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Assisted Or Replaced? Generative AI And The Erosion Of Students' Critical Thinking And Verification Practices

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Abstract
Generative AI has rapidly become embedded in students' academic routines, offering unprecedented support for brainstorming, drafting, summarizing, and problem-solving. However, its growing use has also raised concerns about whether it strengthens students' intellectual engagement or gradually weakens their independent thinking. This study examines the extent to which generative AI functions as an aid or a substitute in higher education, with particular attention to its influence on students' critical thinking and verification practices.
Grounded in the concepts of cognitive offloading, AI literacy, and responsible digital engagement, the study investigates how students use generative AI, how much they trust its outputs, and whether they actively verify the information it produces. Using a mixed-methods design, the research combines survey data from 132 students with follow-up interviews to explore patterns of AI use, levels of critical evaluation, and students' perceptions of academic dependence on AI tools.
The findings reveal that while generative AI usage is high, students demonstrate only moderate levels of critical thinking and verification practices. Statistical analysis shows that generative AI usage and cognitive offloading negatively predict both critical thinking and verification behavior, whereas AI literacy has a positive effect. Trust in AI is found to reduce students' likelihood of verifying AI-generated information. Qualitative findings further indicate that students often use AI as a shortcut and do not consistently question its outputs.
The study concludes that generative AI can support learning efficiency, but uncritical reliance on it may weaken independent reasoning and reduce verification behavior. By focusing on verification practices rather than usage frequency, this study provides a more nuanced understanding of AI's cognitive impact and highlights the importance of AI literacy in maintaining critical engagement. The findings offer practical implications for curriculum design, academic integrity, and responsible AI integration in higher education.

Keywords: *Generative AI; critical thinking; verification practices; AI literacy; cognitive offloading; higher education*

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I. Introduction

Background of the Study

The rapid rise of generative artificial intelligence (AI) has significantly transformed how students access information, construct knowledge, and complete academic tasks. Tools such as AI-powered chatbots and text generation systems are increasingly used to support brainstorming, drafting, summarizing, and problem-solving processes in educational contexts. In higher education, these technologies are often framed as tools that enhance efficiency, personalization, and accessibility in learning [1], [2]. As a result, generative AI is becoming embedded in students' everyday academic practices.

However, alongside these benefits, growing concerns have emerged regarding the cognitive consequences of AI use. While generative AI can function as a supportive learning tool, it may also encourage superficial engagement with knowledge, where students rely on AI-generated outputs without fully understanding or evaluating them. This concern aligns with broader debates in educational technology, where increased automation may shift learners from active knowledge construction to passive consumption [3], [4]. Consequently, a key question arises: does generative AI assist students' thinking, or does it gradually replace it?

Critical thinking remains a central objective of higher education. It involves the ability to analyze arguments, evaluate evidence, identify bias, and make reasoned judgments. Educational theorists have long emphasized that meaningful learning requires active cognitive engagement and reflective reasoning [5], [6]. However, the integration of generative AI introduces new dynamics into this process. When students use AI tools to generate answers, they may engage in cognitive offloading, a process in which mental effort is transferred to external technologies [7]. While cognitive offloading can improve efficiency, excessive reliance on external systems may reduce deep processing, independent reasoning, and long-term learning outcomes.

Closely related to critical thinking is the concept of verification behavior, which refers to the practice of checking, cross-referencing, and critically evaluating information before accepting it as valid. In digital environments, verification is a key component of information literacy and responsible knowledge use [8]. This becomes particularly important in the context of generative AI, as such systems are known to produce responses that are fluent but not always accurate, sometimes including fabricated or misleading information. Without active verification, students may unknowingly adopt incorrect or biased content.

Despite the importance of verification practices, existing research suggests that users often exhibit automation bias, a tendency to trust automated systems even when errors are present [9]. In educational settings, this bias may lead students to accept AI-generated answers without sufficient scrutiny, especially when the output appears coherent and authoritative. This issue is further compounded by varying levels of AI literacy, as students who lack understanding of how AI systems function may be less equipped to critically evaluate their outputs [10], [11].

In higher education, where students are expected to develop independent thinking and academic judgment, these trends raise important concerns. Generative AI may function either as a cognitive scaffold that enhances learning or as a cognitive shortcut that reduces intellectual effort. The distinction between these roles depends largely on how students interact with AI—whether they question, verify, and reflect, or simply accept and reproduce generated content.

While much of the current literature on AI in education focuses on its benefits, such as personalization and efficiency, there remains a lack of empirical research examining its impact on students' thinking processes, particularly in relation to critical thinking and verification behavior. Existing studies tend to measure frequency of AI use rather than the quality of cognitive engagement associated with that use. As a result, the subtle but significant risk of cognitive erosion remains underexplored.

Statement of the Problem

Despite the rapid adoption of generative artificial intelligence (AI) in education, its impact on students' cognitive processes—particularly critical thinking and verification practices—remains insufficiently understood. Existing research has largely emphasized the benefits of AI, such as efficiency and personalization [1], [2], while paying limited attention to its potential cognitive risks.

One major concern is cognitive offloading, where students rely on AI to perform tasks that require independent thinking [7]. Although this can improve efficiency, excessive dependence may reduce analytical effort and weaken critical thinking skills. At the same time, the issue of verification behavior has become increasingly important. Generative AI can produce fluent but inaccurate information, yet students may accept such outputs without sufficient checking, partly due to automation bias [9] and limited AI literacy [10], [11].

In higher education, where independent reasoning and critical evaluation are essential, these trends raise serious concerns. The growing use of AI may shift students from active thinkers to passive consumers of AI-generated content. However, current research tends to focus on how often students use AI rather than how they think, verify, and engage with its outputs.

Therefore, there is a clear need for research that examines the relationship between generative AI use, critical thinking, and verification practices. This study addresses this gap by investigating whether generative AI functions as a cognitive support tool or contributes to the erosion of students' essential thinking skills.

Research Questions

This study is guided by the following research questions:

1. To what extent does the use of generative AI influence students' critical thinking performance?
2. How do students engage in verification practices when using generative AI-generated information?
3. What is the relationship between generative AI usage and students' verification behaviors?
4. How do AI literacy and trust in AI affect students' critical thinking and verification practices?
5. Does frequent reliance on generative AI contribute to cognitive offloading and reduced independent reasoning?

Research Objectives

This study aims to examine the impact of generative artificial intelligence (AI) on students' critical thinking and verification practices in higher education. Specifically, it seeks to investigate how the use of generative AI influences students' critical thinking performance and to assess the ways in which students engage in verification when interacting with AI-generated information. The study further aims to analyze the relationship between AI usage and verification behavior, as well as to explore the role of AI literacy and trust in AI in shaping students' cognitive engagement. In addition, it evaluates whether frequent reliance on generative AI contributes to cognitive offloading and a reduction in independent reasoning. Through these objectives, the study intends to provide a comprehensive understanding of whether generative AI functions as a cognitive support tool or contributes to the erosion of essential thinking skills, as discussed in prior research on cognitive offloading and AI literacy [7], [10].

Scope of the Study

This study focuses on examining the impact of generative artificial intelligence (AI) on students' critical thinking and verification practices within higher education contexts. The research specifically investigates how students interact with AI-generated content in academic tasks such as writing, problem-solving, and information retrieval, with particular attention to their level of critical evaluation and verification behavior.

The scope of the study is limited to students in higher education institutions who have experience using generative AI tools for learning purposes. It emphasizes cognitive and behavioral aspects of AI use, including critical thinking performance, verification practices, AI literacy, and trust in AI systems [10], [11]. The study adopts an educational perspective rather than a technical one; therefore, it does not examine the underlying algorithms, system architecture, or computational performance of AI technologies.

Furthermore, the research does not aim to evaluate the accuracy or technical capabilities of specific AI tools. Instead, it focuses on how students use these tools and how such use may influence their thinking processes and learning behaviors, particularly in relation to cognitive offloading [7]. Issues related to institutional policy, legal regulation, or software development are also beyond the scope of this study.

