# AI AS A COGNITIVE PROSTHESIS: DOES EDUCATIONAL AI REDUCE INTELLECTUAL AUTONOMY?

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| ARTICLE INFO | ABSTRACT |
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| | The rapid integration of generative artificial intelligence (AI) in education has positioned AI not merely as a technological tool, but increasingly as a cognitive prosthesis that extends learners' cognitive capacities. While AI-driven systems offer substantial benefits—such as personalized learning, scaffolding, enhanced metacognitive regulation, and instructional efficiency—concerns persist regarding cognitive offloading, diminished critical thinking, reduced intellectual autonomy, and ethical risks. This study aims to critically examine the dual role of generative AI as a cognitive prosthesis in learning by synthesizing recent empirical and theoretical literature. Employing a literature review methodology, this study analyzes peer-reviewed articles and proceedings indexed in Scopus and Copernicus published between 2015 and 2025. The reviewed studies are organized into two thematic domains: (1) the advantages and limitations of generative AI as a cognitive prosthesis in learning, and (2) the evolving roles of teachers and students in AI-mediated educational environments. The findings indicate that while generative AI can enhance metacognitive skills, creativity, learning efficiency, and personalized instruction, excessive dependence may lead to cognitive laziness, surface learning, weakened critical thinking, and ethical challenges related to data privacy and academic integrity. The study concludes that generative AI should be positioned as a supportive cognitive partner rather than a replacement for human cognition. Effective integration requires strong pedagogical design, ethical governance, and active mediation by educators to ensure that AI enhances learning without undermining intellectual autonomy. |

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## INTRODUCTION

The use of AI (artificial intelligence) has increased in various fields, particularly in education. AI-based learning can provide more personalized, inclusive learning and enhance the effectiveness of the learning experience (Iman et al., 2024). Stakeholders

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including teachers, students, parents acknowledge that AI has very high potential to develop individual needs, provide better access to learning, and fulfill certain student competencies that are difficult to fulfill through traditional learning (Kinshuk et al., 2016). However, the potential of AI still has a negative side or impact on students, especially those who have lower self-control compared to teachers (Rodríguez-Ruiz et al., 2025). This negative impact, if not immediately addressed, will cause learning loss such as in the Covid 19 pandemic.

The adoption of AI in learning needs to be monitored and provided with rules in accordance with scientific codes of ethics. Ethical issues such as data privacy violations, the digital divide, and discrepancies between urban and rural school facilities are among the challenges encountered in implementing AI in learning (Hacker & Mason, 2003; Olanrewaju et al., 2021). Student data security and privacy are major concerns due to the large amount of personal student data being uploaded to AI, without anyone knowing who can access and manage the data (Huang, 2023). Furthermore, implementing AI in learning also requires financial support in the form of investments in hardware, software, and high-speed internet connections (Mhlangan, 2021). Moreover, this is difficult for students in rural areas to achieve. Another issue identified is teacher resistance to the use of AI in learning (Feng & Xiao, 2024). This is especially true for senior teachers. The lack of interaction between students and teachers in AI-based learning is also a serious problem. Therefore, understanding and proper utilization of the role of AI are essential as a cognitive prosthesis in learning.

Cognitive Prosthesis (CP) refers to assistive technology or systems designed to help improve and restore an individual's cognitive function. In this context, the student is the subject or individual (Cole & Dehdashti, 1998). AI has sophisticated algorithms and techniques to meet user needs at all times as a CP. AI can be integrated into several application devices to provide support to students in completing complex assignments (Kamruzzaman et al., 2023). Thus, AI as a CP aims to develop independence and facilitate students' learning of complex material. However, teacher control and monitoring are still required to ensure students do not become overly dependent on AI, thus weakening their logic and reasoning skills.

