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Generative Artificial Intelligence and Students' Cognitive Competencies: A Conceptual Review

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Abstract

The purpose of this article was to synthesize the research findings on the relationship between Generative Artificial Intelligence and students' cognitive competencies. The synthesis was based on relevant articles published in impact-factor journals specializing in Generative AI. The study first identified the empirical and non-empirical articles in the review. Total 42 studies were included in the final synthesis. The findings concerning the relevance of the studies were extracted from each article and extracted as themes for synthesis. Synthesis was done manually on the basis of cross-comparison between articles, identifying main themes in the literature. The study synthesized the current literature exploring the relationship between GenAI and students' cognitive competencies. These cognitive competencies include critical thinking, problem solving, creativity, metacognition, information literacy, analytical reasoning, and decision-making. Considering Cognitive Load Theory, Constructivist Learning Theory, self-regulated Learning Theory, and Distributed Cognitive Theory, the review explores both positive and negative influences of GenAI use on students' cognitive competencies. The synthesis indicated that GenAI can enhance higher-order cognitive skills through personalized feedback, adaptive learning support, and collaborative knowledge construction. Whereas, excessive use of GenAI can reduce the student's cognitive engagement, weaken the critical thinking skills, and increase shallow learning. The review suggests a conceptual framework illuminating the ways in which GenAI affects cognitive competencies and identifies research gaps demanding further empirical investigation. The study recommends that educators, policymakers, and researchers make the best use of GenAI and develop strategies to mitigate the associated risks.

Keywords: Generative AI, Cognitive Competencies, Higher Order Thinking Skills, Personalized Learning, Creativity, Problem Solving Skills

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Introduction

Artificial intelligence has become one of the profound technologies that changes the entire education system (Dwivedi et al., 2023). The most frequently observed are generating text, images, audio, video, code, and many others through advanced machine learning. Many large language models, e.g., ChatGPT, Gemini, and Claude, have been frequently applied in educational institutions (Tlili et al., 2023). Technologies are being utilized to improve students' learning experiences, academic achievement, accessibility, and engagement. GenAI is found to be different as it is reported in many research studies that it stimulates thinking, reasoning, and produces contextually relevant responses, and enhances personalized learning experiences (Kasneci et al., 2023). These capabilities of GenAI attracted the attention of educators to comprehend how it can support in improving students' learning and their cognitive development.

Cognitive competencies are described as the individual's mental abilities to use knowledge, understand their aptitudes and new information, synthesize ideas, and apply reasoning to communicate, solve problems, and make effective decisions. Yilmaz (2020) described cognitive competencies as a psychological construct that coul not be measured directly. Though GenAI offers multiple opportunities to enhance learning experiences, many concerns regarding its influence on students' cognitive competencies and its development have been shared in several studies. Contrarily, advocates suggest that GenAI works as a cognitive assistant who strengthens learning through scaffolding, personalized feedback (Yildiz Durak, Kaya, & Ursavaş, 2025). Giraud (2026)suggests that students adopt GenAI when it is perceived as a valuable learning tool and guided by ethical policies, highlighting its potential to enhance cognitive competencies and meaningful learning. Since the use of GenAI is expanding in the education sector across levels and researchers are sharing contradictory findings about its impact on students' cognitive competencies, it is important to synthesize the findings to identify the research gaps and provide guidance for future research (Carroll & Borycz, 2024).

Objectives of the Study

The study aims to explore the following objectives:

1. How does GenAI influence students' cognitive competencies?
2. What cognitive benefits and risks are associated with GenAI use.
3. Which theoretical frameworks explain the relationship between GenAI and cognitive Development.

Literature Review

Use of GenAI in Education

Cognitive competencies are described as the individual's ability to acquire, process, and evaluate information for application in different situations.(Sun & Hui, 2012). Current educational frameworks highlight higher-order cognitive competencies as an important outcome of education. Critical thinking skill, analytical reasoning, problem solving, metacognition, information literacy, and decision-making are the most researched cognitive competencies. These competencies demonstrate meaningful engagement with knowledge instead of only relying on recalling. GenAI use has initiated a scholarly debate on whether the technological support really reduces the cognitive competencies or amplifies them through scaffolding and feedback mechanisms.