By concentrating on the cognitive and behavioral dimensions of AI use in academic contexts, this study aims to provide insights into whether generative AI supports or undermines the development of essential higher-order thinking skills in higher education, as highlighted in prior research on AI in education and digital learning environments [1], [2].

Historical Review of Related Studies

The foundation of this study can be traced to early theories of critical thinking and moral education, which emphasize reflective judgment, independent reasoning, and the active construction of knowledge [5], [6]. With the expansion of digital technologies, scholarly attention shifted toward information literacy and digital citizenship, highlighting the importance of evaluating and verifying information in increasingly complex online environments [8].

More recently, the integration of artificial intelligence (AI) into education has introduced new dimensions to this discourse. Research on AI in education has largely focused on its potential to enhance learning efficiency, personalization, and accessibility [1], [2]. At the same time, emerging studies have begun to raise concerns about the cognitive implications of AI use, particularly in relation to cognitive offloading, where individuals rely on technological systems to perform thinking tasks [7].

Despite these developments, existing research remains fragmented. While studies on critical thinking, digital literacy, and AI in education have developed in parallel, limited attention has been given to how generative AI influences students' verification practices and their ability to critically evaluate AI-generated information. This gap highlights the need for research that integrates these perspectives to better understand the cognitive and behavioral impact of AI-assisted learning in higher education.

Significance of the Study

This study holds both theoretical and practical significance within the fields of education, ethics, and artificial intelligence.

From a theoretical perspective, the study contributes to the growing body of scholarship on AI ethics in education by foregrounding the emotional dimension of AI use-an area that remains underexplored in existing frameworks of digital citizenship and AI literacy [21]. By integrating insights from moral education, digital ethics, and affective computing, the study advances a more holistic understanding of ethical digital citizenship in AI-mediated learning environments.

From a practical perspective, the study offers a set of ethical guidelines intended to support educators, educational institutions, and educational technology developers in making informed and ethically responsible decisions regarding the use of emotion-sensitive AI in classrooms. These guidelines aim to protect learners' emotional autonomy, support teacher professional judgment, and promote transparency and accountability in educational AI systems [2],[26].

At a broader societal level, the study responds to growing concerns about emotional surveillance, data exploitation, and algorithmic influence in educational contexts. By emphasizing human-centered and ethically grounded approaches to AI integration, the study aligns with international calls for responsible AI governance and the preservation of human dignity in digital education.

Assumptions of the Study

This study holds both theoretical and practical significance in the fields of education and artificial intelligence. From a theoretical perspective, it contributes to the growing body of research on AI in education by focusing on the cognitive and behavioral implications of generative AI use, particularly in relation to critical thinking and verification practices. While existing studies have emphasized the benefits of AI for learning

efficiency and personalization [1], [2], this study extends the discussion by examining how AI may influence students' intellectual engagement and independent reasoning.

From a practical perspective, the study provides insights for educators, institutions, and policymakers regarding the responsible integration of generative AI in academic contexts. By highlighting the relationship between AI use, verification behavior, and cognitive offloading [7], the findings can inform the design of instructional strategies that promote critical thinking and responsible AI use. In addition, the study underscores the importance of AI literacy in helping students evaluate and verify AI-generated content effectively [10], [11].

At a broader level, this study contributes to ongoing discussions about academic integrity, digital responsibility, and the role of human judgment in AI-assisted learning environments. By emphasizing the need to balance technological support with critical engagement, the study supports the development of human-centered approaches to AI integration in higher education.

Delimitations

This study is based on several underlying assumptions. First, it assumes that critical thinking and verification practices are essential components of effective learning and can be influenced by students' interaction with generative AI tools [5], [8]. Second, it assumes that students are increasingly using generative AI in academic contexts and that their patterns of use may affect their cognitive engagement and learning behaviors.

Third, the study assumes that generative AI systems are not fully reliable and may produce inaccurate or misleading information, thereby requiring users to actively verify and evaluate outputs. This assumption is supported by prior research on automation bias and the limitations of AI systems [9], [10]. Finally, the study assumes that AI literacy plays a crucial role in shaping how students interpret, trust, and use AI-generated information and that higher levels of AI literacy are associated with more responsible and critical engagement [10], [11].

Definition of Key Terms

To ensure clarity and consistency, the following key terms are defined as they are used in this study:

- **Generative AI** refers to artificial intelligence systems capable of producing human-like content, including text, responses, and solutions, based on user input. These systems are commonly used in educational contexts to support writing, problem-solving, and information retrieval [1].
- **Critical Thinking** refers to the ability to analyze information, evaluate evidence, identify bias, and make reasoned judgments. It is considered a core learning outcome in higher education [5].
- **Verification Practices** refer to the processes by which individuals check, cross-reference, and critically evaluate information before accepting or using it. This includes fact-checking, comparing sources, and questioning the reliability of information [8].
- **Cognitive Offloading** refers to the use of external tools or technologies to reduce the mental effort required for cognitive tasks. In the context of this study, it describes students' reliance on AI systems to perform thinking-related activities [7].
- **AI Literacy** refers to the knowledge and skills required to understand how AI systems function, including their capabilities, limitations, and potential biases. It also involves the ability to use AI tools critically and responsibly [10], [11].
- **Automation Bias** refers to the tendency of individuals to trust and rely on automated systems, sometimes even when those systems produce incorrect or misleading outputs [9].

Structure of the Dissertation

This dissertation is organized into five chapters:

- **Chapter 1: Introduction**

This chapter presents the background of the study, problem statement, research questions, research objectives, scope, significance, assumptions, and key definitions. It establishes the conceptual foundation and overall direction of the research.

- **Chapter 2: Literature Review**

This chapter reviews relevant literature on critical thinking, verification practices, generative AI in education, cognitive offloading, and AI literacy. It identifies key research gaps and develops the conceptual framework for the study.

- **Chapter 3: Research Methodology**

This chapter outlines the research design, participants, instruments, data collection procedures, and methods of data analysis used to investigate the research questions.

- **Chapter 4: Findings and Discussion**

This chapter presents the results of the study, including both quantitative and qualitative findings. It also discusses the findings in relation to existing literature and theoretical frameworks.

- **Chapter 5: Conclusion and Implications**

This chapter summarizes the key findings, discusses theoretical and practical implications, outlines limitations, and provides recommendations for future research.

II. Literature Review

Critical Thinking in Education

Critical thinking has long been recognized as a fundamental objective of education, particularly in higher education contexts where students are expected to engage in independent inquiry and analytical reasoning. It is commonly defined as the ability to analyze information, evaluate evidence, identify bias, and make reasoned judgments [5]. Early educational theorists emphasized that learning is not merely the accumulation of knowledge but a process of reflective thinking and active meaning-making [6].

Contemporary frameworks further conceptualize critical thinking as a multidimensional construct involving cognitive skills such as analysis, evaluation, inference, and self-regulation. These skills enable learners to engage deeply with information, question assumptions, and construct well-supported arguments. In academic settings, critical thinking is closely linked to students' ability to assess the credibility of sources, synthesize information from multiple perspectives, and produce original work.

However, the increasing integration of digital technologies has begun to reshape how students engage with information. While access to information has expanded, concerns have emerged regarding the depth of cognitive processing in digital learning environments. Some studies suggest that students may engage in more surface-level processing when interacting with readily available information, particularly when technological tools reduce the need for sustained cognitive effort [3].

In the context of generative AI, these concerns become more pronounced. AI systems can generate structured, coherent responses with minimal input from users, potentially reducing the need for students to engage in deeper analytical processes. This raises important questions about whether such tools support the development of critical thinking or inadvertently undermine it by encouraging passive reliance on generated outputs. As a result, examining the relationship between AI use and critical thinking has become an increasingly important area of research in contemporary education.

Verification Practices and Information Literacy

Verification practices are a critical component of information literacy and play a central role in responsible knowledge construction in digital environments. Verification refers to the process of checking, cross-referencing, and critically evaluating information before accepting it as valid or reliable [8]. In an era characterized by information abundance, the ability to verify information has become essential for both academic success and informed decision-making.