The integration of AI into learning is like a double-edged sword, offering benefits on one hand and disadvantages on the other if not managed properly. Several studies demonstrate the positive benefits students experience from AI-based learning. A study by Zhan et al (2022) stated that AI integration can increase student motivation, problem-solving skills, and participation. Pratama et al., (2023) revealed that through AI, students can have personalized learning tailored to their individual needs.

Implementing AI can reduce students' cognitive load, thereby increasing their focus on learning (Gkintoni et al., 2025). However, there are still many studies discussing the negative impacts of AI as a CP or learning aid. Gerlich (2025) shows that dependence (overuse) on AI can also causecognitive offloading, namely, students do not use their critical thinking and analytical skills to solve problems in class. On the other hand, the accumulation of information presented in AI also impacts cognitive fatigue and reduces learning efficiency (Parekh et al., 2020). The study conducted Wan et al., (2025) revealed that AI- driven instruction resulting in students only learning at the level surface learning. Most teachers are also concerned about data privacy security issues and monotonous learning interactions due to using AI (Al-Mughairi & Bhaskar, 2025). Thus, it can be concluded that the study of AI as CP in learning is still very important to be researched to date because it still reaps pros and cons.

A study of how researchers respond to AI as CP is very interesting to study further. To date, there are still limited sources and references that provide a balanced discussion of generative AI, both from a pro and con perspective. To bridge this gap, a literature review entitled "AI as Cognitive Pros thesis: Does Educational AI Reduce Intellectual Autonomy?". The objectives of this research are to analyze the pros and cons of Generative AI as a Cognitive Prosthesis in learning and identify the role of teachers and students in the future regarding the use of Generative AI as a Cognitive Prosthesis in learning.

**METHODS**

This research is classified as a literature review or literature study which attempts to uncover the phenomenon Cognitive Prosthesis through the latest research (Cheater, 2019). However, this study only used limited inclusion criteria such as keywords, year scope, and journal index to improve the quality of literature review research. The studies used for theoretical support are reference sources indexed by Scopus and Copernicus. This to ensure the novelty of the studies used for discussion, journal articles and proceedings from the last ten years, from 2015 to 2025, were used. Furthermore, each article was assigned a theme that corresponds to the topic. Cognitive Prosthesis namely (1) the use of Generative AI as Cognitive Prosthesis in learning, (2) the role of teachers and students in the future regarding the use of Generative AI as Cognitive Prosthesis in learning. Keywords used in reference searches include: cognitive prosthesis, intellectual autonomy, generative AI in education, AI-assisted learning, or other terms that have the same meaning, including combinations Boolean operators (AND/OR) to expand on the findings. Furthermore, based on the article selection results, research conclusions will be determined according to the two types of themes that will be the main topics of discussion. Each

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of these theme descriptions will be discussed further using a qualitative descriptive approach.

## RESULTS AND DISCUSSION

### Results

The findings of this study can be seen in Table 1.

**Table 1. Results of a Literature Review of AI as a Cognitive Prosthesis**

| Research Question | Analytical Aspect | Key Research Findings | Educational Implications |
|---|---|---|---|
| The advantages and limitations of Generative AI function as a Cognitive Prosthesis | AI Advantages | Generative AI functions as a cognitive extension through scaffolding, personalized learning, real-time feedback, and improved instructional efficiency. | Supports adaptive learning environments and differentiated instruction based on individual learner needs. |
| | Metacognition & Creativity | AI enhances self-regulated learning, metacognitive reflection, idea exploration, and student creativity through responsive interaction. | AI has the potential to strengthen higher-order thinking skills when pedagogically guided. |
| | Instructional Efficiency | AI accelerates learning material production, automates multimedia development, and supports academic administration processes. | Reduces teachers' workload while improving pedagogical productivity. |
| | Cognitive Risks | Excessive reliance on AI leads to cognitive offloading, surface learning, reduced critical thinking, and metacognitive laziness. | Requires carefully designed pedagogical control and reflective learning strategies. |
| | Academic & Ethical Risks | Issues include AI hallucination, algorithmic bias, plagiarism risks, data privacy concerns, and digital inequality. | Necessitates ethical governance frameworks and institutional AI literacy policies. |
| The future roles of teachers and students in utilizing Generative AI as a Cognitive Prosthesis | Teachers' Roles | Teachers transform into facilitators of critical thinking, learning designers, and ethical mediators of AI use. | Shift from content delivery toward learning orchestration and guidance. |
| | Teachers as Learning Designers | Teachers design inquiry-based activities requiring students to critically evaluate AI-generated outputs. | AI becomes a catalyst for knowledge construction rather than a replacement for cognition. |
| | Teachers as AI Mediators | Teachers establish boundaries for AI usage, maintain academic integrity, and validate AI-generated content. | Ensures AI enhances rather than undermines intellectual autonomy. |
| | Students' Roles | Students act as active collaborators with AI in | Learning evolves into a human–AI collaborative model. |

