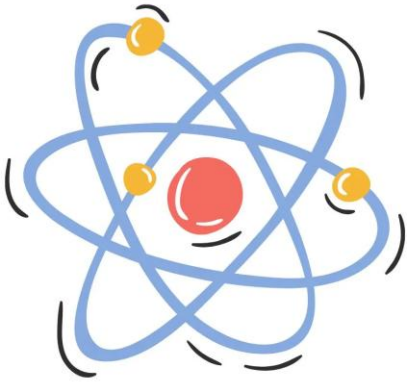

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Ghada Nasr Elmorsy[1], Walaa Mohamed Mahmoud Ahmed[2], Abdelrahim Fathy Ismail[3]

[1, 3]College of Education, King Faisal University, Al Ahsa, Saudi Arabia

[2]PhD, Faculty of Education, South Valley University, Qena, Egypt

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EFFECTIVENESS OF A DIGITAL AI LITERACY PROGRAM IN PROMOTING ACADEMIC LEARNING AMONG UNIVERSITY STUDENTS: TOWARD BEHAVIORAL AND COGNITIVE CONTROL

Ghada Nasr Elmorsy[1], Walaa Mohamed Mahmoud Ahmed[2], Abdelrahim Fathy Ismail[3]

[1, 3]College of Education, King Faisal University, Al Ahsa, Saudi Arabia

[2]PhD, Faculty of Education, South Valley University, Qena, Egypt

Correspondence: Ghada Nasr Elmorsy (gelmorsy@Kfu.edu.sa)

Abstract: Despite the rapid rise of generative artificial intelligence (AI) tools, many university students remain unaware of their full potential in academic learning. Instead, students often resort to superficial and passive use, overlooking the possibilities of deeper cognitive engagement. This study aimed to investigate the effectiveness of a digital AI literacy program in enhancing academic learning among university students, within a framework oriented toward behavioral and cognitive control. A quasi-experimental design was employed, using pre- and post-measurements to assess changes in learning performance. The sample included 50 undergraduate students from the College of Arts at King Faisal University. To achieve the study's goals, a targeted educational program was developed to promote digital literacy in the effective academic use of AI tools. The program focused on meaningful interaction with AI, emphasizing critical thinking, deep inquiry, and practical applications, rather than passive reliance on instant outputs. An observation checklist was constructed to assess students' academic learning across four key domains: (1) AI-assisted information searching, (2) idea generation and content planning, (3) argument development and writing refinement, and (4) academic task organization and time management. Over six weeks, students participated in 18 interactive sessions involving guided training, reflective tasks, and applied practice. Findings revealed significant improvements in both cognitive and behavioral dimensions of academic learning. Students demonstrated enhanced control over their learning processes, more strategic use of AI tools, and increased academic self-regulation. These results suggest that structured training on purposeful AI use can shift students from passive consumption to empowered, skillful engagement with AI technologies in higher education.

Keywords: Artificial intelligence literacy, academic learning, behavioral control, cognitive engagement, generative AI tools, higher education, learning dynamics.

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Introduction and Theoretical Background

The integration of artificial intelligence (AI) tools into academic learning is no longer a futuristic vision-it is a present reality shaping how students think, search, write, and manage their learning (Al Ka'bi, 2023). However, this rapid integration brings with it a fundamental paradox: AI tools can serve as either a superficial shortcut or a profound enhancer of intellectual engagement. On the one hand, students may use AI to generate instant answers, bypass effort, and disengage from critical thought (Malik et al., 2023). On the other, these same tools-when used thoughtfully-can scaffold higher-order thinking, support inquiry-based learning, and foster autonomy in academic tasks. The difference lies not in the tools themselves, but in the literacy with which they are used (Bali et al., 2023).

In the context of higher education, generative AI tools such as language models, automated planners, and intelligent content generators are becoming increasingly accessible to students (Sabzalieva & Valentini, 2023). These tools offer real-time support in tasks ranging from researching scholarly content and organizing ideas, to refining arguments and even managing deadlines. For many students, especially those navigating the complexities of academic writing and independent learning, AI tools can serve as silent partners offering suggestions, clarifying structure, and making sense of overwhelming information (Hooda et al., 2022).

Despite the wide availability of AI tools and their increasing integration into academic environments, many university students are still navigating this landscape with uncertainty. Some interact with AI in ways that are passive, habitual, or even careless-using it for convenience rather than for meaningful growth (Chang, 2022). Others simply avoid it, unsure of how to use these tools effectively or ethically. This gap between the potential of AI and students' actual use highlights a clear need: not only for access to technology, but for structured learning experiences that help students become intentional, reflective, and skillful users (Fuchs & Aguilos, 2023).

