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Research Paper

Understanding the Relationship between Generative AI Dependence and Students' Problem-Solving Ability: The Roles of Cognitive Offloading and AI Literacy

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Abstract

Today, Generative Artificial Intelligence (GenAI) is quickly becoming a staple of university students' work, as it can provide instant answers to information search, writing, explanation and problem solving. While GenAI can aid in learning, overreliance can lessen students' independent thinking. This study explores the ties between generative AI reliance and students' problem-solving skills, focusing on cognitive offloading as a mediation factor and AI literacy as a moderation factor. A quantitative, cross-sectional research design is suggested with a sample of 100 University students. The data will be analyzed using descriptive statistics, reliability analysis, Pearson correlation, regression, and mediation and moderation analysis through SPSS. The conceptual model suggests that students' problem-solving ability may be linked to their degree of cognitive offloading, which could be further linked to their reliance on GenAI. The authors suggest AI literacy as a boundary condition that could affect the relationship between GenAI dependence and problem solving ability. New studies suggest that students' use of GenAI in problem-solving is multi-layered and constructive, as well as thoughtless, and that there are four aspects of AI literacy: knowledge, application, evaluation, and understanding of ethical issues. Thus, the present study is centered on not only students' usage of GenAI, but also how reliance on GenAI can impact their thinking processes when addressing academic challenges.

Keywords: Generative Artificial Intelligence, Genai Dependence, Cognitive Offloading, AI Literacy, Problem-Solving Ability, University Students.

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Introduction

G.A.I. has transformed the way university students look for solutions, come up with ideas, work on assignments, and look at academic problems. Large language model-powered tools can give explanations, examples, suggestions, summaries and possible solutions in seconds. This is why more and more, GenAI is being used not just as an information source, but also as a cognitive partner in academic tasks. Recent studies have demonstrated that when used appropriately, GenAI can lead to positive learning outcomes, but it can also have a different impact depending on how students interact with it and the design of learning activities (Chen & Cheung, 2025; Liu et al., 2025).While the educational potential of GenAI is clear, so too is the reality that such use doesn't always benefit the learner if it is too frequent or they depend on it too often. There should be a difference between using AI as a tool and relying on AI to do cognitive tasks which students could do on their own. Recent studies have specifically focused on students' dependence on GenAI when solving problems and discovered various types of dependence: reflective, cautious, thoughtless, and collaborative (Hou et al., 2025). The distinction is crucial as it does not account for why students use GenAI at all and how that use is either beneficial or detrimental to their independent problem-solving.One psychological process that could account for this relationship is cognitive offloading. This process of using external resources to involve less mental effort is called cognitive offloading (Risko & Gilbert, 2016). Conventional examples would be calculator, notes, reminder or diagrams. GenAI is a much more powerful source of external cognitive support as students can offload aspects of information processing, idea generation, explaining, comparing, and developing solutions to an AI system.It's not the offloading itself that's bad, it's whether it's a bad thing. The use of external tools can help to minimise unnecessary mental effort and enable students to concentrate on more demanding tasks. This is where a concern lies, that core reasoning processes are routinely transferred to GenAI by students without their own evaluation or reconstruction of the answer. Research on technological dependence also indicated that GenAI can enhance the perceived efficiency but present risks to independent learning (Zhang & Xu, 2025).Meanwhile, students vary greatly in their comprehension and assessment of information created by AI. This ability is often referred to as AI literacy. Recent reviews suggest that AI Literacy encompasses competencies like understanding AI, utilizing AI, assessing AI results, and tackling ethical matters (Lintner, 2024; Park, 2025).Advanced students with a better understanding of AI literacy might be more likely to identify the constraints of GenAI, confirm the answers it provides, design suitable prompts, and integrate AI with their own thinking. Hence, AI literacy could impact the negative or positive effects of GenAI dependency on students' problem-solving skills.While there is considerable research on the application of GenAI in education, there is a significant gap in the literature. Many studies have been conducted on either general acceptance or academic performance, learning outcomes, or students' attitudes toward AI. The psychological mechanism in which dependence on GenAI can affect problem-solving should be given more attention. This is addressed by the present study, which includes an examination of cognitive offloading as a possible mediating variable and AI literacy as a possible moderating variable.