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| | brainstorming and complex problem-solving processes. | |
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| Students as Critical Evaluators | Students critically verify accuracy, relevance, and validity of AI-generated information. | Strengthens critical digital literacy and evaluative judgement. |
| Students as Ethical Users | Students adhere to responsible AI practices aligned with academic integrity principles. | Promotes ethical academic culture and responsible technology use. |

## Disscusion

### *Pros and Cons of Generative AI as a Cognitive Prosthesis (CP) in Learning*

CP in the context of education leads to the use of AI as a cognitive aid to solve learning problems such as finding ideas, drawing conclusions, providing alternative solutions, and providing feedback. The concept of CP is rooted in the idea that humans can have cognitive extender (cognitive aids) to facilitate learning. The integration of AI in learning in this context serves as a cognitive extension, facilitating learning, and supporting the personal needs of students and teachers, particularly in developing Zone of Proximal Development (ZPD).

There are several studies that support AI as a cognitive CP. Generally, these studies emphasize the concept scaffolding, ease of personalization, increased metacognitive skills, creativity and exploration of ideas, as well as improving the efficiency and quality of materials designed by teachers. Scaffolding is an important concept in learning. AI such as GPT chat helps students to break down material into smaller concepts (chunking), so that it is easy for students to understand (Kosaraju, 2024). Further study Hajiyev et al., (2024) conveyed that the integration of AI in completing student assignments provides effective recommendations and increases student productivity. In addition to supporting the concept scaffolding AI also supports the need for personalized learning. A study conducted by Chakkaravarthy et al., (2025) found that AI can continuously evaluate student performance, identify learning gaps, and modify learning materials. AI also provides feedback customized and recommendations real time (Kaswan et al., 2024).

Several recent studies have shown how AI can foster the development of students' metacognitive abilities and creativity. Mehmoodet al., (2025) shows that AI plays a role in developing self-regulated students and provide adaptive feedback. Self-regulated learning is one part of metacognitive strategies. Further studies from Yang & Xia, (2023) shows that AI-based learning is able to support students' metacognitive abilities because it provides responses in areal time, comprehensive and good analysis. In addition, other studies show that the integration of AI in learning gives students more effective control over cognitive functions (Khotimah et

al., 2024). In addition to metacognitive mental processes related to AI, student creativity is also involved. Personalized learning tailored to the needs of teachers and students, including providing learning resources and experiences that support student creativity (Hasibuan & Andina Azizah, 2023). In geometry learning studies such as robotics learning, AI can foster motivation and provide personalized materials that can support students' creative thinking skills (Yao et al., 2025). Furthermore, a specific study on AI-based exploration shows that the use of semantic navigation supports students to solve problems more effectively (Sandholm et al., 2024). Thus, it can be concluded that AI can support students' metacognitive abilities and creativity.