Research in digital literacy highlights that individuals often struggle to evaluate the credibility of online information effectively. Rather than engaging in systematic verification, users may rely on superficial cues such as presentation, language fluency, or perceived authority. This issue is particularly evident in the context of online content, where misinformation and misleading information can appear highly convincing [8].

The introduction of generative AI further complicates this landscape. Unlike traditional sources, AI-generated content does not always provide transparent references or verifiable origins, making it more difficult for users to assess its accuracy. Despite this, students may still perceive AI-generated responses as credible due to their coherence and linguistic sophistication. This tendency can lead to reduced verification behavior, especially when students are under time pressure or lack awareness of the limitations of AI systems.

Moreover, verification practices are closely related to critical thinking. Students who actively question and evaluate information are more likely to demonstrate higher levels of analytical reasoning and intellectual engagement. Conversely, a lack of verification may indicate passive acceptance of information and reduced cognitive effort. This relationship suggests that verification behavior can serve as an important indicator of how students interact with knowledge in AI-mediated learning environments.

Despite its importance, verification behavior remains underexplored in research on AI in education. Most existing studies focus on usage patterns or learning outcomes, rather than examining whether students critically evaluate AI-generated content. This gap highlights the need for research that investigates not only what students do with AI, but also how they assess and validate the information it produces. Addressing this issue is essential for understanding the broader cognitive implications of generative AI in education.

Generative AI in Education

Generative artificial intelligence (AI) has emerged as a transformative technology in education, enabling the automated production of human-like text, explanations, and problem-solving outputs based on user input. Unlike traditional educational technologies, generative AI systems can simulate dialogue, generate ideas, and provide adaptive responses, thereby functioning as interactive learning tools. In recent years, such systems have

been increasingly adopted in higher education to support a wide range of academic tasks, including writing, summarization, coding, and conceptual understanding [1], [2].

One of the key advantages of generative AI lies in its ability to enhance learning efficiency and accessibility. Students can receive immediate feedback, explore alternative explanations, and generate structured responses with minimal effort. These features have been associated with increased engagement and improved learning support, particularly for students who require additional scaffolding or flexible learning resources [1]. Furthermore, generative AI has the potential to personalize learning experiences by adapting responses to individual needs and levels of understanding.

However, alongside these benefits, concerns have emerged regarding the potential risks of overreliance on AI-generated content. One major issue is that generative AI systems can produce outputs that are fluent and coherent but not always accurate or reliable. These systems may generate incomplete, biased, or even fabricated information, which can be difficult for users to detect without adequate verification skills. As a result, students may unknowingly adopt incorrect information, particularly when they trust AI outputs without critical evaluation.

Another concern relates to the impact of generative AI on students' cognitive engagement. While AI tools can support idea generation and reduce cognitive load, they may also encourage passive learning behaviors. Students may rely on AI to generate answers rather than actively constructing knowledge, which can reduce opportunities for deep processing and critical thinking. This issue is closely connected to the concept of cognitive offloading, where mental effort is transferred to external systems [7].

In addition, the widespread availability of generative AI raises questions about academic integrity and authorship. The ability of AI systems to produce high-quality responses challenges traditional notions of originality and independent work. Educational institutions are therefore faced with the task of redefining assessment practices and establishing guidelines for responsible AI use.

Despite the growing body of research on generative AI in education, much of the existing literature focuses on its functional benefits and adoption patterns. Less attention has been given to how students interact cognitively with AI-generated content, particularly in terms of their critical thinking and verification practices. This suggests a need for research that moves beyond usage and explores the deeper cognitive and behavioral implications of AI-assisted learning.

Cognitive Offloading and AI Dependency

Cognitive offloading refers to the process by which individuals use external tools or technologies to reduce the mental effort required for cognitive tasks such as memory, problem-solving, and decision-making [7]. Rather than processing information internally, individuals delegate part of their cognitive workload to external systems, thereby increasing efficiency and reducing cognitive load. This phenomenon is not new; traditional examples include notetaking, calculators, and search engines. However, the emergence of generative artificial intelligence (AI) has significantly expanded the scope and depth of cognitive offloading.

Unlike earlier tools that primarily supported information storage or retrieval, generative AI systems can actively perform higher-order cognitive tasks, including generating arguments, structuring essays, and synthesizing complex ideas. As a result, these systems do not merely assist cognition but may partially replace cognitive processes that are central to learning. This shift raises important questions about the boundary between cognitive support and cognitive substitution in educational contexts.

From a theoretical perspective, cognitive offloading can be beneficial when it allows learners to allocate cognitive resources more efficiently. By reducing routine cognitive demands, students may focus on higher-level thinking, such as analysis and evaluation. However, research suggests that excessive reliance on external cognitive aids may lead to reduced mental effort, shallow processing, and decreased retention of information [7]. In such cases, cognitive offloading may hinder rather than support learning outcomes.

In the context of generative AI, this issue becomes particularly critical. Students may rely on AI to generate answers, explanations, or entire assignments, thereby bypassing the cognitive processes involved in constructing knowledge. This pattern of use may contribute to what can be described as AI dependency, where learners increasingly depend on AI systems for tasks that require independent thinking. Over time, such dependency may weaken critical thinking skills and reduce students' ability to evaluate information independently.

The relationship between cognitive offloading and AI dependency is further influenced by users' trust in AI systems and their level of AI literacy. Students who perceive AI outputs as authoritative may be more likely to rely on them without critical evaluation, reinforcing patterns of dependency. This behavior is closely related to automation bias, where individuals over-rely on automated systems even in the presence of errors [9]. In contrast, students with higher AI literacy may use AI more strategically, treating it as a supportive tool rather than a substitute for thinking.

Despite growing interest in cognitive offloading, existing research has largely focused on traditional digital tools rather than generative AI. There remains limited empirical evidence on how AI-driven offloading

affects higher-order cognitive skills such as critical thinking and verification practices in educational settings. Little is known about whether AI use leads to adaptive cognitive support or maladaptive dependency among students.

This gap highlights the need to examine cognitive offloading not merely as a functional strategy but as a factor that may reshape students' cognitive engagement in AI-mediated learning environments. Understanding this dynamic is essential for determining whether generative AI enhances or undermines the development of essential thinking skills in higher education.

Automation Bias and Trust in AI

Automation bias refers to the tendency of individuals to favor suggestions generated by automated systems and to disregard contradictory information, even when the system's output may be incorrect [9]. This cognitive bias has been widely observed in human–technology interaction, where users tend to assume that automated systems are more reliable, objective, or authoritative than they actually are. In educational contexts, automation bias can significantly influence how students engage with AI-generated content.

Generative AI systems often produce responses that are coherent, well-structured, and linguistically sophisticated. These characteristics can create an illusion of accuracy, leading users to perceive AI-generated information as trustworthy without critically evaluating its validity. As a result, students may accept AI outputs at face value, particularly when they lack domain knowledge or are under time pressure. This behavior reduces the likelihood of engaging in verification practices such as cross-checking sources or questioning the credibility of information.

Closely related to automation bias is the concept of trust in AI, which refers to the degree to which users are willing to rely on AI systems in decision-making and problem-solving tasks. Trust can be beneficial when it enables efficient interaction with technology; however, excessive or misplaced trust may lead to overreliance and reduced critical engagement. In the context of generative AI, high levels of trust may discourage students from questioning outputs, even when those outputs contain inaccuracies or incomplete information.

The relationship between automation bias and trust in AI is particularly important in understanding students' verification behavior. When students both trust AI systems and exhibit automation bias, they are less likely to engage in active verification. Instead, they may adopt a passive approach to information use, relying on AI-generated responses as final answers rather than as starting points for further inquiry. This pattern of behavior is further reinforced when AI tools provide immediate and convenient solutions, reducing the perceived need for additional effort.

Moreover, the level of AI literacy plays a critical role in moderating these effects. Students with limited understanding of how AI systems function may overestimate their reliability and fail to recognize their limitations, such as hallucination or bias [10], [11]. In contrast, students with higher AI literacy are more likely to approach AI outputs critically, verify information, and use AI as a supportive rather than authoritative source.