Literature Review

Generative AI Dependence and Problem-Solving

The ability of GenAI to give students quick explanations and potential solutions can be invaluable. A recent meta-analyze showed that using GenAI can positively impact a number of

student outcomes, though the effects are dependent on the context, how students interact with GenAI, the subject, and the length of time GenAI is used (Liu et al., 2025; Chen & Cheung, 2025). the promise of GenAI is not dependent upon unchecked reliance. To capture undergraduate students' dependence on GenAI and solve this challenge, Hou et al. (2025) created and assessed a scale designed to measure undergraduate students' reliance on GenAI in problem-solving. Their research revealed that reliance is not a single act, students can rely on AI reflectively and collaboratively, and they can rely on AI thoughtlessly. This discovery helps pave the way for the analysis of dependence as a psychological and behavioural phenomenon, rather than being limited to the number of times AI is used.Likewise, Zhang and Xu (2025) found that using GenAI could enhance student perceived efficiency and self-confidence, but could also raise concerns regarding technological dependency and student independent learning.The results indicate that GenAI could have two faces. Use of the appropriate amount may be helpful for learning, while more use may be counterproductive for students to analyze and build solutions themselves. Hence, the association between GenAI dependence and problem-solving capability should be directly examined empirically.

Cognitive Offloading as a Mediating Mechanism

The concept of cognitive offloading offers a theoretical framework to explain the impact of technology on the cognitive processes of users. According to Risko and Gilbert (2016), cognitive offloading is the process of involving external actions and resources to decrease the cognitive load of a task. The idea is applicable to GenAI because it is now possible to offload increasingly complex mental tasks to an AI system.Some of the cognitive effort of the student is outsourced to the external system when a student asks GenAI to solve a problem instead of trying to solve it independently. This can be effective but if the learner keeps going back to this, they may not need to process as much by themselves.There is concern about this possibility that has been backed by recent research in the field of education. The concept of GenAI dependence has been linked to cognitive outsourcing, and decreased independent learning (Hou et al., 2025; Zhang & Xu, 2025), the pattern of dependence during problem-solving was investigated, revealing a spectrum of reliance patterns among students (Hou et al., 2025; Zhang & Xu, 2025).Therefore, the phenomenon of cognitive offloading could be a connection between GenAI dependence and problem-solving skills. A tendency to rely on GenAI may lead students to delegating either parts or the entirety of problem formulation, information processing, solution generation or evaluation to the external system. This decrease in the independent effort for cognition could have an effect on their problem-solving ability.

AI Literacy.

With GenAI increasingly being adopted in educational settings, AI literacy is emerging as a key focus point. Lintern (2024) conducted a systematic review of existing AI literacy scales in 22 validation studies, which found 16 scales overall and highlighted the need for reliable (and valid) scales to measure AI literacy.The recent study also showed that there are several dimensions related to AI literacy. Zhong and Liu (2025) put forward an AI literacy framework consisting of knowledge, affectivity and thinking, and Chen et al. (2025) explored the GenAI literacy of the students through four dimensions, including utilization, interaction, output evaluation, and ethics.Based on a systematic review of 51 empirical studies, Park (2025) suggested that GenAI literacy should comprise the skills of understanding GenAI, using GenAI, reviewing and integrating its results, values and ethics, and attitudes towards GenAI.The results

show that students' attitudes toward using AI assistance might be influenced by their AI literacy. A higher-literacy student might comprehend that an answer from an AI needs to be verified and compared, as well as their own reasoning. On the other hand, if a student is less adept at AI literacy, they might be more inclined to take the information that AI provides without critically evaluating it.As such, AI literacy could potentially alter the link between AI dependence and problem-solving capacity.

Research Gap

While the literature has clearly shown that GenAI can have an impact on student learning and cognitive outcomes, it is important to note that there are questions about dependence, not just use. The use of GenAI in problem solving and technological dependence have been studied in recent years and in the studies on AI literacy, the focus has been on measurement of AI knowledge, skills, evaluation and attitudes. Despite this, the scientific study of GenAI dependence in education is still in its early stages, with only a few empirical studies that bring these elements together in one educational psychology model, where GenAI dependence is the predictor, cognitive offloading is the explanatory mechanism, problem solving is the outcome, and AI literacy is a boundary condition. The present study aims to fill this void by examining this combined model with university students.

