

From Assistance to Substitution: Generative AI and Undergraduate Research Skills

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Abstract— Generative artificial intelligence has become part of the daily academic works for the university students, whether it develops research competence or simply improves the quality and speed of immediate problem solving and response. This integrative literature review examines that question through five related dimensions of undergraduate research competence: information literacy, critical thinking and problem-solving, academic writing, self-regulated learning and research independence, and research ethics. The review synthesizes recent systematic reviews, meta-analyses, empirical studies, and established educational frameworks. However, GenAI looks most useful when it functions as an assistive tool: students use it to possibility generation, feedback receiving, alternatives comparing, or revise their work while retaining responsibility for source evaluation, reasoning, and final decisions. By contrast, substitutive use where the system performs substantial portions of the cognitive or research process creates problems of cognitive offloading, weak source studying, overconfidence, wrong references, and reduced human research independence. The review therefore argues that the central educational issue is not whether the generative artificial intelligence is beneficial or harmful in itself, but under what conditions AI-assisted performance becomes genuine, transferable research competence. Three recurring moderators are especially important: instructional directions, assessment design, and the limit of responsibility respected by the student. The review concludes with a conceptual framework distinguishing assistive from substitutive usage and proposes a research agenda centered on new designs, objective skill assessment, discipline-sensitive studies, and assessments that require students to demonstrate their own reasoning.

Keywords— Generative Artificial Intelligence, ChatGPT, Undergraduate Research Skills, Information Literacy, Critical Thinking, Academic Writing, Self-Regulated Learning, Academic Integrity.

Introduction

The artificial intelligence becomes a very wide used in the education. Since the real public appearance of ChatGPT in 2022, students have begun using model tools of large language to research topics brainstorming, search terms generating, difficult concepts explaining, readings summarizing, prose revising, text translating, and substantial parts of academic assignments producing. Recent reviews show that this is no longer a marginal use of technology: research has expanded across disciplines, with ChatGPT examined as an assistance for learning and writing, feedback tool, and source of personalized

support (Baig & Yadegaridehkordi, 2024; Lo et al., 2024).

The speed of response has created a real educational question. A student may complete a research task faster and produce a more improved text with AI assistance, but this does not necessarily mean that the student has become better at research conducting. Research competence is not simply the ability to produce an acceptable final product. It includes evidence finding and judging, worthwhile questions asking, arguments constructing and testing, findings communicating, monitoring one's own learning, and

ethically acting. A technology can improve the visible product while leaving these underlying capabilities unchanged, in some circumstances, weakening them.

This review takes that distinction as its starting point. Rather than treating AI usage as a single behavior, it distinguishes between assistive use, in which students remain responsible for the produced work with AI as a support and substitutive use, in which AI plays a substantial role of the reasoning, synthesis, writing, or decision-making that the student is requested to know. This distinction helps reconcile evidence showing that GenAI can improve the performance of the academic students while also raising concerns about independent thinking, source evaluation, and long-term skill development (Deng et al., 2025; Gu & Yan, 2025; Jin & Sercu, 2025).

Baig and Yadegaridehkordi (2024) synthesized 57 studies of ChatGPT in higher education. Lo et al. (2024) reviewed 72 studies on student engagement. Jin and Sercu (2025) analyzed 21 experimental intervention studies and found that effects on skills varied by intervention type and duration. Deng et al. (2025) synthesized 69 experimental studies and found positive effects on academic performance, affective-motivational outcomes, and higher-order thinking propensities, while also identifying methodological limitations. Li and Awang (2026) subsequently reviewed 99 empirical studies on GenAI and student skill development. These reviews provide a strong foundation, but they also reveal a fragmented evidence base: different reviews emphasize performance, perceptions, writing, engagement, or critical thinking rather than undergraduate research competence as a connected set of capabilities.

The present review addresses that fragmentation by bringing five dimensions into one analytical frame: information literacy, critical thinking and problem-solving, academic writing, self-regulated learning and research independence, and research ethics. These dimensions are not presented as the only skills relevant to research. Rather, together they cover key stages of the undergraduate research process, from finding information and evaluating evidence to constructing knowledge, communicating it, managing the research process, and doing so responsibly.

