

College Students' Cognitive Outsourcing Behavior in the Context of Generative Artificial Intelligence

Lin Miao^{1*}

¹Department of Educational Studies, Colgate University, Hamilton, 13346, USA

Abstract. The application of generative artificial intelligence in education has garnered widespread attention, yet the accompanying practice of cognitive outsourcing poses potential challenges to cultivating college students' critical thinking and independent reasoning abilities. Current research predominantly focuses on enhancing AI-driven teaching efficiency while overlooking the pivotal role of AI literacy in mitigating cognitive inertia and strengthening critical thinking skills. This study examines learner behavior within generative AI environments, systematically analyzes the mechanisms through which cognitive outsourcing impacts critical thinking, and explores the moderating effect of AI literacy. Findings reveal that students lacking foundational AI literacy tend to over-rely on AI for analytical tasks, resulting in diminished capabilities in information discernment, logical reasoning, and reflective questioning; conversely, those with basic AI literacy demonstrate more rational utilization of AI tools, enabling deeper collaborative human-machine thinking. Based on these findings, this paper argues that rapid advancements in generative AI lead to cognitive outsourcing behaviors among students, where excessive reliance on AI diminishes independent thinking capacity and fosters information homogenization. Consequently, the study analyzes cognitive outsourcing patterns and proposes innovative teaching methodologies tailored for AI integration.

1 Introduction

In recent years, generative artificial intelligence (AI) has gradually entered university classrooms, serving as a vital assistant for contemporary students in writing, searching, and summarizing [1]. For college students, generative AI significantly enhances learning efficiency, with tools like ChatGPT providing extensive information supported by massive datasets--far faster and more accurate than traditional browser searches. Research indicates that AI tools such as ChatGPT can offer real-time, targeted assistance to students, thereby improving learning efficiency to some extent [2]. However, as these tools become widely adopted, researchers have begun examining their profound impacts on learning processes and cognitive approaches, particularly whether students are increasingly lacking cognitive

* Corresponding author: lmiao@colgate.edu

engagement during learning and consequently altering their knowledge construction methods [3]. This leads to the primary focus of this study: cognitive outsourcing. Some scholars have found that the user-friendly nature of AI tools reduces students' cognitive effort, encouraging them to delegate complex tasks to AI, which may undermine deep learning and critical thinking skills [4].

Therefore, the primary question this paper aims to address is whether the excessive use of AI by college students, amid the prevalence of generative artificial intelligence, leads to "cognitive offloading," thereby diminishing their cognitive abilities and academic performance. The paper analyzes this phenomenon from three perspectives: the manifestations and types of cognitive offloading, its underlying mechanisms and impacts, and potential educational countermeasures.

2 College students' use of cognitive outsourcing in Generative Artificial Intelligence

2.1 Basic characteristics of cognitive outsourcing

In the conventional sense, cognitive outsourcing refers to the practice where individuals, when attempting to solve a problem, do not begin by acquiring foundational knowledge about it but instead consult an expert to obtain answers or solutions swiftly. However, cognitive outsourcing driven by artificial intelligence involves AI assisting college students in "understanding" and "thinking." Students transfer the critical learning process of comprehending content and knowledge to artificial intelligence, thereby establishing the cognitive construction framework of "cognitive outsourcing". While this approach significantly reduces time expenditure, it incurs cognitive costs [4]. Cognitive costs refer to the effort required to comprehend, compare, evaluate information, and make decisions--in other words, the cost of transforming information into actionable decisions. By filtering and discerning information, students save time but devote more effort to decision-making.

2.2 Main types of cognitive outsourcing

Currently, the cognitive outsourcing relied upon by college students can be categorized into four main types: auxiliary, substitutive, dependent, and unconscious. Auxiliary cognitive outsourcing involves students using AI sparingly without integrating it into their primary thinking processes; it merely enhances specific tasks--such as optimizing language, organizing ideas, or explaining concepts. Substitutive cognitive outsourcing partially replaces students' independent thinking, going beyond merely assisting with academic assignments; students delegate core tasks to AI, such as drafting thesis outlines or leveraging AI to analyze texts/data and draw conclusions. Dependent cognitive outsourcing refers to the ingrained habit developed through prolonged use of generative AI tools like ChatGPT, where students instinctively turn to AI for solutions rather than engaging in independent reasoning when facing challenges. This seemingly minor shift in behavior reveals profound changes in students' learning approaches and thought patterns.