Method and Material

A quantitative cross sectional survey design is suggested. This study explores the relationships between GenAI dependence, cognitive offloading, AI literacy and problem-solving. The sample size for this is 100 students of universities selected by random sampling. The participants should be students who have experience in using generative AI tools like Chat GPT, Gemini, Copilot, or similar tools for academic tasks. However, if it is a Q1 submission, then the final sample should be explained by using an a priori power analysis. The number of 100 participants may not be enough for a complex mediation–moderation model, depending on the expected effect sizes. As a result, if the power analysis suggests so, the final study should have more participants. Use of instruments, established or modified, should be used for all constructs:

Generative AI Dependence: Items measure the degree of dependence that students experience in relation to academic thinking, information processing, task completion, and problem-solving with GenAI (Hou et al., 2025). Items include measures of cognitive offloading, which is based on the cognitive offloading framework by Risko and Gilbert (2016).

AI Literacy: Student's understanding of, interaction with, evaluation of and responsibility for AI systems (Lintner, 2024; Zhong & Liu, 2025).

Problem Solving Ability: Expresses or demonstrates problem solving skills in identifying problems, analyzing information, generating solutions, evaluating solutions, and drawing conclusions. All items are measured on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). *IBM SPSS Statistics is to be used to analyze the data. The analysis includes:*

Demographic characteristics: Frequencies and percentages. Study variables means and standard deviations. Cronbach's alpha for internal consistency. Pearson correlation analysis. Regression analysis. Mediation analysis by means of the bootstrapping (PROCESS macro, 5000 resamples).

Moderation analysis involving an interaction term. Note: The following values are simulated and presented in the APA 7th standard as well as SPSS output presentation format. They exhibit the appropriate reporting format for N = 100 cases.

Results and Discussion

Table 1

Demographic Characteristics of Participants (N = 100)

Variable	Category	f (%)
Gender	Male	52 (52.0%)
	Female	48 (48.0%)
Age	18–21	35 (35.0%)
	22–25	38 (38.0%)
	26–30	19 (19.0%)
	31+	8 (8.0%)
Study Level	Undergraduate	62 (62.0%)
	Master's	38 (38.0%)
Discipline	Education	35 (35.0%)
	Social Sciences	25 (25.0%)

Table 2

Descriptive Statistics and Reliability of Study Variables

Variable	*M*	*SD*	Cronbach's α
1. Generative AI Dependence	3.21	0.71	.88
2. Cognitive Offloading	3.17	0.68	.86
3. AI Literacy	3.42	0.64	.90
4. Problem-Solving Ability	3.08	0.66	.87

Table 3

Pearson Correlations Among Study Variables

Variable	1	2	3	4
1. GenAI Dependence	—			
2. Cognitive Offloading	.53**	—		
3. AI Literacy	-.21*	-.16	—	
4. Problem-Solving Ability	-.42**	-.47**	.35**	—

Note. * p < .05, ** p < .01.

The correlation matrix indicates a significant negative association between GenAI dependence and problem-solving ability (r = -.42, p < .01). Cognitive offloading is positively associated with GenAI dependence (r = .53, p < .01) and negatively associated with problem-solving ability (r = -.47, p < .01). AI literacy shows a positive relationship with problem-solving ability (r = .35, p < .01).

Table 4

Regression Analysis Predicting Cognitive Offloading

Predictor	*B*	*SE B*	*β*	*p*
GenAI Dependence	0.51	0.08	.53	< .001
AI Literacy	-0.09	0.08	-.08	.280

Table 5

Moderated Regression Analysis Predicting Problem-Solving Ability

Predictor	*B*	*SE B*	*β*	*p*

GenAI Dependence	-0.28	0.09	-.30	.003
Cognitive Offloading	-0.36	0.09	-.37	< .001
AI Literacy	0.17	0.08	.17	.041
GenAI Dependence × AI Literacy	0.20	0.08	.21	.018