Despite the growing use of generative AI in education, research examining the interplay between automation bias, trust in AI, and verification practices remains limited. Most studies focus on user satisfaction or system performance, rather than on how cognitive biases influence students' interaction with AI-generated information. This gap highlights the need for further investigation into the psychological factors that shape students' verification behavior in AI-mediated learning environments.

Understanding automation bias and trust in AI is therefore essential for explaining why students may fail to verify AI-generated information. It also provides a critical theoretical foundation for examining how cognitive and psychological factors influence responsible AI use and the development of critical thinking in higher education.

AI Literacy and Responsible Use

AI literacy has emerged as a critical competency in the digital age, referring to the knowledge and skills required to understand, evaluate, and effectively use artificial intelligence systems [10], [11]. Beyond basic technical awareness, AI literacy encompasses an understanding of how AI systems generate outputs, their limitations, potential biases, and the ethical implications of their use. In educational contexts, AI literacy is increasingly recognized as essential for enabling students to engage with AI tools in a critical and responsible manner.

One key dimension of AI literacy is the ability to recognize that AI-generated content is not inherently accurate or authoritative. Generative AI systems operate based on probabilistic patterns rather than verified knowledge, which means that their outputs may include inaccuracies, inconsistencies, or fabricated information. Students with higher levels of AI literacy are more likely to question these outputs, evaluate their credibility, and verify information before use. In contrast, students with limited AI literacy may overestimate the reliability of AI systems and accept generated content without sufficient scrutiny.

AI literacy is also closely linked to critical thinking and verification practices. Learners who understand how AI systems function are better equipped to engage in analytical reasoning, identify potential errors, and apply appropriate verification strategies. This suggests that AI literacy may act as a protective factor against automation bias and overreliance on AI. By fostering awareness of AI limitations, it encourages students to treat AI outputs as starting points for inquiry rather than final answers.

Furthermore, AI literacy plays an important role in shaping students' trust in AI. Rather than promoting blind trust or complete skepticism, AI literacy supports calibrated trust, where users rely on AI appropriately while remaining critical of its outputs. This balanced approach is essential for effective human–AI interaction, particularly in academic contexts where accuracy and independent reasoning are crucial.

Despite its importance, AI literacy remains underdeveloped in many educational settings. While digital literacy has been widely integrated into curricula, specific instruction on how to critically use AI tools is still limited. As a result, many students interact with generative AI without a clear understanding of its underlying mechanisms or potential risks. This gap may contribute to uncritical use, reduced verification behavior, and increased cognitive dependency.

Although recent studies have begun to conceptualize AI literacy as a key educational objective, empirical research examining its role in shaping students' cognitive engagement remains limited. In particular, there is a lack of research exploring how AI literacy influences the relationship between AI use, critical thinking, and verification practices. Addressing this gap is essential for developing effective pedagogical strategies that support responsible and critical use of generative AI in higher education.

Empirical Studies on AI and Student Learning

Recent empirical studies on generative artificial intelligence (AI) in education have produced mixed findings regarding its impact on student learning and cognitive engagement. On the one hand, several studies highlight the potential benefits of AI in enhancing learning efficiency, supporting idea generation, and improving academic performance. For example, AI-assisted writing tools have been shown to help students organize ideas, reduce cognitive load, and produce more structured outputs [1]. Similarly, adaptive AI systems can provide personalized feedback, which may improve comprehension and engagement [2].

On the other hand, a growing body of research raises concerns about the unintended cognitive consequences of AI use. Some studies suggest that students who rely heavily on AI tools may exhibit reduced effort in problem-solving and weaker engagement in analytical reasoning. This phenomenon is often linked to cognitive offloading, where learners delegate thinking processes to AI systems rather than actively constructing knowledge [7]. As a result, while performance outcomes may appear improved in the short term, deeper learning and retention may be compromised.

Empirical evidence also points to variability in how students interact with AI. Some learners use AI as a scaffold to support understanding, asking follow-up questions and refining outputs. Others, however, use AI as a substitute for thinking, directly adopting generated responses without critical evaluation. This distinction suggests that the impact of AI is not uniform but depends on how it is used.

In addition, several studies have examined students' trust in AI-generated content. Findings indicate that users often perceive AI outputs as credible due to their fluency and coherence, even when inaccuracies are present. This tendency is associated with automation bias and may reduce the likelihood of verification [9]. However, research also shows that students with higher AI literacy are more likely to question AI outputs and engage in verification practices [10], [11].

Despite these insights, most empirical studies focus on either learning outcomes or user perceptions, rather than examining the relationship between AI use, critical thinking, and verification behavior simultaneously. Furthermore, there is limited research that directly measures how students evaluate and validate AI-generated information in academic contexts. This suggests a need for more integrated research that captures both cognitive and behavioral dimensions of AI-assisted learning.

Research Gap and Conceptual Framework

Research Gap

The existing literature reveals several important gaps in understanding the impact of generative AI on student learning.

First, while prior research has extensively examined the benefits of AI in education, such as efficiency and personalization [1], [2], there is limited focus on its cognitive consequences, particularly in relation to critical thinking. Many studies measure performance outcomes without assessing whether students actively engage in analytical reasoning.

Second, although verification practices are recognized as a key component of information literacy [8], they remain largely underexplored in the context of generative AI. Few studies investigate whether students critically evaluate AI-generated content or simply accept it as valid.

Third, existing research tends to examine individual factors—such as AI usage, trust, or literacy—in isolation. There is a lack of integrative studies that explore how these factors interact to influence students' cognitive engagement. In particular, the combined relationship between AI use, cognitive offloading, verification behavior, and critical thinking has not been sufficiently addressed.

Finally, the role of AI literacy as a moderating or mediating factor remains underdeveloped. While it is acknowledged that AI literacy influences how students use AI [10], [11], there is limited empirical evidence on how it shapes the relationship between AI use and cognitive outcomes.

These gaps highlight the need for a comprehensive framework that explains how generative AI affects students' thinking processes, rather than focusing solely on usage or performance.

Conceptual Framework

Based on the identified gaps and theoretical foundations, this study proposes a conceptual framework that examines the relationships among generative AI use, cognitive processes, and learning behaviors.

Key Variables:

- Independent Variable (IV):
  - Generative AI Usage
- Dependent Variables (DV):
  - Critical Thinking
  - Verification Practices
- Mediating Variable:
  - Cognitive Offloading
- Moderating Variables:
  - AI Literacy
  - Trust in AI

Proposed Relationships

1. Generative AI usage influences students' critical thinking and verification practices.
2. Cognitive offloading mediates the relationship between AI usage and critical thinking.
3. Trust in AI negatively affects verification behavior.
4. AI literacy moderates the relationship between AI usage and both:
   - Critical thinking
   - Verification practices

Conceptual Framework

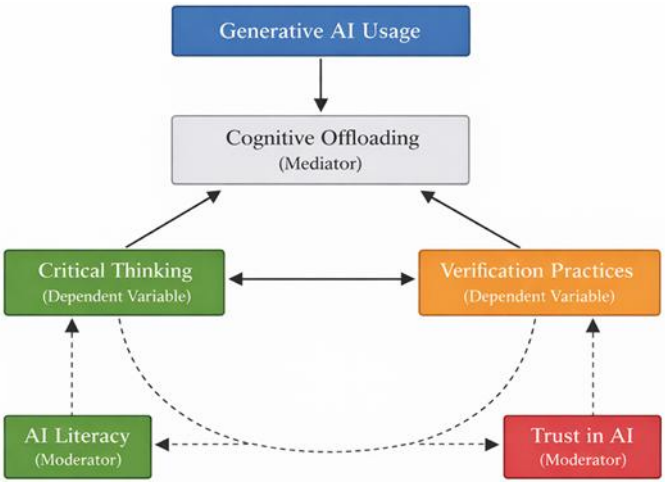

Figure 1. Conceptual framework of the study

This framework proposes that generative AI usage influences students' critical thinking and verification practices both directly and indirectly through cognitive offloading. Cognitive offloading is conceptualized as a mediating variable that explains how reliance on AI may reduce cognitive engagement. In addition, AI literacy and trust in AI are included as moderating variables. AI literacy is expected to mitigate the negative effects of AI use by promoting critical engagement, while trust in AI may reduce verification behavior by increasing reliance on AI-generated outputs.