Yet, as promising as these tools are, their true impact depends on how students interact with them. When used merely for convenience, AI tools can reinforce surface-level engagement, short attention spans, and dependency on ready-made answers (Wang et al., 2023). But when students are guided to use these tools critically and strategically, they can unlock a deeper academic experience one that involves reflection, planning, decision-making, and refinement. In this way, AI in higher education is not just a technological advancement, but a test of digital maturity and intellectual self-discipline (Chen et al., 2020).

AI literacy is emerging as a critical competence in modern education, particularly in university contexts where students are expected to manage complex tasks such as research, writing, and project planning (Slimi et al., 2025). More than just the ability to operate AI tools, AI literacy involves understanding how these systems work, recognizing their limitations, and using them in ways that enhance rather than replace human thinking. It

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includes not only technical skills but also ethical awareness, critical thinking, and strategic decision-making (Alqahtani et al., 2023).

For university students, developing AI literacy means moving beyond casual or passive interaction with generative tools. It means learning how to prompt effectively, evaluate generated outputs, refine content collaboratively with AI, and ensure academic integrity (Khalid, 2020). Without this literacy, students risk falling into patterns of superficial use relying on AI for quick answers while missing opportunities to deepen their academic learning. Therefore, fostering AI literacy is not optional; it is essential for preparing students to engage meaningfully with knowledge in an AI-augmented world (Ma et al., 2024).

Among the most recent and comprehensive reviews in the field, Crompton and Burke (2023) conducted a systematic analysis of artificial intelligence integration in higher education. Their study highlighted the growing use of AI technologies to support academic processes such as personalized learning, automated assessment, instructional planning, and enhanced student engagement. Importantly, they emphasized that while these tools offer transformative opportunities, their actual impact on learning outcomes is highly dependent on students' digital literacy and the intentionality of use. The authors also pointed to several challenges, including ethical concerns, data privacy, algorithmic bias, and the risk of dependency on AI systems. They concluded with a strong call for fostering AI literacy among students and educators alike to ensure purposeful and equitable adoption of such technologies in academic environments (Crompton & Burke, 2023).

In an earlier foundational review, Zawacki-Richter et al. (2019) proposed a conceptual framework for understanding AI literacy, emphasizing its multidimensional nature. Rather than focusing solely on technical skills, the study framed AI literacy as encompassing cognitive, emotional, and sociotechnical dimensions. This includes not only the ability to use AI tools but also the capacity to question, critique, and make informed judgments about AI-generated content. Ng's work underscored the importance of cultivating reflective and ethical dispositions in students, preparing them not just to consume AI outputs but to interact with them responsibly and thoughtfully within academic contexts.

Academic learning in higher education is no longer confined to traditional models of lecture-taking and textbook reading (Obenza et al., 2024). Instead, university students today are expected to demonstrate a range of higher-order skills such as independent research, critical writing, time management, and complex problem-solving. However, the increasing availability of AI tools poses both an opportunity and a challenge to these academic expectations (Jafari & Keykha, 2024). While AI can support and enrich learning, its misuse can undermine the development of essential academic habits.

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To guide students toward more meaningful engagement, it is helpful to break academic learning into core skill areas that are directly impacted by AI usage. In the context of this study, four interrelated domains have been identified:

(1) AI-assisted information searching, which involves using AI tools to locate, filter, and synthesize relevant academic sources;

(2) idea generation and content planning, where AI supports brainstorming, outlining, and concept organization;

(3) argument development and writing refinement, focusing on how AI can aid in structuring coherent arguments and improving academic style; and

(4) academic task organization and time management, which includes scheduling, prioritizing, and tracking learning tasks using intelligent tools.

Together, these domains represent not only functional skills but also cognitive behaviors. The way students approach and control these skills reflects deeper learning patterns-patterns that AI, if used wisely, can help to elevate and sustain.

Kuleto et al. (2021) explored how artificial intelligence and machine learning can transform key dimensions of higher education, including teaching, learning, and administrative operations. Through document analysis and a student survey, their findings revealed that AI has the potential to significantly improve academic efficiency, decision-making, and personalized learning experiences. At the same time, the study drew attention to ethical challenges, concerns around data protection, and the need for responsible implementation. The authors emphasized that equipping students with adequate digital and AI literacy is essential to ensure that these technologies are used purposefully and without reinforcing dependency or inequity in academic environments.