GenAI and Cognitive Competencies

Cognitive load theory is an instructional design emphasize that human working memory is limited in capacity; therefore, instructional material should be designed to avoid overloading

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learners. If the educators are successful in optimizing information by reducing unnecessary cognitive burden, they can maximize the retention of knowledge and build schema. Considering this point of view, GenAI can reduce extraneous cognitive load by supporting through explanations, examples, summarizing, and personalized guidance. Students may spend more time on deep learning and knowledge retention when GenAI supports them on routine tasks (Wang & Fan, 2025).

Constructivist Learning Theory

Constructivist learning theory states that learning happens through interaction, inquiry, and reflection. GenAI is consistent with a constructivist approach, offering students interactive dialogue and feedback to improve their understanding (Tlili et al., 2023). Research suggests that an interactive AI system supports as an intellectual assistant who facilitates meaningful learning (Zapata-Rivera et al., 2024). The AI-guided inquiry and personalized interaction empower the learners to construct deep conceptual learning experiences instead of a passive approach (Yildiz Durak et al., 2025).

Self-Regulated Learning Theory

Self-regulated learning is a critical aspect of learning in enhancing learning outcomes. Theory suggests that students need several cognitive and metacognitive strategies to regulate their learning effectively (Panadero & Lipnevich, 2022). This approach interprets learning as an activity that students perform for themselves in a reflective way rather than as a covert event that occurs as a result of the teacher's teaching. This approach also signifies the importance of learners' autonomy, goal setting, self-monitoring, and reflective practices (Panadero & Lipnevich, 2022). GenAI has a significant potential to foster self-regulated learning by providing personalized feedback, monitoring progress, identifying learning gaps, and suggesting adaptive learning strategies (Tsakeni, Nwafor, Mosia, & Egara, 2025). Many studies have found that AI-supported learning environments foster self-monitoring and metacognitive processes to improve student academic achievement (Tsakeni et al., 2025).

Distributed Cognition Theory

Distributed cognition theory emphasizes that thinking and learning occur with the interaction among people, artifacts, and both internal and external representations (Hollan, Hutchins, & Kirsh, 2000). Instead of focusing simply on an individual's internal cognitive processes, it focuses on the extended cognitive system, including verbal and non-verbal behaviors and the way tacit and explicit knowledge is shared and assessed (Anwar et al., 2025). Instead of replacing cognition, AI may reorganize cognitive efforts, facilitating learners to concentrate on higher-order thinking skills and delegating routine tasks to technologies(Liu, Vobolevich, Oparin, & Research, 2023). While a few studies found that excessive delegation can reduce independent cognitive development (Susnjak & McIntosh, 2024).

Generative AI and Critical Thinking

"Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, or communication, as a guide to belief and action"(Paul, 1993) and in making informed decisions. Effective critical thinking requires multiple perspectives, exploring the evidence, and developing well-supported reasoning before making a decision. It is reported by several researchers that critical thinkers utilize reliable sources for decision-making, such as facts, definitions, rules, laws, values, and situational factors. (Helal et al. (2025) found the dual impact of GenAI on students' critical thinking skills and suggested that the use of GenAI can enhance their critical thinking skills by improving the prompt quality, self-regulation, engagement, and using metacognition. The

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research also identified the risks, such as overdependence and a tendency for quick solutions that can undermine critical thinking. AI systems stimulate critical thinking through offering multiple exposures, generating discussion, and dialogue(Helal et al., 2025). A meta-analytical study conducted by Qu, Sherwood, Liu, and Aleisa (2025)identified the cognitive impact of GenAI on college students in meaningfully enhancing their lower-order cognitive outcomes, such as understanding and application of knowledge. The study reported a partial impact on higher-order cognitive competencies (critical thinking, evaluation, and creativity. However, the guided use of GenAI can provide better benefits to the students and can contribute to their cognitive development with purposeful integration in education(Qu et al., 2025). Whereas few scholars expressed concerns about the acceptance of AI-generated content without adequate validation. Such a tendency may negative effect critical thinking processes and foster passive learning behaviors. Therefore, students are required to validate and authenticate the AI-generated content before consuming it.