1. Research gap and contribution

Three gaps are particularly important. First, many studies measure short-term task performance or students' perceptions rather than durable research competence. Second, AI use is often treated as a single exposure even though asking AI for feedback is educationally different from asking it to produce an

argument or literature review. Third, recent reviews show that instructional design and assessment conditions matter, but these factors have not always been integrated into a single framework for undergraduate research skills. This review responds by synthesizing evidence around the assistive–substitutive distinction and examining the moderators that determine whether AI support is likely to strengthen or bypass the underlying research process.

1.2 Research questions

1. How is generative AI being used in relation to undergraduate research skills?
2. What benefits of GenAI for information literacy, critical thinking, academic writing, self-regulated learning, and research ethics are reported?
3. What risks are associated with heavy, unguided, or substitutive use?
4. Which factors appear to moderate the relationship between GenAI use and research-skill development?
5. What methodological and conceptual gaps remain, particularly regarding durable research competence?

2. Conceptualizing Undergraduate Research Competence

For this review, undergraduate research competence is treated as a multidimensional capability. Information literacy concerns discovering, evaluating, interpreting, and ethically using information. Critical thinking concerns analysis, evaluation, reasoning, and problem-solving. Academic writing concerns communicating ideas while preserving evidence-based argument and authorship. Self-regulated learning concerns goal setting, monitoring, persistence, reflection, and independent management of the research process. Research ethical considerations concern responsible source usage, attribution, privacy, transparency, intellectual property, and appropriate disclosure of AI assistance. The ACRL Framework provides a useful foundation for information literacy, while UNESCO's (2023) guidance provides a broader human-centered and ethical perspective.

2.1 Assistive versus substitutive GenAI use

Assistive use occurs when AI extends a student's capacity without removing responsibility for the core intellectual task. Examples include generating alternative keywords that the student checks, suggesting counterarguments that the student evaluates, offering language feedback, or helping

identify gaps in a draft that remains the student's own. Substitutive use occurs when AI performs the core work the student is expected to learn, such as generating an unsupported literature synthesis,

selecting evidence without verification, constructing the argument, or writing an analysis the student cannot independently explain.

Mode	Student responsibility	Likely value	Main risk
Assistive	High	Scaffolding, feedback, idea expansion, revision	Over-trust if outputs are not checked
Collaborative	Shared	Dialogue, comparison, argument testing	Dependence and blurred responsibility
Substitutive	Low	Short-term efficiency and polished output	Cognitive offloading, weak transfer, integrity concerns

This distinction also helps explain apparently contradictory findings. A study can report better task performance while still raising concerns about learning. The findings are compatible if the intervention improves the product without requiring students to demonstrate the underlying skill. Deng et al. (2025) recommend assessments that require skill demonstration rather than relying only on AI-supported output quality. Urban et al. (2024) similarly found that ChatGPT improved creative problem-solving performance while raising uncertainty about metacognitive calibration.

3. Methodology

3.1 Review approach

This study adopts an integrative literature review approach. Integrative reviews are appropriate when a research problem draws on evidence from different methodological traditions and when the purpose is to interpret patterns across empirical studies, review articles, meta-analyses, and established conceptual or policy frameworks. Rather than treating the literature as a single homogeneous evidence base, this review brings these sources together to examine how generative AI may influence undergraduate research competence and under what conditions those effects are likely to occur. The review focuses specifically on five interconnected dimensions of research competence: information literacy, critical thinking and problem-solving, academic writing, self-regulated learning and research independence, and research ethics. These dimensions were selected because they collectively represent key stages of the undergraduate research process, from identifying and evaluating information to constructing arguments, communicating findings, managing the research process, and conducting research responsibly.

3.2 Literature identification

The literature was identified through targeted searches of major academic sources relevant to higher

education, educational technology, information literacy, and artificial intelligence. Priority was given to peer-reviewed literature published during the rapid expansion of generative AI in higher education, particularly from 2022 onward. Search concepts included generative artificial intelligence, ChatGPT, large language models, undergraduate students, higher education, research skills, information literacy, critical thinking, academic writing, self-regulated learning, research competence, and research ethics.

3.3 Selection considerations

Sources were considered relevant when they addressed generative AI or closely related large-language-model applications in higher education and provided substantive evidence or conceptual discussion concerning at least one of the five research-competency dimensions examined in this review. Peer-reviewed empirical studies, systematic reviews, meta-analyses, and authoritative educational frameworks were prioritized. Studies unrelated to higher education, traditional non-generative AI applications, and sources without sufficient methodological or bibliographic information were not used as substantive evidence.