The first two forms of cognitive outsourcing under artificial intelligence remain at the "tool" and "conscious" levels, while the latter two have deeply penetrated students' thinking patterns. The final unconscious form of cognitive outsourcing involves students seemingly participating in the learning process to understand and absorb AI-provided answers and analyses, but essentially accepting the answers shaped by AI's pre-designed unified thinking framework. Cognitive outsourcing in generative AI contexts is not a singular phenomenon

but follows a continuum ranging from partial assistance to deep substitution, and from active selection to habitual reliance.

3 The formation mechanism and impact of cognitive outsourcing

3.1 Positive impact

The primary reasons for college students' widespread adoption of generative AI fall into several categories: technical convenience, efficiency-oriented considerations, and recognized energy-saving benefits. The greatest advantage of generative AI lies in eliminating the need for students to spend excessive time filtering and selecting information; they simply input their questions and immediately receive answers curated and selected by the AI [5]. This cost-effective and highly efficient approach naturally attracts more students to use it.

Generative AI is not entirely undesirable; tools are merely tools--the key lies in how humans utilize them. Cognitive outsourcing does not invariably yield negative outcomes either. When students properly employ AI as a tool to support rather than replace their own thinking, generative AI becomes an exceptionally efficient and powerful auxiliary tool [6]. Many college students use generative AI for learning and review purposes (e.g., ChatGPT), posing questions they don't understand during lectures and receiving detailed, step-by-step explanations that deepen their comprehension. This learning approach significantly enhances individual student performance.

3.2 Negative impacts

3.2.1 Learning process and cognitive ability

If students treat AI as a tool that completely replaces individual thinking, it will negatively impact the learning process itself. Barcaui demonstrated in an experimental study that students who used ChatGPT for learning achieved lower scores on knowledge retention tests after 45 days compared to those who did not use artificial intelligence, suggesting that AI may impair long-term memory formation by reducing students' cognitive effort [3]. Further research indicates that excessive reliance on AI also adversely affects critical thinking and learning abilities. Tian and Zhang found a negative correlation between college students' AI dependence levels and their critical thinking skills, attributing this association partially to cognitive fatigue. Jia et al. discovered that AI dependence induces "false self-efficacy", where students develop a false impression of having mastered knowledge after completing tasks with AI, despite not truly acquiring the relevant knowledge, thereby negatively impacting their academic performance [7]. These studies collectively demonstrate that AI dependence exerts detrimental effects on learning outcomes.

3.2.2 AI cognitive convergence and homogenization of thinking

In a classroom setting, when all students approach the same learning task by seeking inspiration and answers from a single artificial intelligence system, phenomena such as cognitive convergence or cognitive homogenization may occur. This means students may exhibit high similarity in problem analysis, argument structure, and even expression, thereby diminishing the uniqueness and creativity in their knowledge construction processes [8]. Regarding cognitive outsourcing, this represents not merely the external transfer of cognitive activities but also reflects students' gradual cessation of actively seeking alternative solutions.

If students consistently settle for the optimal answers provided by AI, they may lose their capacity for critical thinking and questioning. Over time, this undermines students' abilities to innovate, make independent decisions, and solve complex problems--thereby potentially undermining the core objective of higher-order thinking cultivation in university education [9].

3.2.3 Formation of the cognitive comfort zone and weakening of higher thinking abilities

College students are currently residing in an unprecedented "cognitive comfort zone." Within this zone, people tend to overestimate the convenience brought by artificial intelligence while underestimating its subtle erosion of human capabilities. The essential cognitive foundation that students should cultivate is gradually eroding: Without generative AI assistance, they cannot draw inspiration from unexplored mental gaps and lose patience for constructing logical frameworks. Before AI emerged, students gained insights through trial-and-error, discovering new ideas and inspirations--a self-transformation process that forged deep understanding and memory of knowledge. 3. Excessive reliance on generative AI causes students to progressively lose their intuitive acuity--a moral judgment and aesthetic intuition rooted in life experiences that cannot be quantified by data.

4 Educational approaches to addressing cognitive outsourcing among college students

Cognitive outsourcing represents a core cognitive challenge faced by college students: as AI progressively replaces individual thinking processes, students not only risk homogenized thinking and weakened critical thinking skills but also fundamentally lose their agency in cognitive transformation and knowledge construction. To address this dilemma, it is essential to avoid simply dismissing the value of AI tools; instead, an education-centered approach should guide students in developing a rational understanding of AI and establishing appropriate usage boundaries. This chapter explores educational strategies for addressing cognitive outsourcing among college students, investigating feasible pathways to achieve synergistic advancement between AI empowerment and cognitive development through perspectives such as individual literacy and educational practice.