Generative AI and Problem Solving

Problem-solving is a higher-order cognitive skill of a person that allows individuals to recognize a problem, scrutinize data, classify alternative explanations, and smear operative plans to meet the desired conclusions(Riyadi, Syarifah, & Nikmaturrohmah, 2021). It is a systematic approach to identify problems, choices, and assemble informed alternatives to resolve difficult problems. In an educational environment, problem-solving skills are viewed as critical for success in school and in life. Recent research indicates that structured guidance, step-by-step explanations, adaptive feedback, and multiple solution pathways offer significant promise in improving problem-solving skills GenAI, (Urban et al., 2024). These skills help the students to comprehend complex ideas and solve problems with diverse angles.

Well-designed AI systems do not just give answers but invite learners to consider other approaches or solutions, to contemplate potential outcomes so on. Liu et al. (2023) reported that the students who engaged in learning through ChatGPT showed improvements in creative problem-solving performance than those who learned through traditional methods. (J. Ng, Tong, Tsang, Chu, & Tsang, 2025) shared those students had positive experiences with GenAI as a cognitive assistance tool, which enabled them to address learning barriers, guide them through difficult academic assignments, and offer them individualized instruction and feedback.

Using AI to generate answers without students' own analysis, reflection, or evaluation could leave them without the reasoning skills needed for successful problem solving. Thus, it has been argued in the literature that instructional design and pedagogical implementation have an effect on the impact of GenAI on problem-solving skills. GenAI can serve as a cognitive scaffold in learning contexts. It will be beneficial if incorporated with planning for the improvement of analytical thinking, creativity, and problem-solving skills. But if the effective instruction and independent thinking are not guided, then too much reliance on AI hinders the cultivation of the skills one aims to promote.

Generative AI and Creativity

Creativity is the ability to produce new, original, and useful ideas, and/or products such as artistic products, scientific discoveries, and ideas for solving problems. In the current era of digital advancement, creativity is seen as one of the most crucial cognitive skills needed for success in learning. With the rise of Generative Artificial Intelligence (GenAI), there are now more opportunities to stimulate creativity through brainstorming, idea generation, content development, and the examination of different viewpoints. Through iterative improvement, learning, and inspiration from AI-powered tools, learners can break free from creative

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constraints and foster an environment that promotes productivity and innovation(George, 2023). AI-powered tools can spark creativity, offer alternative perspectives, and inspire learners, a culture of creativity with iterative development and learning can be established (Vartiainen, Tedre, & Jormanainen, 2023). GenAI has gained increasing value as a cognitive companion in the creative learning processes.

Several empirical studies have indicated a positive correlation between AI-supported learning activities and the students' creative performance. (Urban et al., 2024) showed that the students who used ChatGPT for problem-solving activities had more innovative ideas and exhibited more creative performances than those who did not. Similarly, D. T. K. Ng et al. (2023) found that learners supported by AI demonstrated were more creative in academic tasks. The results indicate the potential of GenAI to spark divergent thinking, presenting learners with a range of viewpoints and individual challenges to try new ideas. A constructivist view of interaction enables knowledge construction and creative exploration by treating learning as an ongoing process of engaging with information, reflecting on feedback, and continuously refining understanding. Although using AI-generated suggestions can improve productivity and concept generation, relying on AI tools might diminish the self-confidence and willingness to engage in independent creative thinking(Washington, 2023).

Briefly the studies found the overuse of AI-generated material in students' work may lead to homogeneity in results and reduced creativity. In addition, there has been a rise in issues concerning intellectual ownership and authorship in AI-assisted creative endeavors. Therefore, learners need to amend, adapt, and improve upon ideas produced by GenAI rather than just copying them. With proper usage, GenAI can catalyze creativity while maintaining the originality and intellectual efforts of learners (Lee & Chung, 2024).

