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Original Research Article

AI AND COGNITIVE OFFLOADING AMONG COLLEGE STUDENTS: A SYSTEMATIC REVIEW

*** Mrs. Ashwini Jadhav,***

** Prof. Ramkrishna More, ACS College (Autonomous), Akurdi, Pune-411044*

Abstract:

The use of artificial intelligence (AI) tools is rapidly increasing among college students. These tools are mainly used to access information, complete assignments, prepare presentations, and even research papers. Cognitive offloading refers to reducing the mental processing required for a task through physical actions, such as writing a shopping list or using a calculator. This review gathers information about how AI is linked to putting mental work onto external tools.

This study reviewed 34 academic papers, mostly released from 2011 through 2025. The findings showed that AI tools have both advantages and disadvantages from offloading. Advantages include students' efficiency, improved accessibility, and adaptive scaffolding. Disadvantages include reduced internalization of knowledge, superficial processing, and diminished metacognitive oversight. Despite the widespread use of AI, evidence of its long-term effects on learning remains limited.

Keywords: *Artificial Intelligence, Cognitive Offloading, Generative AI, Metacognition*

Introduction:

Advances in artificial, specifically generative AI, have introduced infinite opportunities for college students to access, generate, and manipulate information. As students mostly use AI for summarization, problem-solving, drafting, and conceptual clarification, concerns arise about cognitive offloading or the shifting of cognitive tasks from internal processes to external devices or systems.

Definitions of Basic Concepts:

Artificial Intelligence (AI): AI refers to the capability of computational systems to perform complex tasks traditionally associated with human intelligence, encompassing reasoning, pattern recognition, learning, problem-solving, and perception. In higher education, AI includes tools such as generative models (Chat GPT and Claude), adaptive tutoring systems, code assistants, search engines, and automated grading tools.

Cognitive Offloading: A psychological phenomenon in which individuals rely on external resources (notes, smartphones, and AI systems) to reduce internal cognitive load. Offloading may target memory for storing facts externally, procedures for outsourcing steps or calculations, reasoning for delegating analysis or decision making, and metacognition in relying on AI to evaluate quality or correctness.

Metacognition: The ability to monitor, regulate, and evaluate one's own thinking majorly used in research writing and drafting. Excessive reliance on AI may reduce the need for independent or critical monitoring.

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Rationale of the review:

While many studies have investigated AI's helpfulness, very few studies have examined its cognitive consequences, such as effects on memory, reasoning, problem solving, and decision making. Educators worry that AI-based offloading may undermine critical thinking, reduce effortful learning, lead to factual inaccuracy if AI is uncritically accepted, and widen inequities depending on access. This review aims to summarize clearly what research has already discovered and what remains unknown about how college students use AI to offload or shift their thinking tasks.

Methods: A systematic literature review was conducted. A search for relevant studies was carried out using the databases Scopus, Web of Science, Google Scholar, PsycINFO, and IEEE Xplore. Search terms included cognitive offloading, AI offloading, generative AI and students, LLM and learning, external memory, AI in education, critical thinking and AI, college students and AI use, and metacognition and AI. The period covered was from 2011 to 2025, starting with Sparrow et al. (2011), who established foundational offloading theory in the digital era.

Results:

Different Patterns of AI Use and Offloading in Higher Education are found. Studies show that college students use AI for summarizing readings, explaining difficult concepts, brainstorming ideas, writing drafts or outlines, coding and debugging, translating or paraphrasing, solving quantitative problems, and checking their own answers. Students' offload is not only found in memory and information retrieval but also in higher-order thinking, such as reasoning, evaluation, argumentation, and step-by-step problem solving.

