizes education, a balanced approach is vital to prevent cognitive offloading and maintain active learning (Fan et al., 2024; Alessandri-Bonetti et al., 2024).

3.1.3. Cognitive Modeling and Semantic Representation in AI Systems

Cognitive modeling and semantic representation in AI systems aim to simulate human reasoning and language understanding by integrating insights from cognitive science, machine learning, and linguistics. Large language models (LLMs) have demonstrated capabilities in problem-solving, metacognition, and adaptive learning, yet also exhibit human-like biases that require careful design and evaluation (Khlaif et al., 2024; Singh et al., 2024; Gao et al., 2023). Evaluation methods, including human-in-the-loop strategies, are essential to ensure reliable and ethical AI performance (Namboothiri et al., 2024; Atchley et al., 2024). As AI increasingly supports education and clinical decisions, understanding language and meaning becomes critical, particularly given the role of NLP in semantic tasks (Lampinen et al., 2024; Zamrudi, 2024). The broader implications underscore the importance of responsible AI use, addressing dependency, fairness, and the need for ongoing collaboration between educators, technologists, and policymakers (Mogi, 2024; Mannekote et al., 2024; Attah, 2025).

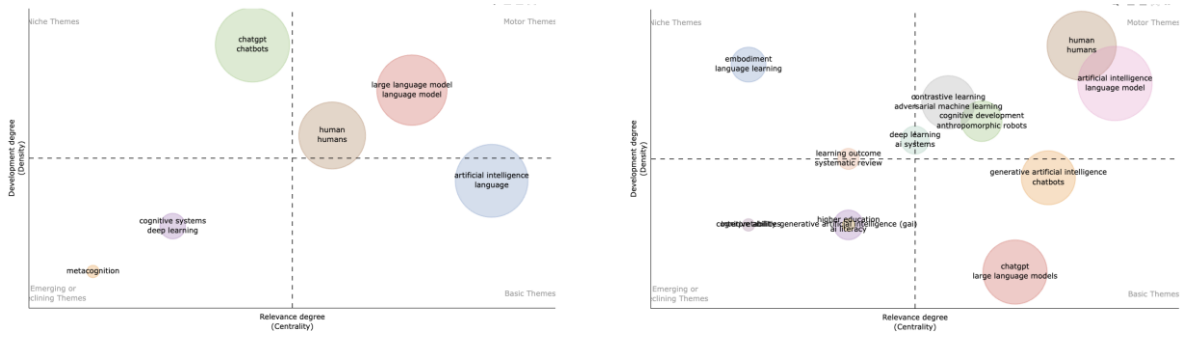
3.1.4. Cognitive-AI Interaction in Decision Making and Knowledge Processing

Cognitive-AI interaction explores how AI can enhance human decision-making and knowledge processing by integrating cognitive science, decision theory, and language technologies. AI tools like ChatGPT support critical thinking, self-regulation, and metacognition, offering adaptive learning and real-time insights (Khlaif et al., 2024; Fan et al., 2024; Bozkurt, 2023). Collaborative decision-making between humans and AI improves outcomes, though care is needed to manage model biases (Hao et al., 2024; Milad et al., 2024). Natural language processing facilitates intuitive interactions, while AI-based learning platforms foster deeper engagement and future-ready skills (Gonsalves, 2024; Zhou et al., 2024; Vasconcelos & Santos, 2023). Effective implementation depends on supportive educational contexts and infrastructure that sustain AI literacy and cognitive involvement (Binz & Schulz, 2023; Namboothiri et al., 2024).

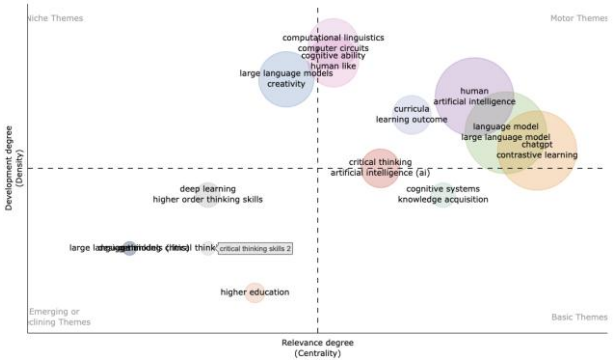
3.2. Thematic Evolution

Thematic evolution is a bibliometric analysis technique used to trace how research topics develop and shift over time within a particular field. By visualizing clusters of keywords across different time slices, this method helps identify emerging, consolidating, or declining themes. It reveals not only the intellectual structure of a research domain but also the dynamics of scholarly attention, offering insights into how priorities, innovations, and conceptual frameworks evolve.

In the third time slice (2025), the thematic evolution reveals a clear shift toward deeper integration of human-centered and language-focused AI research, with computational linguistics, creativity, and semantics emerging as dominant themes. This marks a transition from earlier phases (2016–2024), where AI research primarily emphasized performance and technical development (e.g., deep learning and chatbots), toward a more mature stage focused on how generative AI can understand, mimic, and support complex human cognitive and educational processes. Despite increasing attention, educational frameworks like critical thinking and Bloom's taxonomy remain less central, indicating a gap between AI's technological potential and its practical application in structured learning environments. The 2025 trends highlight the growing importance of aligning AI systems not only with human tasks but also with human language, reasoning, and creativity, making AI more relevant and meaningful in real-world educational and cognitive contexts.



2016 – 2023 2024



2025

Figure 3. Thematic Evolusion between 2016-2023, 2024, and 2025

4. CONCLUSIONS

This study shows that generative AI (GenAI) is changing how people think and learn. Over time, research has moved from focusing just on AI technology to looking at how AI affects human thinking, decision-making, and language use. Using a bibliometric approach, the study groups the research into key themes and shows that in 2025, GenAI is being used in more human-centered ways. These findings help guide future studies and support the smarter, more meaningful use of AI in education and other areas.

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