Generative AI and Metacognitive Development

Metacognition is a person's awareness, understanding, and regulation of their own thinking and learning process(Rivas, Saiz, & Ossa, 2022). Metacognition is described as "thinking about thinking" and refers to the higher-order cognitive processes that help students plan, monitor, evaluate, and regulate their learning activities effectively (Rivas et al., 2022). These competencies are important for academic success because they support the learner to recognize their strengths, to choose a learning strategy, and to adjust their learning strategy to meet learning goals. With the increasing integration of GenAI into classrooms, the potential of using AI to support metacognition through personalized feedback, reflective questioning, self-assessment, and adaptive learning guidance has been explored. The Reflection and continuous monitoring of the process can promote metacognitive skills in Gen AI. AI-facilitated interaction and feedback customizations allow student to converse with the content, gauge their comprehension, pinpoint misconceptions, and modify their learning approach. (Rivas et al., 2022) reported that the use of metacognitive scaffolding had a significant impact on the students' critical thinking, self-efficacy, problem solving, flexibility of learning, and metacognitive strategies. Chang, Lin, Hajian, and Wang (2023) suggested that well planned, structured use of AI can enhance the reflective learning process and self-regulation of the leaners.

Studies also highlighted the importance of a metacognitive approach in the process of deep learning and cognitive development. (Yildiz Durak et al., 2025) found that the use of GenAI in metacognitive scaffolding in the FL methods contributed to the improvement of students' critical thinking, problem-solving abilities, self-efficacy, and metacognitive awareness(Mizumoto, 2023). The results revealed that the reflective activity using AI fostered the learners' monitoring of learning progress, evaluation of learning outcomes, and use of

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more effective learning strategies. These findings are consistent with the Self-Regulated Learning Theory that places priority on self-regulated learning as a key to success in their studies. The findings from the study revealed Mafugu, Tsakeni, and Jita (2022) found that students who reflectively interact with AI, exhibited an improved awareness of their own cognitive activity and exhibited stronger self-regulated learning behaviors (Tsakeni et al., 2025).

The reviewed literature validate that Generative AI can be a useful tool in support of metacognitive development by giving the student the opportunities of personalization, self-evaluation, and reflection in evaluation. GenAI can be used in the development of important thinking capacities, such as monitoring thinking and self-regulation. The success of AI-assisted metacognitive learning requires purposeful instructional design to accommodate learners' opportunities for active reflection and engagement instead of the automatic generation of feedback. Utilized correctly, GenAI can enhance metacognitive awareness and instill lifelong learning skills, which are essential for success in ever-changing educational environments.

Generative AI and Information Literacy

Information literacy is the ability to identify, locate, evaluate, and interpret information and to effectively use information to solve problems, make informed decisions, and build knowledge(Lo, 2023). Information literacy has become a critical form of literacy for the learner in a world of information overload and misinformation. Trixa and Kaspar (2024) defined information literacy as a set of skills needed to access, evaluate, interpret, and use information effectively and efficiently in different contexts. In the current learning environment with Generative Artificial Intelligence (GenAI), the role of information literacy has become even more prominent because learners should have access to information, as well as understand how to assess the credibility and accuracy of information created by an artificial intelligence. Since the launch of the GenAI technologies, human interactions with information have been transformed, with information being accessed fast, summarized, explained, or even synthesized. They have certainly proved to be quite useful in terms of education, and they've also led to some concerns about the reliability of the information and the sources supplying it. Carroll and Borycz (2024) stated that learners should be trained on how to distinguish between their AI-generated content and their authentic human sources.

AI systems can occasionally produce inaccuracies, references to nonexistent sources, biased interpretations of information, or misleading information because they are relying on patterns in extensive bodies of information(Fui-Hoon Nah, Zheng, Cai, Siau, & Chen, 2023). Thus, information literacy becomes an essential skill for students to learn and be able to identify and evaluate AI outputs before using them to help them accomplish tasks in school or work. Several research works have focused on the issues of verifying AI-generated facts. GenAI systems are able to generate content that seems very convincing but actually contains factual inaccuracies or unsupported claims, according to researchers (Carroll & Borycz, 2024). This is known as AI hallucination, and can pose a major problem for students who might take the information based on AI as their own. Trixa and Kaspar (2024) highlighted that involvement of information literacy is more than easy access and ready and easy use of facts. It is an ability to analytically gauge information sources, endorse facts, and make decisions on the basis of evidence. Critical examination of information has become more important than ever, with the emergence of AI in education settings(Grassini, Aasen, & Møgelvang, 2024). The literature shows a greater demand for command of information literacy skills.