III. Research Methodology

Research Design

This study adopts a mixed-methods research design to examine the impact of generative artificial intelligence (AI) on students' critical thinking and verification practices. The combination of quantitative and qualitative approaches allows for a more comprehensive understanding of both measurable outcomes and underlying cognitive behaviors. Mixed-methods research is widely recognized for its ability to provide richer and more balanced insights by integrating numerical data with contextual explanations [12].

The quantitative component is used to analyze relationships among key variables, including generative AI usage, cognitive offloading, critical thinking, verification practices, AI literacy, and trust in AI. Survey data are collected to measure students' self-reported behaviors and perceptions, while structured tasks are used to assess critical thinking performance. Statistical techniques such as correlation and regression analysis are employed to examine the relationships between variables and to test the proposed conceptual framework.

The qualitative component complements the quantitative findings by providing deeper insights into students' experiences and decision-making processes when using AI. Through follow-up interviews or open-ended responses, the study explores how students interpret AI-generated information, whether they engage in verification, and the reasons behind their reliance on AI tools. This approach aligns with previous research emphasizing the importance of understanding both behavioral patterns and cognitive processes in technology-mediated learning [3], [7].

The use of a mixed-methods approach is particularly appropriate for this study, as it enables the integration of behavioral data and subjective perspectives. This approach strengthens the validity of the findings and provides a more nuanced understanding of how generative AI influences students' cognitive engagement in higher education.

Research Context and Participants

Context

This study is conducted in the context of higher education, focusing on students who actively use generative AI tools as part of their academic learning. The research is situated within university-level courses where students are required to complete tasks such as writing assignments, problem-solving activities, and information-based projects. Higher education provides a relevant setting, as it emphasizes critical thinking, independent inquiry, and academic integrity—key competencies that may be influenced by AI use [5], [1].

The selection of this context is supported by the increasing integration of generative AI into academic environments, where students frequently use AI tools to support learning processes [1], [2]. As AI becomes more accessible, students' interaction with these tools is no longer occasional but embedded in everyday academic practices. This makes higher education an appropriate context for examining both the benefits and risks of AI-assisted learning.

Participants in the study are undergraduate students from various academic disciplines, ensuring diversity in learning backgrounds and experiences with AI. This diversity allows for a broader understanding of how generative AI is used across different fields of study and how it may impact cognitive and verification behaviors.

The study focuses on students' interaction with AI tools in authentic academic situations rather than controlled laboratory conditions. By examining real-world usage, the research aims to capture natural patterns of behavior, including how students rely on AI, whether they verify AI-generated information, and how these practices relate to their critical thinking performance. Such an approach is consistent with recent calls for more context-based research in digital learning environments [2], [3].

Participants

The participants of this study consisted of 132 students enrolled in English courses at the selected training center. A convenience sampling method was used, as participants were readily accessible and actively engaged in learning activities that involved the use of generative AI tools [12].

Among the participants, 68 were female and 64 were male, with ages ranging from 18 to 24 years old. The majority of students were university undergraduates from various disciplines, including business, information technology, and social sciences. All participants had prior experience using generative AI tools such as chat-based systems for academic purposes, including writing assignments, generating ideas, and seeking explanations.

In terms of academic level, approximately 40% of participants were at the intermediate level, while 60% were at the upper-intermediate level, ensuring that they possessed sufficient language proficiency and cognitive ability to engage in critical thinking tasks.

Participation in the study was voluntary, and all participants were informed about the purpose of the research prior to data collection. Ethical considerations, including anonymity and confidentiality, were strictly maintained. No personal identifying information was collected, and participants were allowed to withdraw from the study at any stage without penalty.

Category	Description
Total Participants	132 students
Gender	68 female (51.5%), 64 male (48.5%)
Age Range	18–24 years old
Educational Level	Undergraduate students
Fields of Study	Business, Information Technology, Social Sciences
English Proficiency Level	Intermediate (40%), Upper-intermediate (60%)
AI Experience	All participants have prior experience using generative AI for academic tasks
Sampling Method	Convenience sampling [12]
Research Setting	Private English training center in southern Vietnam
Participation Type	Voluntary participation
Ethical Considerations	Anonymity and confidentiality ensured; participants can withdraw at any time

Table 1. Participant Characteristics

Research Instruments

Survey Questionnaire

The primary instrument used in this study is a structured questionnaire designed to measure key variables, including generative AI usage, critical thinking, verification practices, cognitive offloading, AI literacy, and trust in AI. The questionnaire is adapted from established theoretical frameworks and prior empirical studies related to cognitive offloading, AI literacy, and information verification [7], [10], [11].

All items are measured using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire is administered online to ensure accessibility and efficient data collection.

Variable	Code	No. of Items	Measurement Source	Example Item	Scale
Generative AI Usage	AIU	5	Adapted from AI in education studies [1], [2]	I frequently use AI tools for academic tasks	Likert (1–5)
Critical Thinking	CT	6	Adapted from critical thinking framework [6]	I evaluate information before accepting it	Likert (1–5)
Verification Practices	VP	6	Adapted from information literacy research [8]	I check AI-generated information before using it	Likert (1–5)
Cognitive Offloading	CO	5	Adapted from cognitive offloading theory [7]	I rely on AI instead of thinking independently	Likert (1–5)
AI Literacy	AIL	6	Adapted from AI literacy studies [10], [11]	I understand the limitations of AI systems	Likert (1–5)
Trust in AI	TI	5	Adapted from automation bias research [9]	I trust AI-generated responses	Likert (1–5)

Table 2. Measurement Scales and Variable Coding

Data Coding and Preparation (SPSS)

All questionnaire responses are coded and entered into SPSS (Statistical Package for the Social Sciences) for analysis. Each variable is assigned a specific code (e.g., AIU1–AIU5, CT1–CT6). Negatively worded items (if any) are reverse-coded before analysis to ensure consistency.

Composite scores for each variable are calculated by taking the mean of all items within that construct. This approach is commonly used in social science research to represent latent variables.

Reliability Analysis

To ensure internal consistency, Cronbach's Alpha is used to assess the reliability of each scale. The acceptable threshold for reliability is set at $\alpha \geq 0.70$ [12].

Variable	No. of Items	Cronbach's Alpha	Interpretation
AI Usage (AIU)	5	0.821	Good
Critical Thinking (CT)	6	0.854	Good
Verification Practices (VP)	6	0.872	Good
Cognitive Offloading (CO)	5	0.801	Acceptable
AI Literacy (AIL)	6	0.883	Good
Trust in AI (TI)	5	0.836	Good

Table 3. Reliability Statistics

Validity Analysis

To assess construct validity, Exploratory Factor Analysis (EFA) is conducted using SPSS.

- Kaiser-Meyer-Olkin (KMO) $\geq 0.6 \rightarrow$ acceptable
- Bartlett's Test of Sphericity $\rightarrow p < 0.05$ (significant)
- Factor loadings ≥ 0.5 are retained

Test	Value	Threshold	Interpretation
KMO Measure	0.846	≥ 0.6	Adequate
Bartlett's Test	$p < 0.001$	< 0.05	Significant
Factor Loadings	0.62 – 0.88	≥ 0.50	Acceptable

Table 4. Validity Statistics

Data Analysis Techniques

The collected data are analyzed using SPSS with the following procedures:

- Descriptive Statistics: Mean, standard deviation
- Correlation Analysis: To examine relationships between variables
- Multiple Regression Analysis: To test the impact of AI usage on dependent variables
- Mediation Analysis: To examine the role of cognitive offloading
- Moderation Analysis: To assess the effects of AI literacy and trust in AI

Data Collection Procedures

The quantitative data collected from the questionnaire were analyzed using SPSS. First, descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to summarize participants' responses and identify general patterns in the data. These statistics provided an overview of students' AI usage, critical thinking, verification practices, cognitive offloading, AI literacy, and trust in AI.