Generative AI, such as Chat GPT, plays a role in increasing the efficiency of learning material creation Carbonell-Alcocer et al., (2024) show that AI can automate multimedia creation, such as reducing the time and effort required by teachers in creating materials. Further research results Gustafi (2025) shows that the technique prompt engineering deep Learning Management System. An LMS is capable of producing learning materials that meet academic standards, although a human touch is still needed to improve accuracy. At the higher education level, the use of AI is beneficial for streamlining administrative processes, improving learning outcomes, and fostering better teaching practices (Kassaye, 2024).

While there are studies supporting the existence of AI, there are also studies that contradict AI's position as a CP in learning. As a tool to support scaffolding Students, the presence of AI reduces interaction between teachers and students, and often replaces traditional learning processes which do not always have a positive impact (Rabadanova et al., 2024). Utilization AI can widen the gap between students who underprivileged with students who get AI facilities (Mindigulova et al., 2024). On the other hand, the personalization of AI utilization also has a negative impact on students, for example research. Kim (2026) concluded that students experienced a reduction in accuracy in writing skills and decrease in reading skills. The study of Izak et al., (2025) has found that AI often exhibits hallucinations and can reduce the quality of the knowledge imparted. Therefore, it is crucial for teachers and students to use prompts that are detailed and contextually relevant to the issues being discussed. Furthermore, every reference and concept provided by AI needs to be double-checked to ensure the validity of the information provided.

Integration in developing metacognitive learning strategies can be hampered, due to dependence on AI devices, which causes metacognitive laziness (Borjigin & Shen, 2025). Furthermore, students' ability to think independently and critically, which is the basis for developing metacognitive abilities, is also impacted by the use of AI excessive (Gonsalves, 2024). On the other hand, there are also challenges in

developing student creativity. The main challenge is teachers' concerns about students' confidence in developing their own creativity, which could decline without the use of AI (Habib et al., 2024). (Lee, 2025) revealed that the use of Generative AI can reduce students' creativity such as writing skills and creativity in designing materials.

There are several things to consider when designing materials with AI, particularly the potential negative impacts. Teachers should be mindful of potential biases introduced by AI algorithms and closely monitor the materials they have designed (Adamu & Awwalu, 2019). Manual content validation is still needed to maintain the quality of the material (Gustafi, 2025). Sometimes teachers also do not disclose AI authorship in the materials they have created (Adamu & Awwalu, 2019). This is very important to maintain transparency of references to students.

## The Role of Teachers and Students in the Future in Utilizing Generative AI as Cognitive Prosthesis (CP) in Learning

The future integration of generative AI as a cognitive prosthesis (CP) in learning will fundamentally transform the roles of both teachers and students. Teachers will increasingly act as facilitators and guides, leveraging AI tools to personalize instruction, scaffold complex problem-solving, and foster critical thinking skills. Rather than merely delivering content, educators will focus on designing learning experiences that harness AI's capabilities to adapt to individual learner needs, promote metacognitive awareness, and encourage ethical and reflective use of AI-generated outputs. This shift will require teachers to develop new competencies in AI literacy and pedagogical strategies to effectively integrate these technologies into their curricula.

### Teachers as Facilitators of Critical Thinking through Generative AI

Teachers will play a pivotal role in cultivating students' critical thinking skills by guiding them to critically analyze AI-generated content (Calzada, 2024). This involves emphasizing the evaluation of the accuracy, relevance, and ethical dimensions of information produced by generative AI. Rather than allowing students to accept AI outputs uncritically, educators will encourage active engagement with the material, fostering higher-order thinking essential for academic rigor (Estaphan et al., 2025). This facilitation ensures that students develop the ability to discern the quality and applicability of AI-generated information, promoting intellectual autonomy and responsible use of AI as a cognitive prosthesis in learning. This role requires teachers to design learning experiences that integrate AI tools in ways that challenge students to question, evaluate, and reflect on AI outputs, thereby embedding critical analysis into the learning process. Additionally, teachers will

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mediate AI use by establishing ethical guidelines to prevent misuse or overdependence, further supporting the development of critical faculties.