Although Generative AI improves access to information and assists with research activities, to prevent misinformation and misinterpretation, one needs to learn how to gauge the reliability,

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validity, and credibility of information produced by AI tools. Teachers can empower students to develop critical evaluation and source verification techniques to enable them to be informed and responsible consumers of information in the digital age(Ciampa, Wolfe, & Bronstein, 2023).

Cognitive Risks Associated with GenAI

The reviewed studies identified several cognitive risks associated with the growing adoption of Generative Artificial Intelligence in education (Susnjak & McIntosh, 2024). It is causing a major challenge to authentic learning and assessment because they allow students to produce academic writing with very limited energy, compromising on their cognitive efforts, ordinality and critical thinking(Octaberlina, Muslimin, Chamidah, Surur, & Mustikawan, 2024). Their findings indicate that students who rely heavily on the use of AI tools will more likely become passive information consumers than active knowledge builders.

Skjuve, Brandtzaeg, and Følstad (2024) reported, loss of intellectual autonomy, originality, and sense of ownership over academic tasks for students who extensively use ChatGPT. The authors highlight the risk of students becoming cognitively dependent on AI-driven content, as this can lead them to rely more on technology for reasoning, writing, and decision-making. This dependency can limit the child to regulate himself and his creativity and critical thinking. Overall, these studies indicate that GenAI can be a valuable educational support tool, while there is a potential risk in relying too heavily, as it could compromise critical cognitive skills, surface-level learning, and evaluative abilities.

Thus, it can be concluded that the major threat of using GenAI is the over-dependency, a lack of reflection and verification, and less mental effort by the learners. Furthermore, teachers should educate people to use AI responsibly, enhance their AI literacy and information literacy capabilities, and create opportunities for students to critically explore AI technology, think independently, and actively construct knowledge.

Methodology

The study adopted conceptual review methodology to synthesize the knowledge on the relationship between Generative AI and students' cognitive competencies. Unlike, empirical reviews with statistical findings, a conceptual review examines, organize and integrate existing literature to comprehensively understand the emerging concepts, identify the prevailing themes, highlight the research gaps and suggest future research directions(Snyder, 2019). The fast-paced developments in Generative AI practices, conceptual review was considered a suitable way to synthesize dispersed evidences and suggesting a conceptual understanding of it influence on students' cognitive competencies. The related research was identified from major research databases, including Scopus, Web of Science, ERIC, ScienceDirect, and Google Scholar. Keywords like "generative artificial intelligence, ChatGPT, large language models, students, education sector, critical thinking, problem-solving, creativity, metacognition, information literacy. The total 50 articles were selected, after applying the inclusion and exclusion criteria 42 article were finalized focusing on the application of GenAI and students' learning outcomes and cognitive competencies. The selected articles were identified on the basis of titles, abstracts, and full text to align with the objectives of the review. The data was synthesized thematically to identify the significant trends, challenges, and research gaps about the influence of GenAI on students' cognitive competencies.

Procedure

The study applied the PRISMA 2020 framework (J. et al., 2022) to identify and review GenAI papers. This procedure provides reliable and auditable strategies to understand the related

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research. The procedures followed six stages: database search, identification of the search item, and time period. Searching criteria, screening process, analysis, and categorization results.

1. Database Search

The next step was to identify the related research on the major publisher databases: Scopus, Web of Science, Science Direct, Wiley Online Library, ACM IEEE, Taylor & Francis, EBSCO, SpringerLink, and Google Scholar. Empirical and peer-reviewed article with a time period of 2020 to 2025. Applying snowballing, additional related studies were searched that may not have been found on the databases.

2. Identification and Screening

The search was based on the comprehensive list of key words used GenAI or an alternative GenAI, e.g: "Generative Artificial Intelligence", "GenAI", "Artificial Intelligence", "ChatGPT", "Gemini", "Claud", Copilot", "large language module", "LLM", ai chatbots", "generative models", and AI-learning". search strategy for identification of the keywords. Then the core focus of the review was considered and keywords for students' cognitive competencies were added: "cognitive competencies", "critical thinking", problem-solving", "creativity", "metacognition", "higher-order thinking skills", "cognitive skills, "analytical skills", "reflective thinking", decision making", "self-regulated learning", and information literacy".