Table 6

Mediation Analysis (PROCESS Model 4, 5,000 Bootstrap Resamples)

Effect	Effect Size	Boot SE	95% CI
Indirect Effect (GenAI Dep → Cog Off → PS Ability)	-0.18	0.06	[-0.31, -0.08]
Direct Effect (GenAI Dep → PS Ability)	-0.28	0.09	[-0.46, -0.10]

Discussion

The model presented here serves as a response to an educational psychology question: Does the dependence on GenAI change the way that cognitive tasks are performed in such a way as to impact students' problem-solving ability?The illustrative results indicate an increasing correlation between the reliance on GenAI and cognitive offloading with increasing dependence on GenAI. This is in line with the theoretical model of cognitive offloading which posits that people rely on external resources to offload their internal cognition (Risko & Gilbert, 2016). In the case of GenAI, the external resource is significantly more powerful than traditional resources in that it can create explanations, arguments, examples and even full solutions.The hypothesized negative correlation between GenAI dependence and problem solving ability is also aligned with recent concerns with technology dependence and independent learning. A complicated relationship between GenAI use, perceived efficiency, confidence, and dependence with technology was revealed by Zhang & Xu (2025).However, the literature does not lead one to believe that GenAI itself is harmful. According to the evidence-based assessment, the positive effects of GenAI on student learning and higher-order thinking within the classroom are closely associated with the proper adoption of GenAI tools (Chen & Cheung, 2025; Liu et al., 2025).What is important is then the difference between dependence and purposeful usage. Multiple patterns of using GenAI for problem solving were illustrated in the article by Hou et al. (2025), suggesting that this reliance is not necessarily a problem; therefore, one should not assume that any student's use of GenAI for problem-solving is problematic. Another crucial explanation to consider is AI literacy. If students grasp the functionality of GenAI, the limitations of GenAI, the evaluation of the outputs, and the responsible use of GenAI, they may be less likely to give up their thinking skills to GenAI. Evaluation and responsible use are recurring themes that have been consistently highlighted as core aspects of AI and GenAI literacy in recent literature (Lintner, 2024; Chen et al., 2025; Park, 2025).So, the educational task is not just about

minimizing the students' use of GenAI. Rather, universities need to introduce students to using GenAI, but not transfer ownership of the thinking process to the technology.

Educational Implications

University Curriculum: Universities should create GenAI- literacy courses that will help students to validate AI-generated answers instead of accepting them. Pedagogical Design: Assignments can be created where students will need to explain their reasoning to the solution and compare their reasoning with that provided by the AI and be able to identify where the AI is getting wrong. Strategic Integration: Students should be reminded to leverage GenAI tools as an aid, not a replacement, for their own problem-solving abilities. Skill acquisition: There is a need to include skill acquisition in AI literacy, including prompting, fact checking, evaluating output, recognizing hallucination and ethical use. Assessment Practice: Assessment needs to increasingly test students' reasoning processes, not just their answers, as especially when using AI tools, students can give a polished answer within seconds.

Limitations

There are some constraints to be taken into account. The first is that a cross-sectional design cannot make causal inferences. Second, a response bias can occur in self-reported measures. Third, there is a possibility that if the sample size is 100, it might be a small sample size, which could reduce the power of the study and its generalizability, particularly for mediation and moderation analysis. Fourthly, students' reported GenAI use might not match their actual use. Studies with larger samples, longitudinal designs, experimental designs, and performance indicators of problem-solving should therefore be conducted in the future. Additional research might also explore how the relationship between dependence and cognitive performance shifts after structured GenAI training and a comparison of students with varying degrees of AI literacy.

Conclusion

The learning potential of generative AI is newly available for universities, but it is highly reliant on how students use it. The present study suggests that overreliance on GenAI might have a relationship with student problem-solving ability via the cognitive offloading pathway and that AI literacy could affect the strength of this relationship. This is the key innovation of the model, as it asks a much more complex question of whether students use GenAI or not. Instead, it investigates how reliance on GenAI could alter students' thinking processes and if there is a way for students to have a way to remain independent in problem-solving with the support of AI literacy. The study thus offers a specific educational psychology approach for studying GenAI dependence in university education, as well as cognitive offloading and problem-solving.

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