Effective academic learning does not depend solely on access to information or tools-it hinges on the learner's ability to regulate their own behavior and thinking (Al-Zahrani & Alasmari, 2024). Behavioral and cognitive control refer to the student's capacity to manage attention, persist in challenging tasks, organize actions purposefully, and monitor one's learning progress. These forms of self-regulation are especially vital in environments where intelligent systems can easily do the thinking on behalf of the student (McDonald et al., 2025). In the context of AI-supported learning, behavioral control involves resisting the urge to rely blindly on generated content, staying focused on task goals, and using AI as a tool for progress rather than escape. Cognitive control, on the other hand, includes evaluating the relevance and accuracy of AI outputs, making informed decisions, and engaging critically with the content. Without these forms of control, students risk

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becoming passive recipients of machine-generated knowledge. But with them, AI tools can become powerful partners-enhancing, rather than replacing, the learner's agency and thought process (Annamalai et al., 2025).

A study by Zhou (2023) examined the integration of AI technologies into higher education through an experimental evaluation in China. The research employed a controlled design with 356 students using the "Raptivity" personalized learning platform. Results showed significant improvement in students' performance across five subjects, with post-intervention gains ranging from 13% to nearly 23% in areas such as mathematics, computer science, and humanities. These findings confirm that structured AI-based educational interventions, when grounded in digital literacy and pedagogical support, can meaningfully enhance academic outcomes. However, the study also highlighted the need for ethical awareness and safeguards to prevent misuse or over-dependence on AI technologies.

Universities face a crucial challenge-not to limit AI use, but to cultivate literacies that enable students to use it wisely. The question is not whether students should use AI in their academic lives, but how they can do so in ways that promote deep learning, academic integrity, and personal development. In this light, AI literacy is not merely a technical skill; it is a form of cognitive empowerment and behavioral discipline (Ouyang et al., 2022).

Rajki et al. (2025) conducted an extensive empirical study involving 1,027 Hungarian university students to explore patterns of AI tool usage and the factors influencing their adoption. Their research focused particularly on students in the humanities, social sciences, and teacher education. The findings revealed significant differences in AI use depending on course type, gender, and academic level. Many students reported limited awareness of generative AI tools such as ChatGPT, and their use was often shaped by barriers including ethical concerns, uncertainty, and unequal access. The authors concluded that higher education institutions must adopt clear strategies to promote ethical, inclusive, and pedagogically sound use of AI. Their work supports the call for structured AI literacy programs that address both the cognitive and behavioral dimensions of student engagement with AI technologies.

This study responds to that challenge by designing and evaluating a digital AI literacy program tailored to university students. It seeks to measure whether structured exposure to AI tools-framed by clear learning goals and supported by guided practice-can improve students' academic learning across four essential domains: AI-assisted information searching, idea generation and content planning, argument development and writing refinement, and academic task organization and time management. Central to this exploration is the belief that when students develop behavioral and cognitive control over their use of AI, they can transform these tools from shortcuts into catalysts for deeper academic engagement.

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Statement of the Problem

In recent years, the educational landscape has been profoundly reshaped by the emergence of generative artificial intelligence (AI) tools (Slimi et al., 2025). These technologies offer vast potential to support academic learning by enabling faster access to information, refining writing, enhancing organization, and stimulating creative thinking. Yet, in practice, many university students are not equipped with the literacy or mindset needed to use these tools responsibly or effectively (Annamalai et al., 2025). Instead of leveraging AI for deep engagement and cognitive growth, students often fall into patterns of surface-level usage-relying on AI for quick answers, bypassing the critical thinking, planning, and writing processes that academic work demands (Ma et al., 2024).

This growing reliance on AI as a shortcut rather than a learning partner raises important pedagogical concerns. It suggests a gap between what AI can offer and how students are currently using it. Without structured guidance, students may miss opportunities to use AI to develop core academic competencies-such as organizing ideas, generating meaningful arguments, managing tasks, or regulating their own learning. Moreover, this passive approach to AI use may hinder the development of essential behavioral and cognitive control skills that underlie lifelong learning and academic success (Obenza et al., 2024).

Given this context, there is an urgent need for intentional, well-designed educational interventions that promote digital AI literacy among university students. Such interventions should not only introduce AI tools, but also cultivate thoughtful, ethical, and empowered engagement with them.

This study addresses that need by exploring whether a targeted AI literacy program can meaningfully enhance students' academic learning and foster greater behavioral and cognitive control in their engagement with AI technologies. Rather than treating AI as a shortcut for quick results, the program aims to promote purposeful and strategic use of AI across four essential domains of academic learning: AI-assisted information searching, idea generation and content planning, argument development and writing refinement, and academic task organization and time management. These domains were selected not only because they reflect critical academic competencies, but also because they represent the very areas where AI can either support or undermine deep learning-depending on how students interact with it. By equipping students with the literacy and self-regulation needed to use AI tools intentionally, this study seeks to transform their relationship with technology from passive dependence to empowered academic engagement.