Four Cognitive Mechanisms Identified:

1. ***Reduced Encoding and Rehearsal:*** Encoding is the process of converting information into a storable format in memory, and rehearsal is effortful repetition to aid transfer to long-term memory. When students rely on AI to provide answers or explain concepts, they do not retain the information in their own memory. This parallels the "Google effect," where individuals outsource memory to external devices. Students also spend less time repeating or practicing the material, which normally helps them to learn. This happens because the brain does not feel the need to remember something that an external tool can recall anytime, similar to how people stop rehearsing phone numbers.
2. ***Automation Bias:*** This refers to the psychological tendency for humans to over-rely on automated systems, accepting their suggestions and decisions as correct, even when human judgment would indicate otherwise. Students tend to trust AI answers automatically, even when they are incorrect. This happens more when they are stressed, in a hurry, or unsure of their own knowledge. The bias occurs because AI sounds confident and people naturally prefer easy solutions. Scoping reviews show students are more likely to accept AI-generated responses without verification under time-constrained or uncertain conditions. (Yan et al., 2023)
3. ***Attention Redistribution:*** This is the dynamic process of shifting limited cognitive resources based on goals or task requirements. AI can shift a student's mental effort from routine tasks to higher-level thinking, but this only happens when students are trained to use AI wisely. Without training, students may become passive

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and allow AI to perform all tasks. AI handles lower-level tasks (organizing, summarizing), allowing students to focus on interpreting ideas or analyzing arguments. Tomisu et al. (2025) noted that AI can free up working memory for planning, monitoring, and reflection, but only when learners are guided to intentionally reorient their attention.

4. ***Metacognitive Offloading:*** This occurs when students ask AI to judge their work instead of evaluating it themselves. Students seek quick reassurance or correction with minimal effort, and AI seems like a reliable "external brain". This results in them becoming less confident and less skilled at checking their own understanding. The concept of "metacognitive laziness" describes decreased engagement in self-regulatory processes when students rely on AI for revision or error-checking.

Advantages of cognitive offloading on Learning Outcomes:

Cognitive offloading can positively influence learners' performance when used strategically. Research suggests that offloading can enhance productivity, comprehension, and self-regulation when applied appropriately.

1. ***Increased Efficiency:*** AI tools can organize routine academic tasks, allowing students to complete assignments more quickly. Offloading summarization or formatting enables learners to direct resources toward complex processes like analysis and synthesis.
2. ***Improved access to explanations:*** AI provides instant explanations, examples, and alternative ways of understanding concepts, supporting deeper comprehension. Students can obtain real-time clarification, immediate feedback, and personalized explanations.
3. ***Scaffolding for non-native speakers:*** AI serves as a linguistic platform, bridging gaps in vocabulary, grammar, and academic writing. AI helps nonnative speakers express complex ideas more confidently and engage more actively.
4. ***Reduced cognitive load for entry-level tasks:*** AI can offset initial demands, allowing beginners to focus on understanding essential concepts before advanced tasks. For example, AI can help format citations, freeing time to evaluate sources.
5. ***Increased confidence:*** Receiving quick guidance, validation, or correction from AI can boost learner self-efficacy. When students see that they can produce clearer writing, solve problems with support, or obtain immediate clarification, they often feel more capable and motivated.

Disadvantages of cognitive offloading on Learning Outcomes: The literature identifies several drawbacks related to reduced internal cognitive engagement and weaker knowledge retention.

1. ***Shallow learning due to shortcutting cognitive processes:*** Offloading essential mental processes to AI bypasses the deeper cognitive engagement required for meaningful learning. This "shortcuts" mental effort, resulting in quick task completion but minimal conceptual understanding and limiting the ability to apply concepts in new contexts.
2. ***Decreased retention of fundamental concepts:*** Offloading reduces opportunities for active encoding, rehearsal, and retrieval practice. This results in weaker memory strengthening and diminished long-term retention of essential concepts, leading to significant knowledge gaps in cumulative subjects.

