**Int. J. Sci. R. Tech., 2026 3(11)**
A Multidisciplinary peer-reviewed Journal
www.ijsrtjournal.com [ISSN: 2394-7063]

*Original Article*

# Beyond Cognitive Offloading: Long-Term Retention, Independent Problem-Solving, and Transfer in Generative AI-Assisted Higher Education

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## ABSTRACT

Generative artificial intelligence (GenAI) is increasingly used by university students for writing, programming, problem-solving, and personalized guidance. Although these tools can improve the speed and quality of academic tasks, improved AI-assisted performance does not necessarily demonstrate independent learning. This narrative review examines cognitive offloading and its relationship with long-term knowledge retention, unaided problem-solving, and transfer of learning in higher education. It draws on selected research about cognition and AI-supported learning and uses related publications on AI in education, healthcare, engineering, cybersecurity, agriculture, and other settings to illustrate broader questions of human oversight and responsible use. Available experimental findings suggest that unrestricted assistance may create dependence when learners delegate key thinking tasks, whereas structured guidance may preserve more active engagement. However, evidence remains varied, and direct studies of delayed, AI-free assessment are relatively limited. The review recommends guided AI use, independent practice, delayed testing, and explicit evaluation of transfer. This is a narrative review, not a completed systematic review or meta-analysis.

**Keywords:** Generative Artificial Intelligence, Cognitive Offloading, Higher Education, Knowledge Retention, Independent Problem-Solving, Transfer of Learning, AI Literacy

## INTRODUCTION

Generative artificial intelligence has become a practical aid for university students and teachers. Chatbots and other AI tools can explain difficult concepts, draft text, suggest code, summarize information, and provide rapid feedback. Their convenience creates an important educational question: do students learn a concept deeply, or do they merely complete a task successfully with external help? A student may submit an accurate AI-assisted assignment but struggle to reproduce or apply the reasoning without the tool.

Cognitive offloading occurs when a person uses an external resource to reduce the mental effort required for a task (Risko & Gilbert, 2016). Offloading routine activities can be productive, but delegating core reasoning, retrieval, or explanation may interfere with the practice needed for durable learning. The distinction between short-term task performance and long-term learning is established in educational psychology (Soderstrom & Bjork, 2015).

AI is also transforming university services beyond classroom tasks. Kalam and Kaur (2025) discuss applications in admissions, student advising, and research support. These administrative and academic benefits provide useful context, but the effectiveness of AI services should not be confused with evidence that students retain knowledge or solve problems independently.

## AIM AND REVIEW APPROACH

This paper has three aims:

1. to explain cognitive offloading in GenAI-supported university learning;
2. to discuss long-term retention, independent problem-solving, and transfer as distinct educational outcomes; and
3. to suggest accessible strategies for responsible AI integration. It is a selective narrative review based on the supplied manuscript and cited publications. No comprehensive database search, independent full-text screening, formal risk-of-bias assessment, or quantitative pooling was conducted.

**Relevant conflicts of interest/financial disclosures**: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Consequently, the paper does not claim systematic-review completeness.

## COGNITIVE OFFLOADING AND GENERATIVE AI

Students have always used external supports such as notes, calculators, search engines, and online tutorials. GenAI extends this process because it can generate arguments, solutions, and explanations rather than merely retrieve information. This creates two useful patterns of offloading. In supportive offloading, students use AI to obtain hints, compare approaches, and check errors while retaining responsibility for the reasoning. In substitutive offloading, AI supplies the central reasoning or final answer and students may engage only superficially.

The same polished final assignment can arise from either pattern. Therefore, instructors cannot assess student understanding using the final product alone. Learners should also be able to explain their reasoning, identify mistakes, and solve a comparable problem independently. Research on AI use and metacognitive processes highlights the need to examine self-regulation rather than relying entirely on supported performance (Fan et al., 2025).

## MAJOR LEARNING OUTCOMES

### Long-term knowledge retention

Long-term retention describes how well students remember and understand information after a delay. A meaningful retention test should be administered after a stated interval, ideally without GenAI assistance. Barcaui (2025) reported a randomized study involving university students in which the ChatGPT-supported study condition had a lower mean score on a surprise test 45 days later than the traditional-study condition (57.5% versus 68.5%, as reported in the supplied manuscript). This single result raises concern about unrestricted assistance, but its size and direction should not be generalized across different courses, learners, or AI designs.

Students may benefit when AI prompts them to recall an answer before revealing it, requests an explanation in their own words, or supplies feedback after an initial attempt. These forms of active practice are more closely aligned with the goal of retention than copying a complete response.

### Independent problem-solving

Independent problem-solving means completing a task without access to the AI system. GenAI can help students understand programming errors, mathematical procedures, and research concepts, but it can also bypass the thinking steps they need to master. In a high-school mathematics experiment, Bastani et al. (2025) found that the design and constraints of AI support mattered: unrestricted assistance could improve performance during practice yet undermine performance when AI was unavailable. Because the study concerns school pupils, it is illustrative rather than direct university evidence.