3.4 Analytical framework

The literature was organized around five dimensions of undergraduate research competence: information literacy, critical thinking and problem-solving, academic writing, self-regulated learning and research independence, and research ethics. Within each dimension, findings were compared according to the role played by AI, the nature of the learning activity, reported benefits, reported risks, and the conditions that appeared to influence outcomes. Particular attention was given to the distinction between assistive and substitutive AI usage.

3.5 Synthesis approach

The synthesis is interpretive and thematic rather than a statistical aggregation of all available studies. Quantitative findings reported by recent meta-analyses are retained as important evidence anchors, while empirical and qualitative findings are examined for convergence, contradiction, and contextual differences. Greater weight is given to peer-reviewed primary research, high-quality systematic reviews and meta-analyses, and established frameworks. Because the included literature differs substantially in design, population, intervention, and outcome measurement, the review avoids presenting a single overall effect of generative AI on research skills.

4. Results and Evidence Synthesis

4.1 Information literacy and research

The evidence suggests that GenAI is particularly useful at the beginning of research, where students need help turning broad interests into search terms, questions, concepts, or initial lines of inquiry. Recent reviews report frequent use for idea generation, sourcing, summarization, and organization. Li and Awang (2026), reviewing 99 empirical studies, found a broad research landscape in which the mechanisms connecting GenAI use to skill development remain incompletely understood. De Silva et al. (2025) likewise reported benefits in idea generation, sourcing, synthesis, and writing, alongside hallucinated content and over-reliance.

The limitation is that speed is not the same as information literacy. The ACRL Framework emphasizes exploring, evaluating, understanding, and information ethical usage. A chatbot can produce a plausible source or summary without establishing its authority. Verification is therefore a core skill. Baldrich et al. (2025), in a PRISMA-based review of 55 empirical studies, found frequent AI use for idea generation, text structuring, and revision and highlighted the need for critical digital literacy and stronger assessment of preparedness. AI is most defensible here when it helps students for search directions or alternative interpretations generating that they then check and verify against original sources and authoritative databases.

4.2 Critical thinking and problem-solving

Critical thinking produces some of the most mixed findings. Recent reviews increasingly suggest that the real value in education of GenAI which depends on whether students are asked to extract the output.

Stronger designs ask students to ask, check, compare, understand, or revise AI-generated material rather than accept it. Urban et al. (2024) conducted a preregistered experiment with 145 university students and found that ChatGPT developed solution quality, elaboration, and originality. However, participants using ChatGPT reported lower mental effort and showed uncertainty in metacognitive calibration.

Jin and Sercu (2025), reviewing 21 experimental studies, similarly found that ChatGPT was generally effective for knowledge acquisition but that effects on skills varied. Medium-term interventions appeared more promising than short-term interventions, while long-term outcomes were mixed. The evidence therefore points away from a simple “AI improves critical thinking” claim and toward a conditional interpretation based on task design, duration, reflection, and student responsibility.

4.3 Academic writing and communication

Writing is one of the clearest areas in which assistance and substitution diverge. Ramadhanti (2024) found that higher-education students use GenAI for feedback, grammar checking, revision, translation, plagiarism-related checking, and idea generation. Jung (2026) similarly frames generative AI as a tool that can support invention, research, argumentation, drafting, and revision rather than merely generate a finished product.

The problem begins when surface fluency is mistaken for authorship or understanding. A polished paragraph can conceal weak evidence, an unsupported claim, or an argument the student cannot explain. This is particularly important for literature reviews, where tracing claims back to original sources is part of the research skill being assessed. Writing support is therefore strongest when students retain responsibility for evidence and substantive argument.

4.4 Self-regulated learning and research independence

GenAI can reduce friction that causes students to stall. It can provide feedback, suggest next steps, and help break complex tasks into smaller actions. Lo et al. (2024), reviewing 72 studies, found evidence of both engagement and disengagement in ChatGPT-supported learning and highlighted the need for objective measures of study habits, self-regulation, and related outcomes.

Gu and Yan (2025) reported a large overall effect of GenAI interventions on academic performance (Hedges' $g = 0.683$) across 19 studies and 24 effect sizes. However, heterogeneity was very high ($I^2 =$

94.4%), the prediction interval was wide, and teacher support was a significant moderator. The average effect therefore conceals substantial variation. Deng et al. (2025), synthesizing 69 experimental studies, also called for stronger long-term and objective assessment. AI may support self-regulation when it helps students plan, monitor, and reflect; it is less clearly developmental when it removes the need to make those decisions.