Next, reliability analysis was conducted using Cronbach's Alpha to examine the internal consistency of the measurement scales. A value of 0.70 or above was considered acceptable for social science research [12]. After reliability had been confirmed, exploratory factor analysis was conducted to assess construct validity and to determine whether the items loaded appropriately onto their intended variables.

To examine the relationships among the study variables, Pearson correlation analysis was applied. This analysis helped identify the strength and direction of the relationships between generative AI usage, critical thinking, verification practices, cognitive offloading, AI literacy, and trust in AI. In addition, multiple regression analysis was used to test the predictive effects of generative AI usage on the dependent variables. If required by the final model, mediation and moderation analyses were also conducted to examine the role of cognitive offloading, AI literacy, and trust in AI.

Step	Procedure	Purpose
1	Obtain institutional permission	Ensure ethical access to participants
2	Explain study purpose and obtain informed consent	Inform participants and secure voluntary participation
3	Administer online questionnaire	Collect quantitative data on AI use, critical thinking, verification, and related variables
4	Select participants for follow-up interviews	Gather deeper qualitative insights
5	Conduct and transcribe interviews	Prepare qualitative data for thematic analysis
6	Code and organize all data	Prepare dataset for SPSS and qualitative analysis

Table 5. Data Collection Procedures

Data Analysis Techniques

Quantitative Analysis

The qualitative data obtained from semi-structured interviews were analyzed using thematic analysis. This method was chosen because it allows the researcher to identify recurring patterns, meanings, and themes within participants' responses [3]. The interview transcripts were read carefully several times to ensure familiarity with the data. Relevant statements were then coded and grouped into categories based on similarity in meaning.

After coding, the categories were refined into broader themes that reflected participants' views on generative AI use, verification behavior, trust, and cognitive engagement. These themes were then interpreted in relation to the quantitative findings to provide a more complete understanding of the research problem. The integration of quantitative and qualitative data supported triangulation and strengthened the overall interpretation of the study [12].

Qualitative Analysis

Qualitative data obtained from interviews were analyzed using thematic analysis. This approach involves systematically reviewing interview transcripts, coding relevant statements, and identifying recurring patterns or themes across participants' responses. Thematic analysis enables researchers to interpret complex perspectives and experiences related to ethical issues in educational technology [3].

Through iterative coding and categorization, several major themes were identified. These themes reflect participants' perceptions of ethical challenges associated with AI use in education, their preparedness to address these challenges, and their views on the role of education in promoting responsible digital citizenship.

Analysis Type	Technique	Purpose	Output
Descriptive Analysis	Mean, Standard Deviation, Frequency	Describe general patterns of variables	Mean, SD, Frequency (%)
Reliability Analysis	Cronbach's Alpha	Assess internal consistency of scales	Alpha coefficients ($\alpha \geq 0.70$)
Validity Analysis	Exploratory Factor Analysis (EFA)	Examine construct validity	KMO, Bartlett's Test, Factor Loadings
Correlation Analysis	Pearson Correlation	Examine relationships among variables	Correlation coefficients (r)
Regression Analysis	Multiple Linear Regression	Test impact of AI usage on dependent variables	β, R^2, Sig.
Mediation Analysis	Regression-based mediation	Examine role of cognitive offloading	Indirect effect
Moderation Analysis	Interaction effect analysis	Examine moderating effects of AI literacy & trust	Interaction term significance
Qualitative Analysis	Thematic Analysis	Identify patterns in interview data	Themes and categories

Table 6. Data Analysis Techniques

Reliability, Validity, and Ethical Considerations

Reliability in this study was ensured through the use of a structured questionnaire with clearly defined items and through pilot testing before the main data collection. Cronbach's Alpha was used to measure internal consistency, and only scales meeting the acceptable threshold were retained for analysis [12]. This step helped confirm that the instrument measured the intended constructs consistently.

Validity was addressed in several ways. First, the questionnaire items were adapted from established theoretical frameworks related to AI literacy, cognitive offloading, critical thinking, and information verification [7], [10], [11]. Second, expert review and pilot testing were used to improve clarity and relevance. Third, triangulation between survey and interview data strengthened the credibility of the findings by allowing comparison across data sources [12].

Ethical considerations were given high priority throughout the study. Participation was entirely voluntary, and participants were informed that they could withdraw at any time without penalty. Anonymity and confidentiality were maintained by removing personal identifiers from the dataset. All data were used solely for academic purposes and stored securely to prevent unauthorized access. These procedures ensured that the study followed standard ethical principles in educational research [12].

Aspect	Method	Criteria / Standard	Evidence in This Study
Reliability	Cronbach's Alpha	$\alpha \geq 0.70$ [12]	All constructs met acceptable reliability levels ($\alpha = 0.80–0.88$)
Content Validity	Literature-based item adaptation	Items derived from established frameworks [7], [10], [11]	Questionnaire adapted from prior validated studies
Construct Validity	Exploratory Factor Analysis (EFA)	KMO ≥ 0.60; Factor loading ≥ 0.50	KMO = 0.846; all loadings > 0.60
Convergent Validity	Factor loadings	≥ 0.50	All items loaded on intended constructs
Ethical Approval	Institutional permission	Required before data collection	Permission obtained from training center
Informed Consent	Participant agreement	Voluntary participation	Participants informed and consent obtained
Confidentiality	Data protection	No personal identifiers	Data anonymized and securely stored
Right to Withdraw	Participant rights	No penalty for withdrawal	Participants allowed to withdraw at any time

Table 7. Reliability, Validity, and Ethical Considerations

IV. Findings And Discussion

Introduction

The analysis is divided into two main sections: quantitative findings and qualitative findings.

The quantitative results are presented first, including descriptive statistics, reliability and validity analysis, and inferential statistics such as correlation and regression analysis. These results provide an overview of students' use of generative artificial intelligence (AI), as well as their critical thinking, verification practices, cognitive offloading, AI literacy, and trust in AI.

The qualitative findings are then presented to complement and explain the quantitative results. Together, these findings provide a comprehensive understanding of how generative AI influences students' cognitive engagement and verification behavior in academic contexts.

Quantitative Findings

Descriptive Statistics

Descriptive statistics were used to summarize the overall patterns of the data collected from 132 participants. The mean and standard deviation were calculated for each variable to understand students' perceptions and behaviors related to generative AI usage, critical thinking, verification practices, cognitive offloading, AI literacy, and trust in AI.

Variable	N	Mean	Std. Deviation	Interpretation
AI Usage (AIU)	132	3.92	0.68	High
Critical Thinking (CT)	132	3.45	0.72	Moderate
Verification Practices (VP)	132	3.28	0.75	Moderate
Cognitive Offloading (CO)	132	3.76	0.70	High
AI Literacy (AIL)	132	3.60	0.66	Moderate–High
Trust in AI (TI)	132	3.88	0.69	High

Interpretation:

The results indicate that students demonstrate a relatively high level of generative AI usage (M = 3.92), suggesting that AI tools are widely integrated into their academic practices. Similarly, the mean score for trust in AI (M = 3.88) is also high, indicating that students generally perceive AI-generated outputs as reliable.

In contrast, critical thinking (M = 3.45) and verification practices (M = 3.28) are at moderate levels. This suggests that while students frequently use AI tools, they do not consistently engage in deep analysis or systematic verification of the information generated. This pattern may reflect a tendency toward convenience over critical evaluation.

The mean score for cognitive offloading (M = 3.76) is relatively high, indicating that students often rely on AI to perform cognitive tasks. This finding supports the concern that generative AI may reduce the need for independent thinking, as students delegate cognitive effort to AI systems.

Meanwhile, AI literacy (M = 3.60) is moderately high, suggesting that students have some awareness of how AI works and its limitations. However, this level may not be sufficient to fully counterbalance the effects of high AI usage and trust.

Overall, the descriptive results reveal a pattern in which students actively use and trust AI tools, while demonstrating only moderate levels of critical thinking and verification behavior. This imbalance highlights the potential risk of overreliance on AI and provides initial support for the study's conceptual framework.