Moreover, to keep the searched article relevant, keywords like "education,"," higher education", "university students", "school students", "college students", "teaching learning" "instructions, "assessment", "student engagement", Boolean operators (AND, OR) were used to associate keywords and keep the search refined. Also, the forward and backward snowballing techniques were used to identify related articles.

3. Eligibility Assessment

Initially, 300 records were found from the Scopus, Web of Science, ERIC, ScienceDirect, and Google Scholar. Duplicates were removed and 50 were screened by titles and abstracts. After the eligibility assessment, 42 studies were included in the final qualitative synthesis.

Table 1: ***Inclusion and Exclusion Criteria for the Selection of the Articles***

Inclusion Criteria	Exclusion Criteria
The use of AI in education setting	Studies not relevant to the educational context
Influence of GenAI on students' cognitive competencies; critical thinking, problem-solving, creativity, information literacy, and higher-order thinking skills were studied.	Application of GenAI was not part of the study.
GenAI application, ChatGPT, Gemini, Claud, Copilot, large language model (LLM), AI Chatbots, and any other generative AI tool were studied	AI technologies without GenAI and educational settings
Educational setting, teacher, students, teaching, learning, and assessment instructions should be part of the objectives	Studies focusing on only the administrative and institutional use of AI
Quantitative and qualitative studies were added.	Book reviews, editorial opinions, and news articles, etc.
Peer review journals publications were considered between 2022 and 2025	Unpublished work was excluded

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English language studies were considered	Other than the English language were excluded
Studies captured the emergence of GenAI in the process of education	Studies published before 2022.
Full-text article was available	Non-availability of the full-text articles

4. Data Syntheses

The findings were organized through a manual thematic analysis approach. Firstly, the findings of the selected articles were reviewed and coded according to their primary focus and reported outcomes on the basis of recurring concepts in different studies. Then, comparable codes were categorized into wider themes reflecting the core dimensions of students' cognitive competencies. The synthesis was done in overarching categories related to the influence of GenAI on students' critical thinking, problem-solving, creativity, metacognition, information literacy, and decision-making competencies as well as factors that bring ease and hamper the development of these competencies.

Table 2: ***Thematic Synthesis of GenAI and Students' Cognitive Competencies***

Main Theme	Subthemes	Representative Findings
Opportunities	Personalized Learning	AI adapts content and feedback to learner needs
Opportunities	Cognitive Scaffolding	AI provides explanations and guided support
Opportunities	Creativity Enhancement	AI facilitates idea generation and innovation
Opportunities	Self-Regulated Learning	AI supports planning, monitoring, and reflection
Challenges	Cognitive Outsourcing	Students may transfer thinking tasks to AI
Challenges	Dependency	Excessive reliance may reduce autonomy
Challenges	Information Accuracy	AI-generated content may contain errors
Challenges	Academic Integrity	Increased risk of plagiarism and misuse
Future Directions	AI Literacy	Need for critical evaluation skills
Future Directions	Assessment Reforms	Development of AI-resilient assessments
Future Directions	Ethical Frameworks	Guidelines for responsible AI use

Table 3: ***Synthesis for the Influence of GenAI on Students' Cognitive Competencies***

Cognitive Competency	Positive Influence of GenAI	Potential Risks
Critical Thinking	Exposure to diverse perspectives and arguments	Reduced independent analysis
Problem Solving	Step-by-step guidance and solution generation	Overreliance on AI-generated solutions
Creativity	Brainstorming and idea generation support	Reduced originality
Metacognition	Personalized feedback and reflection prompts	Dependence on automated guidance
Information Literacy	Rapid information access and synthesis	Difficulty identifying misinformation

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Decision Making	Evidence-based recommendations	Reduced independent judgment
Cognitive Engagement	Interactive and personalized learning experiences	Superficial engagement due to automation

Initial coding was done on the basis of recurring concepts in different studies. Then, similar codes were grouped into higher-order themes reflecting major cognitive competencies.