4.5 Research ethics, integrity, and responsible use

Ethical concerns are part of research competence rather than a separate policy issue. The literature repeatedly identifies fabricated references, unattributed AI-generated text, ambiguous authorship, privacy concerns, and unequal access to advanced tools. De Silva et al. (2025) identified hallucinated content, over-reliance, and academic integrity as recurring concerns. Dos (2025) found that trust in ChatGPT is conditional: students tend to accept it for routine tasks but express greater uncertainty where accuracy, discipline-specific knowledge, and deep analysis matter.

UNESCO's (2023) guidance emphasizes human agency, privacy, inclusion, equity, and ethical

participation. The practical implication is that responsible AI use cannot be reduced to a list of prohibitions. Students need competence in checking sources, protecting sensitive information, distinguishing evidence from generated text, documenting AI assistance where required, and recognizing when AI output is too uncertain to support a claim.

5. Cross-Cutting Findings

5.1 The performance–competence gap

One of the most important findings across the literature is the difference between improving performance on a task and improving the capability that the task is intended to teach. GenAI can make a task easier and improve its visible output without necessarily improving the student's independent capability. Deng et al. (2025) therefore recommend assessments that require students to demonstrate skills rather than relying only on output quality. Urban et al. (2024) provide a related example: students produced stronger creative solutions with ChatGPT, but metacognitive calibration did not clearly improve.

5.2 Moderating factors

Moderator	Evidence pattern	Implication
Instructor Direction	Repeatedly associated with stronger outcomes; teacher support was significant in Gu & Yan (2025).	Embed AI within guided learning activities.
Intervention duration	Short-term gains may not persist; longer-term evidence remains mixed.	Use longitudinal follow-up.
Assessment design	Output quality can improve without independent skill.	Assess process, reasoning, verification, and transfer.
Prior knowledge	Students need domain knowledge to judge AI output effectively.	Pair AI literacy with disciplinary knowledge.
Discipline	Evidence is concentrated in language, STEM, and technology contexts.	Expand research beyond these fields.
AI responsibility	Assistive and substitutive uses have different implications.	Measure what the student and AI each actually did.

5.3 Proposed conceptual framework

The framework proposed by this review begins with the role assigned to AI rather than treating “AI use” as a single treatment. Assistive use keeps the student responsible for inquiry, evidence evaluation, reasoning, and reflection. Collaborative use shares

cognitive work while preserving visible student judgment. Substitutive use transfers core research functions to the system. The effect of each mode is shaped by instructional guidance assessment design, student prior knowledge, discipline, and duration.

AI role	Student process	Moderators	Immediate outcome	Expected competence
Assistive	Student asks, checks, compares, revises	Guidance; AI literacy; discipline; assessment	Efficiency and feedback	Potential growth
Collaborative	Student and AI exchange ideas and critique	Task complexity; reflection	Alternative reasoning	Potential growth if responsibility remains
Substitutive	AI performs core research/reasoning	Weak guidance; output-only assessment	Fast, polished output	Risk of shallow learning and dependence

This framework leads to a testable proposition: the relationship between GenAI use and research competence should be stronger when students remain responsible for evidence evaluation, reasoning, and reflection. When AI performs these functions and assessment does not require students to demonstrate them independently, improved task performance should not be interpreted as evidence of competence development.

6. Discussion

The literature does not support either simple position that GenAI is inherently harmful or that it automatically improves education. The more consistent pattern is conditional. GenAI can support undergraduate research when it is embedded in a structure that makes student thinking visible. It can also make it easier to avoid the activities through which research skills are developed.

This conditional pattern appears across all five competencies. In information literacy, AI can reduce the time needed to generate search directions but cannot remove the student's responsibility to verify evidence. In critical thinking, AI can provide alternatives to test, but accepting a plausible answer without interrogation can turn the tool into a substitute for reasoning. In writing, AI can support language and revision, but generated prose becomes problematic when it replaces substantive argument. In self-regulated learning, immediate support can help persistence, but removing every difficult decision may reduce opportunities to learn how to manage research independently. In ethics, AI creates new failure modes but also provides a realistic context for teaching responsible information practices.