*Teacher as Designers of Learning Experience*

Teachers will take on the role of designing dynamic, AI-integrated learning experiences that move beyond traditional content delivery toward inquiry-driven and creative education. This involves crafting curricula and instructional tasks that seamlessly embed generative AI tools as catalysts for exploration, problem-solving, and original idea generation. By doing so, educators shift the pedagogical focus from rote memorization to active knowledge construction, enabling students to engage deeply with subject matter through AI-augmented cognitive processes (Fidalgo & Thormann, 2024; Hutson & Ceballos, 2023).

Specifically in design student Learning Experience teacher must: (1) develop assignments and projects that require students to interact critically and creatively with AI-generated outputs, fostering inquiry and innovation (Holman, Kenneth et al., 2024), (2) integrate AI functionalities that adapt to individual learner needs, promoting personalized pathways for discovery and mastery (Jiao, 2024), (3) design scaffolded learning sequences where AI supports complex problem-solving and iterative refinement of ideas encourage metacognitive reflection by having students evaluate the AI's contributions, thus embedding critical thinking within the learning process (Hong et al., 2025), (4) utilize AI-driven analytics to inform instructional adjustments, ensuring that learning experiences remain responsive and effective (Kim et al., 2025). This design approach positions teachers as architects of AI-enhanced educational environments that empower students to harness AI as an active cognitive partner, thereby transforming learning into a collaborative, adaptive, and creative endeavor.

*Teacher as AI Mediators*

Teachers will establish and enforce ethical guidelines and boundaries around AI usage to prevent misuse, overdependence, and breaches of academic integrity (Kim et al., 2025). This includes setting clear expectations for responsible AI engagement and guiding students on navigating the limitations and potential biases of AI systems (Malik et al., 2025). Teachers must also provide ongoing support and feedback to help students critically assess AI-generated content and develop their own reasoning skills. Additionally, fostering a classroom culture that values transparency and accountability in AI use is essential for maintaining academic integrity. Through these measures, educators can ensure that AI serves as a tool for empowerment rather than a shortcut that undermines learning outcomes. Educators should also implement clear guidelines on ethical AI use to help students understand the boundaries and

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appropriate applications of these technologies (Grandmother, 2024). Integrating discussions about AI's limitations and potential biases into the curriculum can further enhance critical thinking and digital literacy. Ultimately, this comprehensive approach supports the responsible adoption of AI tools, ensuring they complement rather than compromise educational goals. Besides the teacher role in utilization of AI as CP, teachers must set boundaries in utilization of AI in the learning process.

*Students as AI Active Collaborators*

Students will interact with generative AI as a cognitive partner, using it to augment processes such as brainstorming, drafting, and complex problem-solving. Student collaboration transforms AI from a passive resource into an active co-learner that enhances cognitive capacity (Atchley et al., 2024). This shift requires educators to design learning environments that encourage experimentation and critical thinking while guiding ethical AI use (Ahmed et al., 2024; Wang, 2025). Clear guidelines and assessment criteria must be established to ensure academic integrity and meaningful engagement. Ultimately, this partnership between students and AI fosters deeper understanding and innovation in the learning process. This collaboration also promotes the development of critical digital literacy skills, enabling students to evaluate AI-generated content effectively (Calzada, 2024). Educators must emphasize the importance of ethical considerations, ensuring students understand the implications of AI use in academic contexts. By fostering a balanced partnership, students can leverage AI to enhance creativity and problem-solving while maintaining academic integrity.

*Student as Critical Evaluators*

Learners will develop the skills necessary to scrutinize AI outputs critically, verifying validity, assessing relevance, and integrating information thoughtfully. This critical evaluation safeguards academic standards and promotes intellectual autonomy. Furthermore, this approach promotes critical evaluation and refinement of AI-generated information by students rather than uncritical acceptance (Bearman et al., 2024). Educators should facilitate the recognition of biases and limitations, thereby fostering responsible and informed utilization of AI in academic work (Maphosa, 2024). This necessitates the integration of pedagogical strategies that encourage students to critically assess AI outputs rather than passively accept them. By embedding such critical frameworks within curricula, educators can empower learners to discern the reliability and validity of AI-generated content. Ultimately, this approach cultivates academic integrity and enhances the development of independent analytical skills.