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3. ***Reduced practice of problem-solving steps:*** Relying on AI for worked-out solutions causes students to lose the opportunity to engage deeply in procedural stages. This lack of practice impairs procedural fluency and strategic development, weakening independent problem-solving skills.
4. ***Overconfidence based on the AI-generated accuracy illusion:*** AI outputs often appear polished and confident, creating an illusion of accuracy. This leads students to overestimate AI's reliability and underestimate the need for critical evaluation.
5. ***Potential long-term decay of foundational skills:*** When AI consistently performs functions like summarizing or grammar checking, students lose valuable opportunities to practice these abilities. This can diminish core competencies, including logical reasoning, writing clarity, and independent analytical thinking.

Moderating Factors in Cognitive Offloading: Several factors influence the extent to which students offload AI and whether it helps or harms their learning.

1. ***Prior knowledge:*** New learners offload more because they lack foundational knowledge, making them less likely to fully understand or remember the material..
2. ***AI literacy:*** Knowledgeable students strategically use AI. Students who know how AI works tend to offload only the correct tasks and still think critically.
3. ***Self-regulation:*** High self-regulation is beneficial for offloading, as students can decide when to use AI, whereas low self-regulation often lets AI think, weakening skills.
4. ***Discipline:*** STEM students offload procedural tasks like calculations and coding. HSS students offload writing and syntheses, such as rewriting paragraphs or summarizing long texts.
5. ***Task complexity:*** The harder the task, the more likely students are to outsource reasoning, which carries the risk of learning about AI instead of learning the difficult parts themselves.

Interventions Identified in the Literature: Harmful cognitive offloading can be reduced through targeted teaching strategies.

1. ***Metacognitive prompts:*** Questions like “Explain how you verified AI output” encourage students to reflect on how they use AI rather than passively accepting answers.
2. ***AI usage logs or annotations:*** Requiring students to document when, why, and how they use AI tools increases transparency and encourages responsibility (Dwivedi et al., 2023; Holmes et al., 2022).
3. ***Scaffolded assignments:*** Breaking down complex tasks and requiring the justification of steps (e.g., showing calculations) prevents shortcut-taking and supports deeper learning.
4. ***AI literacy in curriculum:*** Teaching AI literacy helps students understand its limitations and common errors, leading to wiser and safer use. (Long & Magerko, 2020; Druga et al., 2021).
5. ***Assessment redesign:*** Researchers recommend designing tasks that require original thinking, such as oral evaluations or genuine real-world projects, to make it harder for students to rely solely on AI. (Susnjak 2023; Seldon 2023).

Thus, these interventions consistently help students use AI more responsibly and reduce harmful offloading.

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Discussion:

These findings confirm that AI increases cognitive offloading beyond what earlier digital tools are enabled. Offloading can be beneficial if it supports accessibility, provides adaptive scaffolds, and reduces unnecessary load. However, it also reduces deliberate practice of skills that require effortful thinking.

Excessive offloading may diminish the development of critical thinking, working memory, analytic reasoning, and independent writing skills. This review supports the extension of Sparrow et al.'s "Google effect" into the AI era, where students now know not only 'where' to find information but also 'how' to generate complex solutions. Cognitive ecosystems are becoming hybrid systems—part internal, part algorithmic.

Practical and ethical implications for Higher Education are clear. Assessment redesign is necessary, as traditional assignments can be completed by AI without understanding. AI Literacy should be counted as a skill for verifying, interpreting, and adapting AI outputs. Equity is a major ethical issue, as uneven access to AI could widen achievement gaps. Academic integrity must shift from rule-based restriction to reflective disclosure.

Conclusion:

AI has become an integral part of college students' cognitive environment. This systematic review shows that AI can both support and undermine learning depending on how it is used. The most consequential impacts involve higher-order cognitive offloading, where reasoning itself is assigned to AI. A balanced approach guided by AI literacy, metacognitive reflection, and reimagined assessment can help institutions leverage AI's advantages while protecting students' cognitive development. Future research must investigate long-term effects, design effective interventions, and explore disciplinary differences

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