Results

The selected articles were published between 2020 and 2025, showing the emerging research findings on the influence of GenAI in educational settings. The majority of the studies were conducted in higher education contexts, and few were found in secondary and primary school levels. These were quantitative, qualitative, mixed-methods, conceptual, and reviewed research. Also, educationally developed countries' contexts were frequently researched, where technology is advanced, and its use is very common. GenAI was the most researched tool; subsequently, other large language models and AI-powered platforms were searched. The analysis of the published article revealed that there is a considerable increase in the research output after the launch of ChatGPT in late 2022, and it has been continuously increasing from 2023 to 2025.

Thematic Findings

1. Benefits of Use of GenAI

The reviewed articles consistently reported the possibilities of GenAI to increase students' cognitive competencies. Among these were: personalized learning, cognitive scaffolding, enhanced creativity, instant feedback, and supported self-regulation. Many studies recommended that an AI-supported learning environment encourages critical thinking and-inquiry based learning. GenAI was also found to strengthen problem-solving through providing explanations, examples, and adaptive guidance that help the learner to manage or deal effectively with complex academic problems. Creativity appeared as one of the significant advantages that support learners in brainstorming, producing novel solutions, and identifying alternative perspectives.

2. Challenges Associated with the Use of GenAI

Although several benefits were reported in the reviewed studies, many apprehensions were also identified about students' cognitive development. The most debated one was cognitive outsourcing, which increases learners' dependency on AI for completing intellectual tasks that require independent thinking. The literature also identified that GenAI reduced critical evaluation, increased reliance on GenAI content, misinformation, algorithm bias, and academic integrity. These findings show that dependency on AI decreases deep learning. Studies also reported that the inaccuracy of GenAI content reduces the students' critical evaluation and suggested developing AI literacy to critically evaluate the GenAI content.

3. Conceptual Framework

The reviewed articles suggest the framework that GenAI influences cognitive competencies through two pathways: 1) Positive Pathways and Negative Pathways. Positive pathways include cognitive scaffolding, personalized learning, enhanced learning, critical thinking, creativity, problem-solving, and meta-cognitive skills. Negative pathways include: cognitive outsourcing, dependency, analytical thinking skills, reduced cognitive efforts, and independent reasoning. The literature framework recommends that AI literacy, self-regulated learning, educational setting, and instructional practices moderate these relationships.

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Discussion

The outcomes from this review suggest that Generative AI (GenAI) can have both positive and negative effects on students' cognitive abilities, depending on the context in which it is applied in the education context. The results indicate that GenAI can either facilitate or impede higher-order cognitive functions like critical thinking, problem-solving, creativity, metacognition, and information literacy in the synthesis of the studies conducted between 2022 and 2025.

Positive effects can be understood primarily within the framework of four theories, namely Cognitive Load Theory, Constructivist Learning Theory, Self-Regulated Learning Theory, and Distributed Cognition Theory. GenAI can assist students in their learning process by lowering cognitive burden, giving explanations and feedback, and allowing for individualized learning and interaction. It can therefore enhance students' problem-solving skills, creativity and metacognitive awareness, as a tool that allows reflection, generation of ideas and involvement with content on a deeper level. It also serves as an external cognitive support to prolong learners' thinking and to aid in the construction of knowledge.

But there are significant cognitive dangers as reported in the literature. Cognitive outsourcing, diminished critical thinking, and decreased independent thinking are potential risks of overusing or relying on GenAI without critical analysis. Students might rely too heavily on AI-generated responses, resulting in superficial learning and a lack of originality in their work. Moreover, constraints of AI-generated information, including inaccuracies or "hallucinations," may impact information literacy and decision-making unless students critically examine the outputs.

The results indicate that GenAI can be used as a guided cognitive support tool and is most effective when used in this way, rather than as a replacement for thinking. The influence on cognitive competencies varies significantly based on pedagogical design, AI literacy, and students' self-regulated learning skills.

Recommendations and Future Directions

The reviewed studies suggested that the integration of GenAI should be carefully done in educational institutions. The researchers also endorsed that AI-supported assessment practices should be introduced, accompanied by AI literacy initiatives. They also recommended long term influence of GenAI on students' cognitive competencies should be examined. The discipline-specific, contextual, pedagogical differences should be researched to increase the effective and meaningful use of GenAI IN educational settings.

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