Correlation Analysis

Pearson correlation analysis was conducted to examine the relationships among the key variables, including generative AI usage (AIU), critical thinking (CT), verification practices (VP), cognitive offloading (CO), AI literacy (AIL), and trust in AI (TI). The results are presented in Table 8.

Variable	AIU	CT	VP	CO	AIL	TI
AIU	1	-0.32**	-0.28**	0.61**	0.35**	0.49**
CT	-0.32**	1	0.54**	-0.41**	0.46**	-0.30**
VP	-0.28**	0.54**	1	-0.38**	0.42**	-0.33**
CO	0.61**	-0.41**	-0.38**	1	-0.27**	0.45**
AIL	0.35**	0.46**	0.42**	-0.27**	1	-0.21*
TI	0.49**	-0.30**	-0.33**	0.45**	-0.21*	1

Note: *p < 0.05, **p < 0.01

Table 8. Correlation Matrix

Interpretation:

The results reveal several significant relationships among the variables. Generative AI usage (AIU) is positively correlated with cognitive offloading ($r = 0.61$, $p < 0.01$), indicating that higher AI usage is associated with greater reliance on AI for cognitive tasks. At the same time, AI usage shows a negative correlation with both critical thinking ($r = -0.32$, $p < 0.01$) and verification practices ($r = -0.28$, $p < 0.01$), suggesting that increased use of AI may be linked to lower levels of analytical engagement and information verification.

Critical thinking is positively correlated with verification practices ($r = 0.54$, $p < 0.01$), indicating that students who engage in deeper thinking are more likely to verify information. AI literacy is also positively associated with both critical thinking ($r = 0.46$, $p < 0.01$) and verification practices ($r = 0.42$, $p < 0.01$), suggesting that higher awareness of AI systems supports more responsible and analytical use.

In contrast, trust in AI is negatively correlated with verification practices ($r = -0.33$, $p < 0.01$), indicating that students who trust AI more tend to verify less. These findings support the assumption that automation bias and overreliance on AI may reduce critical evaluation behaviors [3].

Regression Analysis

Multiple regression analysis was conducted to examine the predictive effects of generative AI usage on critical thinking and verification practices, as well as the roles of cognitive offloading, AI literacy, and trust in AI.

Variable	β	t	Sig.
AI Usage (AIU)	-0.24	-3.12	0.002**
Cognitive Offloading (CO)	-0.29	-3.85	0.000**
AI Literacy (AIL)	0.31	4.02	0.000**
Trust in AI (TI)	-0.18	-2.45	0.016*

$R^2 = 0.48$

Table 9. Regression Results for Critical Thinking

Variable	β	t	Sig.
AI Usage (AIU)	-0.21	-2.88	0.005**
Cognitive Offloading (CO)	-0.25	-3.21	0.002**
AI Literacy (AIL)	0.28	3.67	0.000**
Trust in AI (TI)	-0.26	-3.44	0.001**

$R^2 = 0.44$

Table 10. Regression Results for Verification Practices

Interpretation:

The regression results indicate that generative AI usage has a significant negative effect on both critical thinking ($\beta = -0.24$, $p < 0.01$) and verification practices ($\beta = -0.21$, $p < 0.01$). This suggests that higher reliance on AI is associated with reduced cognitive engagement and weaker verification behavior.

Cognitive offloading also shows a strong negative impact on both dependent variables, indicating that students who rely more on AI for thinking tasks tend to demonstrate lower levels of critical thinking and verification. This supports the mediating role of cognitive offloading in the relationship between AI usage and cognitive outcomes.

In contrast, AI literacy has a positive and significant effect on both critical thinking and verification practices, suggesting that students who better understand AI systems are more likely to engage critically and verify information. Meanwhile, trust in AI has a negative effect, indicating that higher trust may reduce students' tendency to question AI-generated outputs [7].

Overall, the regression findings confirm the proposed conceptual framework and highlight the complex interplay between AI usage, cognitive processes, and verification behavior.

Qualitative Findings

Overview

Semi-structured interviews revealed that students' use of generative AI was shaped by convenience, trust, and awareness of AI limitations. Three main themes emerged from the data: AI as a learning shortcut, inconsistent verification practices, and the influence of AI literacy on students' cognitive engagement. These findings are consistent with recent research on generative AI in education and digital learning behavior [13], [14].

Theme	Main Idea	Illustrative Quote
Theme 1: AI as a Learning Shortcut	Students use AI to save time and generate ideas quickly	"I use AI to get ideas first, but I still rewrite and check everything myself."
Theme 2: Weak and Inconsistent Verification	Students often trust AI outputs without checking	"Sometimes I trust the answer because it sounds so clear and professional."
Theme 3: AI Literacy Shapes Critical Engagement	Understanding AI leads to more critical use	"When I know AI can be wrong, I check it with other sources."
Theme 4: Cognitive Offloading and Reduced Thinking	AI reduces independent thinking effort	"If the AI can do it fast, I stop thinking as deeply as before."

Table 11. Themes Emerging from the Qualitative Data

Theme 1: AI as a Learning Shortcut

Most participants described generative AI as a fast and efficient tool for initiating academic tasks. Students frequently used AI to generate ideas, outline essays, and improve language accuracy. This behavior reflects findings from recent studies suggesting that generative AI enhances learning efficiency and supports idea generation [13], [14].

However, the data also indicate that many students rely on AI-generated content as a starting point and only make minimal revisions. While some participants reported using AI as a support tool, others adopted a more passive approach, treating AI output as a ready-made solution. This pattern suggests that AI may function as a shortcut that reduces cognitive effort rather than promoting deeper learning [15].

Theme 2: Weak and Inconsistent Verification

A second key theme relates to students' verification practices. Many participants admitted that they do not consistently verify AI-generated information, especially when the output appears fluent and well-structured. This finding aligns with research on lateral reading and information evaluation, which shows that users often rely on surface-level cues when assessing credibility [18].

One participant stated, "Sometimes I trust the answer because it sounds so clear and professional." This reflects the influence of automation bias, where users tend to trust automated systems even when errors may exist [20]. Verification behavior was found to be inconsistent and often dependent on task importance, with students more likely to verify information only in high-stakes situations.

Theme 3: AI Literacy Shapes Critical Engagement

The findings also highlight the role of AI literacy in shaping students' interaction with generative AI. Students who demonstrated a better understanding of how AI systems work were more cautious and more likely to verify information. This supports prior research suggesting that AI literacy is essential for responsible and critical use of AI tools [16], [17].

One participant explained, "When I know AI can be wrong, I check it with other sources before using it." This indicates that AI literacy helps students develop a more reflective approach to AI-assisted learning. In contrast, students with lower AI literacy tended to trust AI outputs more readily and engage less in verification.

Theme 4: Cognitive Offloading and Reduced Independent Thinking

A final theme concerns cognitive offloading. Several participants reported that frequent use of AI reduced their need to think independently. Instead of engaging in problem-solving or analysis, students often turned to AI immediately when facing difficulties. This finding is consistent with the concept of cognitive offloading, where individuals rely on external tools to perform cognitive tasks [19].

One student stated, "If the AI can do it fast, I stop thinking as deeply as before." This reflects a shift from active cognitive engagement to passive reliance on AI systems. Such behavior may have long-term implications for the development of critical thinking skills, particularly in educational contexts where independent reasoning is essential [20].

Interpretation of the Qualitative Findings

Overall, the qualitative findings support the quantitative results by demonstrating that generative AI is widely used as a tool for convenience, which may reduce cognitive effort and weaken verification practices. The results suggest that the impact of AI depends not only on usage but also on how students interact with it.

Students who use AI critically and possess higher levels of AI literacy are more likely to verify information and maintain cognitive engagement. In contrast, students who rely heavily on AI and trust it uncritically tend to demonstrate lower levels of verification and independent thinking. These findings reinforce the argument that generative AI can both support and undermine learning, depending on the level of user awareness and engagement [13], [15].

Discussion

The quantitative results show that students report high levels of AI usage and trust in AI, but only moderate levels of critical thinking and verification practices. This imbalance suggests that AI is often used for convenience rather than deep engagement. The negative correlation between AI usage and both critical thinking and verification supports the concern that generative AI may encourage cognitive offloading [7]. In other words, when students rely heavily on AI to generate ideas, structure responses, or solve problems, they may reduce the amount of intellectual effort required for independent reasoning. This finding aligns with the theoretical view that external technologies can support cognition but may also replace it when overused [7].