4.1 Enhancing AI literacy and information literacy

Enhancing information literacy has become particularly crucial in today's era of rampant big data and artificial intelligence. This paper argues that college students should focus on three key areas to improve their information literacy: establishing a cognitive framework, developing a specialized knowledge system, and refining critical judgment [1,5]. First, regarding the cognitive framework, students should learn to effectively utilize AI as a learning tool. By leveraging AI to organize and integrate fragmented knowledge points, they can rapidly construct a foundational cognitive structure. Combining this with their own learning experiences and life insights enables them to naturally develop a personalized cognitive system that they can apply effectively in daily life and academic pursuits. Second, concerning the specialized knowledge system, students should consult cutting-edge journals and core content related to their field, then, through independent study and reflection, formulate practical learning methods that resonate with them--gradually accumulating these strategies over time. Finally, enhancing judgment skills is essential: students must cultivate critical thinking abilities to verify the authenticity and feasibility of information obtained

from online sources and AI tools, avoiding blind adherence to methods recommended by artificial intelligence systems.

4.2 Optimizing teaching design

The ultimate approach to educational assessment profoundly influences college students' heavy reliance on AI. School evaluations prioritize final outcomes rather than examining students' "active thinking processes." This compels many students to abandon independent reasoning in pursuit of high scores, knowing that AI consistently provides flawless, high-scoring answers. To effectively reduce cognitive outsourcing, reliance should extend beyond individual student self-discipline to include strategic adjustments in instructional design that minimize AI usage. First, greater emphasis should be placed on problem formulation and thought progression. When submitting assignments, students should submit not only final versions but also their "drafts" --documenting their thought processes, such as justifying analytical perspectives, argument development, and evidence sourcing. This visualizes cognitive activities. Professors can further encourage individual thinking through score distribution modifications: reducing the weight of final assignments or evaluating students based on submitted drafts rather than final results, thereby observing their reasoning processes through these drafts.

Simultaneously, educators can design more open-ended questions. In teaching practices, the number of questions with only standard answers should be reduced, encouraging students to compare different viewpoints and express their unique insights--even if these insights contain errors or logical gaps--without penalty points being imposed. This approach genuinely motivates students to voice their ideas; otherwise, driven solely by higher scores, they might resort to AI assistance, as its proposed methods often appear "perfect." Additionally, answering open-ended questions preserves greater space for independent thinking. Beyond optimizing instructional design, schools should systematically implement artificial intelligence literacy and academic ethics education to establish clear cognitive and behavioral boundaries for students' rational use of AI.

The course content covers the working principles, applicable scenarios, and limitations of generative AI, helping students understand AI and develop critical analytical skills for evaluating AI-generated content. It also teaches AI-assisted learning methods, guiding students to utilize AI for idea generation and data organization rather than replacing human thinking and creative processes. Institutions can establish clear AI usage guidelines that define appropriate boundaries in academic settings--such as which assignments or papers permit AI assistance, which stages prohibit direct AI-generated content, and how to properly document AI tool usage--to prevent academic misconduct risks arising from improper AI application.

Schools can also enhance students' critical thinking by leveraging AI in reverse [10]. For example, they could assign students a paper entirely written by generative AI, requiring them to identify flaws and biases within the text and propose their own new insights. This approach trains students not merely to "obtain answers," but to "evaluate answers."

5 Conclusion

In summary, generative artificial intelligence has been widely applied in university education, influencing students' cognitive activities and, to some extent, altering their behavioral habits. Higher education must strike a balance between technological application and cognitive development. By enhancing students' information literacy, refining instructional design, and strengthening formative assessment, artificial intelligence can serve as a tool to facilitate thinking rather than replace it.

Comprehensive reviews of existing research indicate that generative artificial intelligence (GAI) serves as a "double-edged sword" in college students' learning. It enables students to rapidly acquire information, organize materials, and optimize their expression, thereby enhancing learning efficiency to some extent. Therefore, when used appropriately, GAI can function as a cognitive support tool to assist students in completing learning tasks.

In the future, research on generative AI and cognitive outsourcing among college students still has significant room for further exploration. While existing studies have preliminarily revealed the relationship between AI dependence and cognitive effort, critical thinking, and academic performance, its long-term impacts require additional longitudinal studies for verification--particularly regarding whether sustained AI use leads to deeper changes in students' creativity, problem-solving abilities, and cognitive diversity. Future research should not merely focus on whether to adopt AI, but rather concentrate on how to effectively utilize AI while maintaining learners' agency and cognitive engagement, thereby enabling generative AI to genuinely serve the deep learning objectives of higher education.

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