*Students as Ethical User*

Students as Ethical Users while using AI as a cognitive prosthesis (CP) will internalize principles of responsible AI engagement, recognizing both the capabilities and limitations of generative AI tools. They will adhere strictly to academic integrity policies, avoiding plagiarism, misuse, and overreliance on AI outputs (Chavez, et al., 2024). This ethical awareness fosters trustworthiness and accountability in academic work, ensuring that AI serves as a support rather than a substitute for original thinking. By understanding the societal and academic implications of AI use, students will develop a conscientious approach that balances innovation with respect for intellectual property and ethical norms (Song, 2024). Educators should embed ethical guidelines and discussions on AI's potential biases and limitations within curricula to reinforce this responsible use (Rane et al., 2024). Ultimately, students as ethical users contribute to an academic culture where AI enhances learning without compromising integrity or intellectual rigor.

Conceptually, this article makes an important contribution in positioning Generative AI as a cognitive prosthesis that is pedagogically mediated rather than technologically deterministic. However, in order to increase its scientific strength and empirical contribution, further research is recommended not only to stop at the synthesis of the literature, but to develop a conceptual framework into an empirical model that can be tested through mixed-method or quasi-experimental research designs. In addition, the integration of operational indicators such as intellectual autonomy, metacognitive regulation, and critical thinking needs to be constructed in the form of standardized instruments so that the relationship between the use of AI and intellectual independence can be measured quantitatively. Strengthening the analytical framework (for example, using extended cognition theory or self-regulated learning as the grand theory) will also improve the position of the article in the international discourse on AI in Education. Thus, this research has the potential to be an important reference if it is able to move from narrative synthesis to evidence-based pedagogical model.

**CONCLUSION**

This literature review highlights that generative artificial intelligence, when conceptualized as a cognitive prosthesis, represents both a powerful opportunity and a significant pedagogical risk in contemporary education. On one hand, AI demonstrates considerable potential to support scaffolding, personalized learning, metacognitive development, creativity, and instructional efficiency. These affordances position AI as an effective cognitive extension capable of assisting learners in navigating complex learning tasks and supporting teachers in designing adaptive

learning experiences. On the other hand, the findings consistently indicate that unregulated or excessive reliance on AI may lead to cognitive offloading, reduced critical thinking, surface-level learning, diminished creativity, and erosion of students' intellectual autonomy. Ethical concerns—particularly related to data privacy, algorithmic bias, academic integrity, and digital inequality—further complicate its educational deployment.

The review underscores that the impact of AI as a cognitive prosthesis is not technologically deterministic, but fundamentally pedagogical. The future of AI-enhanced learning depends heavily on the roles assumed by teachers and students. Teachers must evolve into facilitators, learning designers, and ethical mediators who guide critical engagement with AI, establish clear boundaries of use, and embed metacognitive and evaluative practices into instruction. Simultaneously, students must be positioned as active collaborators, critical evaluators, and ethical users of AI, capable of questioning AI outputs rather than accepting them uncritically. In conclusion, generative AI does not inherently reduce intellectual autonomy; rather, intellectual autonomy is compromised when AI replaces reflective thinking instead of supporting it.

## SUGGESTIONS

Future research should empirically investigate the impact of generative AI as a cognitive prosthesis on intellectual autonomy, critical thinking, and metacognitive regulation through experimental or mixed-method designs using validated measurement instruments. Additionally, studies should develop and test pedagogical frameworks that position AI as a collaborative cognitive partner while integrating ethical governance, AI literacy, and assessment redesign to ensure balanced cognitive development.

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