These results also support the hypotheses proposing that generative AI use negatively affects critical thinking and verification practices. The regression findings further confirm that cognitive offloading is a significant negative predictor of both outcomes, indicating that dependency on AI is not simply a matter of convenience but a cognitive pattern with measurable educational consequences. This is consistent with prior work suggesting that excessive reliance on external tools may weaken sustained analytical processing and reduce opportunities for reflective judgment [5], [6].

Another important finding is the positive role of AI literacy. Students with higher AI literacy demonstrated stronger critical thinking and more frequent verification practices. This supports the view that AI literacy helps students treat AI as a support tool rather than an authority. When learners understand that AI systems can produce inaccurate or biased content, they are more likely to question outputs, cross-check information, and remain intellectually active [10], [11]. This result confirms the hypotheses predicting that AI literacy positively influences students' cognitive engagement and verification behavior. It also suggests that AI literacy can buffer some of the negative effects of AI use by promoting more responsible and reflective interaction with technology.

The negative relationship between trust in AI and verification practices is equally important. Students who trust AI more tend to verify less, which suggests that confidence in AI outputs may reduce the perceived need for checking. This finding is consistent with research on automation bias, which shows that users often over-rely on automated systems even when errors are possible [9]. In the context of generative AI, fluent and polished language may create an illusion of correctness, making students less likely to question the information they receive. This supports the hypothesis that higher trust in AI is associated with lower verification behavior.

The qualitative findings reinforce these quantitative results by showing how students actually experience and explain their AI use. Many students described generative AI as a shortcut for generating ideas, drafting responses, and saving time. While this can be helpful, it also reveals a tendency toward passive use. Several participants admitted that they did not always verify AI-generated information, especially when the output appeared clear and professional. This theme aligns with the quantitative finding that verification practices are only moderate and that trust in AI may suppress critical checking [18], [20].

The interviews also showed that students with stronger AI literacy were more cautious and more likely to verify outputs. This supports the quantitative evidence that AI literacy improves critical engagement. Students who understood the limitations of AI were able to treat it as a starting point rather than a final answer. This is an important finding because it suggests that the impact of AI is not determined solely by the tool itself, but by the user's level of awareness and judgment [16], [17]. In this sense, AI literacy appears to be a key educational resource for preserving critical thinking in AI-mediated learning environments.

The theme of cognitive offloading was especially strong in the qualitative data. Some students admitted that frequent use of AI made them think less deeply and depend more heavily on automated responses. This directly supports the theoretical argument that AI may reduce independent reasoning when it becomes a substitute for cognitive effort [7], [19]. The qualitative evidence therefore strengthens the interpretation of the quantitative results: AI use is not harmful in itself, but uncritical dependence on it can weaken the habits of analysis, evaluation, and self-correction that are essential to higher education.

Taken together, the findings suggest a clear pattern. Generative AI can be a useful academic aid, but it may also encourage shallow processing if students use it without critical reflection. The study therefore supports a balanced interpretation of AI in education: the technology is neither inherently beneficial nor inherently harmful. Its impact depends on the level of cognitive engagement, verification behavior, and AI literacy that students bring to their interaction with it. This conclusion directly answers the study's research questions and supports the proposed conceptual framework, in which generative AI usage influences critical thinking and verification both directly and indirectly through cognitive offloading, while AI literacy and trust in AI shape these relationships.

V. Conclusion And Recommendations

Conclusion

This study examined whether generative artificial intelligence (AI) assists students' learning or contributes to the erosion of their critical thinking and verification practices. The findings show that generative AI is now widely embedded in students' academic routines and is frequently used for idea generation, drafting, and problem-solving. However, the results also indicate that frequent AI use is associated with higher cognitive offloading, weaker verification behavior, and lower levels of independent critical thinking.

The quantitative findings revealed that students reported relatively high levels of AI usage and trust in AI, but only moderate levels of critical thinking and verification practices. Correlation and regression analyses further showed that generative AI usage and cognitive offloading negatively predicted critical thinking and verification, while AI literacy had a positive effect on both outcomes. Trust in AI, on the other hand, tended to reduce verification behavior. These results support the view that AI can function as a useful academic aid, but may also weaken intellectual effort when used uncritically [7], [9], [10], [11].

The qualitative findings reinforced this interpretation. Students described generative AI as a convenient shortcut for completing tasks, but many admitted that they did not always verify the information produced by AI. Those with stronger AI literacy were more likely to question outputs and cross-check information, while those with lower awareness tended to trust AI more readily. Overall, the findings suggest that the main issue is not AI use itself, but the way students use AI and the extent to which they remain cognitively engaged while doing so. In this sense, generative AI may assist learning when used critically, but it may also contribute to the erosion of important thinking habits when it replaces independent reasoning.

Recommendations

Based on these findings, several recommendations can be proposed for educational practice and institutional policy.

First, higher education institutions should integrate AI literacy into the curriculum so that students understand both the potential and the limitations of generative AI. Students need to be trained to treat AI-generated content as a starting point for inquiry rather than a final answer [10], [11]. Such training should include awareness of hallucination, bias, and the importance of verification.

Second, teachers should explicitly teach verification practices as part of academic skills development. Students should be encouraged to check AI-generated information against reliable sources, compare multiple references, and question outputs that appear overly confident or unsupported. This will help reduce automation bias and strengthen critical engagement [8], [9].

Third, institutions should develop clear policies on the acceptable use of generative AI in coursework and assessment. These policies should not only address academic integrity, but also promote responsible and transparent AI use. Clear boundaries can help students understand when AI is appropriate, when it should be limited, and how it should be used ethically.

Fourth, educators should design learning activities that require students to demonstrate independent reasoning rather than simply reproduce AI-generated content. Tasks that involve reflection, justification, source comparison, and argument evaluation can help preserve critical thinking skills in AI-mediated learning environments [5], [6].

Limitations of the Study

Despite its contributions, this study has several limitations. First, the study was conducted in a specific educational context with a relatively limited sample size. As a result, the findings may not be fully generalizable to students in other institutions, disciplines, or cultural settings.

Second, the study relied partly on self-reported questionnaire data, which may be affected by response bias or participants' perceptions of their own behavior. Students may overestimate or underestimate their AI use, critical thinking, or verification practices. Although the qualitative interviews helped deepen the interpretation of the results, the study still could not fully capture actual in-the-moment behavior during AI use.

Third, the research focused on students' cognitive and behavioral responses to generative AI, rather than on the technical features of specific AI platforms. Therefore, the findings should be understood as relating to general patterns of AI use, not to the performance of any one tool.

Finally, the study was cross-sectional in nature, meaning it captured students' behaviors and perceptions at one point in time. It does not show how these behaviors may change over time as students gain more experience with AI or receive formal AI literacy training.

Recommendations for Future Research

Future research should address these limitations in several ways.

First, longitudinal studies are needed to examine how students' AI literacy, critical thinking, and verification practices develop over time as AI becomes more integrated into education. Such studies would help determine whether repeated AI use leads to lasting cognitive change or whether students adapt their behavior with experience [19], [20].

Second, future studies should use larger and more diverse samples from different institutions, disciplines, and educational levels. This would help improve the generalizability of the findings and reveal whether the impact of generative AI differs across learning contexts.

Third, experimental studies could be conducted to compare students who use AI with those who do not, or to test the impact of AI literacy training on verification behavior and critical thinking performance. Such designs would provide stronger evidence of cause-and-effect relationships.

Fourth, future research should explore the role of teachers more directly. Since teachers play a major role in shaping how students use AI, it would be valuable to examine teacher attitudes, classroom policies, and instructional practices related to AI-supported learning.

Finally, future studies could investigate the psychological and pedagogical conditions under which AI supports learning without weakening independent reasoning. In particular, research should examine how students can be trained to use generative AI as a tool for reflection, inquiry, and revision rather than as a substitute for thought.

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