For higher education, an effective approach is to allow students to consult AI after attempting the problem themselves. Asking for a short written explanation of the chosen solution can further show whether the student understands the underlying method. Courses should test independent reasoning in addition to collaborative human–AI output.

### Transfer of learning

Transfer refers to applying knowledge to a new task or situation. Near transfer occurs when the new problem resembles the original learning task; far transfer requires applying a principle in a different context. A student who solves a practice programming exercise with AI may still find it difficult to design a solution to a new problem without assistance. To measure transfer properly, educators should provide new and appropriately challenging tasks rather than infer transfer from assignment grades or satisfaction surveys.

AI applications across disciplines demonstrate why transfer is important, although application papers do not themselves measure educational transfer. For example, the agricultural disease-prediction review of Kaur and Kumar (2020) and the drug-discovery discussion by Akram and Kaur (2025) represent different applied contexts in which students might be asked to interpret methods independently and adapt ideas to new problems.

## BROADER APPLICATIONS AND RESPONSIBLE AI USE

AI systems now support many fields that university students encounter. The literature supplied for this review includes discussions of AI in healthcare consultations (Kaur, 2025), gene-expression research using big data and neural networks (Muthalvan et al.,

2026), and quantum-integrated deep learning for neurological disease modeling (Subashini et al., 2026). Such examples show the growing importance of understanding AI outputs, data quality, and limitations. They do not directly establish whether GenAI improves or harms student retention.

The importance of verification is also apparent in security-oriented applications. Kaur (2026a) addresses AI-powered behavior analytics for fraud detection, while Kaur and Kaur (2026) examine security, privacy, and digital trust in cloud- and 6G-enabled metaverse systems. These topics provide a useful analogy for education: students should not automatically trust plausible AI responses and should learn to inspect the evidence and reasoning behind them.

At the institutional level, Kaur (2026b) reviews ICT applications in smart cities, and Harshvardhan et al. (2025) discuss sustainable waste management using AI and robotics. Kaur and Kaur (2025) also review the role of AI in engineering and finance. Together, these publications illustrate how broadly AI is being adopted, strengthening the case for teaching AI literacy, responsible use, and domain-specific judgment. Their contributions are contextual; they are not substitutes for controlled studies of AI-assisted university learning.

## BENEFITS AND CHALLENGES IN HIGHER EDUCATION

When used carefully, GenAI may provide immediate feedback, accessible explanations, language assistance, and opportunities for self-paced practice. It may help teachers develop sample problems and let students compare alternative solutions. These possibilities fit broader accounts of AI-supported university services and teaching (Kalam & Kaur, 2025).

However, challenges include overreliance, unverified or fabricated outputs, superficial understanding, unequal access, privacy risks, and difficulty determining which parts of submitted work represent independent student competence. The central educational risk is not the mere presence of AI but the replacement of important cognitive activities with automated answers. Teaching should therefore distinguish productive assistance from dependence.

## PRACTICAL RECOMMENDATIONS

- Encourage a student-first attempt: students should outline an answer or solve an initial version before requesting AI support.
- Prefer hints and feedback over complete solutions for concepts that students are expected to master.
- Combine AI-assisted coursework with regular closed-tool exercises, short oral explanations, and individual demonstrations.
- Use delayed quizzes to check retention instead of relying only on immediate test scores or final assignments.
- Assess transfer with unfamiliar cases and clearly describe whether AI was allowed during the assessment.
- Teach AI literacy, including source verification, disclosure of AI use, privacy, and recognition of model errors.

## RESEARCH GAPS AND FUTURE DIRECTIONS

More university-based experiments are needed to compare unrestricted AI use, hint-based tutoring, and independently completed practice. Future studies should assess both assisted and unaided performance; specify the period between learning and delayed assessment; use genuine near- and far-transfer tasks; and report the subject, tool version, baseline skill, and level of permitted support. Multi-institution research would help test whether findings differ across disciplines and learner groups. Carefully reported findings are essential before broad claims can be made about the long-term educational impact of GenAI.

## CONCLUSION

Generative AI offers valuable support for higher education, but effective task completion is not the same as lasting learning. Cognitive offloading becomes educationally problematic when students hand over the thinking activities they are supposed to develop. Evidence from selected learning studies suggests the design of AI assistance and the conditions of assessment matter. Universities should combine guided AI use with independent practice, delayed retention tests, and transfer-focused tasks. This balanced approach can preserve the practical benefits of AI while protecting students' ability to understand, reason, and work without it.

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HOW TO CITE: Dr. Manpreet Kaur, Beyond Cognitive Offloading: Long-Term Retention, Independent Problem-Solving, and Transfer in Generative AI-Assisted Higher Education, Int. J. Sci. R. Tech., 2026, 3 (11), 780-784. https://doi.org/10.5281/zenodo.24278791