The strongest recent evidence also shows why effect sizes should be interpreted in context. Gu and Yan's (2025) large pooled effect is accompanied by very high heterogeneity, while Deng et al. (2025) identify methodological weaknesses and call for better post-intervention assessments. Jin and Sercu (2025) show that intervention design and duration matter, and Urban et al. (2024) show that better performance can

coexist with uncertainty about metacognitive calibration. The relevant unit of analysis is therefore not simply "AI use," but an AI-supported learning design involving a particular task, student group, level of guidance, and assessment.

A second issue is measurement. Much of the literature relies on perceived usefulness, confidence, motivation, or engagement. These measures are valuable, but they are not equivalent to demonstrated competence. Future studies should pair self-report with direct assessment, such as source-evaluation tasks, oral defense, AI-free transfer tasks, argument-quality rubrics, research-process logs, or delayed follow-up.

A third issue is discipline. Research competence looks different in a chemistry laboratory, a history archive, an education literature review, and a policy analysis. The assistive–substitutive framework should therefore be tested across disciplines rather than assumed to operate identically everywhere.

7. Implications for Teaching and Assessment

7.1 For instructors

- Teach verification explicitly and require students to inspect original sources behind important AI-generated claims.
- Use AI for critique as well as production: ask students to identify weaknesses, missing evidence, assumptions, and alternative interpretations.
- Require process evidence through research logs, annotated bibliographies, drafts, reflection notes, or short oral explanations.
- Separate language support from substantive generation where appropriate, while keeping evidence and argument under student control.
- Use AI-free transfer tasks after AI-supported activities to test whether the underlying skill has been learned.

7.2 For universities

- Move from blanket permission or prohibition toward clear categories of acceptable, restricted, and prohibited AI use.
- Provide practical AI and information-literacy training rather than relying only on academic-integrity warnings.
- Address equity where assessment assumes access to premium AI systems.
- Develop guidance on privacy, sensitive data, attribution, disclosure, and responsible use.
- Support instructors in redesigning assessments so that learning remains observable when AI is available.

As an integrative review, this study does not claim the exhaustive, protocol-driven identification of every publication in the field. Its purpose is to provide a structured and critical synthesis of the most relevant evidence and to connect findings that are often discussed separately. This approach also means that conclusions should be interpreted as evidence-informed synthesis rather than as a pooled estimate of a single treatment effect.

8. Limitations and Future Research

This review has several limitations. The field is developing faster than conventional review cycles, so conclusions can become outdated quickly. The evidence is heterogeneous in design, outcomes, disciplines, and duration, limiting direct comparison. A substantial proportion of studies rely on self-report or short-term outcomes. The literature is also uneven across geographic and disciplinary contexts. Finally, because the original manuscript did not preserve a complete database export and screening log, the present revision provides a valuable result but does not invent final screening counts. Those counts must be generated from the author's final database search before submission.

8.1 Priority research agenda

- Longitudinal studies testing whether AI-supported gains persist after the intervention.
- Experimental comparisons of assistive, collaborative, and substitutive AI conditions.
- Objective assessments of source evaluation, reasoning, writing, research planning, and transfer.
- Discipline-specific research beyond the current concentration in language, STEM, computing, and educational technology.

- Studies measuring the student AI division of cognitive labor.
- Research on instructor capability and assessment redesign.
- Research on equity, privacy, intellectual property, and differential access to paid AI tools.

9. Conclusion

Generative AI is changing undergraduate research faster than educational systems can fully evaluate it. The evidence reviewed here suggests that the important question is not simply whether students use AI, but what the use of AI requires students to do. When students use GenAI to explore possibilities, obtain feedback, compare arguments, improve language, and then verify and revise the result themselves, the technology can function as a useful scaffold. When AI performs the central work of finding evidence, judging it, constructing the argument, and producing the analysis, the immediate product may improve while the underlying research skill remains uncertain.

The assistive–substitutive distinction offers a practical way to interpret mixed findings and provides a basis for future empirical testing. Universities do not need to choose between unrestricted AI use and prohibition. They need learning designs that preserve student responsibility for inquiry, evidence, reasoning, reflection, and ethical judgment. Future research should therefore move beyond asking whether AI improves grades or perceptions and examine whether students become more capable researchers when the AI is no longer doing the work for them.

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Human Participants

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Originality Note

The authors confirm that the manuscript is their original work, and if others' works are used, they are properly cited/quoted.

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