Research Objectives

This study aims to investigate the effectiveness of a structured digital AI literacy program in enhancing academic learning among university students. The primary objective is to determine whether guided, purposeful

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engagement with AI tools can improve students' learning performance within a framework of behavioral and cognitive control. Specifically, the study seeks to:

- Promote university students' ability to use AI tools in ways that support deep, reflective, and ethical learning.
- Enhance students' academic performance across four key domains:

(a) AI-assisted information searching,

(b) idea generation and content planning,

(c) argument development and writing refinement, and

(d) academic task organization and time management.

- Develop students' behavioral control in how they interact with AI tools, including focus, intention, and responsible use.
- Strengthen students' cognitive control by fostering critical thinking, evaluation, and self-monitoring while working with AI-generated content.

Research Questions

To address the objectives of this study, the following research questions were formulated:

-To what extent is the digital AI literacy program effective in enhancing university students' academic learning performance?

- How does the program impact students' performance across the following domains of academic learning?
  a. AI-assisted information searching
  b. Idea generation and content planning
  c. Argument development and writing refinement
  d. Academic task organization and time management
- In what ways does the program contribute to the development of behavioral control in students' use of AI tools?
- In what ways does the program enhance students' cognitive control when engaging with AI technologies?

Methodology

Research Design

This study aimed to examine the effectiveness of a structured digital AI literacy program in enhancing academic learning among university students, with particular attention to the development of behavioral and cognitive

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control. To fulfill this aim, the study employed a quasi-experimental design, specifically a one-group pretest-posttest design, which involved measuring students' academic learning performance before and after participating in the intervention. This research design was selected because it allows for the observation of changes over time within the same group of participants, especially in real educational settings where random assignment is often impractical. By using this approach, the study could directly assess the extent to which the AI literacy program influenced students' academic practices and self-regulatory behaviors related to AI use. The sample consisted of 50 undergraduate students enrolled in the College of Arts at King Faisal University. These students participated in a six-week educational program specifically developed to promote digital literacy for academic use of AI tools. The program emphasized purposeful engagement with AI through critical thinking, deep inquiry, and practical application, rather than passive reliance on instant outputs or superficial use.

To evaluate the impact of the intervention, the study used a structured observation checklist as its main assessment instrument. The checklist captured students' academic learning across four key domains: AI-assisted information searching, Idea generation and content planning, Argument development and writing refinement & Academic task organization and time management

Over the course of six weeks, students attended 18 interactive training sessions, where they engaged in guided practice, reflective activities, and applied tasks involving real academic assignments and AI tool integration. These sessions were designed to mirror authentic university learning contexts and promote self-directed use of AI in alignment with academic goals.

The differences observed between students' pre- and post-program performance across the four domains were analyzed using appropriate statistical methods to determine the significance and magnitude of change. The findings provided insights into how structured AI literacy instruction can shift students from passive users of technology to reflective, intentional learners who are better equipped to manage their academic tasks and thinking processes with the aid of AI.

Participants and Sampling

The study sample consisted of 50 male undergraduate students from the College of Arts at King Faisal University, all enrolled in their fourth academic level. The participants were drawn from various academic sections within the humanities, specifically from five departments: Arabic Language, English Language, Media, History, and Geography. These students represented different classroom sections across the departments, ensuring a diverse yet academically comparable participant group.

To select the sample, a simple random sampling technique was employed. As a preliminary step, a diagnostic questionnaire was distributed to all students across the five sections. This instrument was designed to measure

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students' current level of engagement and interest in using generative AI tools for academic purposes, specifically across four dimensions:

(1) AI-assisted information searching,

(2) idea generation and content planning,

(3) argument development and writing refinement, and

(4) academic task organization and time management.

Based on the responses, the final sample of 50 students was randomly selected, ensuring a balanced representation across departments and an appropriate level of initial variation in AI use. This approach allowed the study to meaningfully assess the impact of the AI literacy program on students with diverse academic backgrounds and initial familiarity with AI tools.

Table 1: Demographic Characteristics of Study Participants (N = 50)

Department	Number of Students	% of Total	AI Use Level: Medium	AI Use Level: High	% Medium	% High
Arabic Language	11	22.0%	7	4	63.6%	36.4%
English Language	9	18.0%	3	6	33.3%	66.7%
Media	10	20.0%	5	5	50.0%	50.0%
History	12	24.0%	8	4	66.7%	33.3%
Geography	8	16.0%	4	4	50.0%	50.0%
Total	**50**	**100%**	**27**	**23**	**54.0%**	**46.0%**

Ethical Considerations

This study was conducted with full adherence to ethical standards in educational research. Prior to the start of the program, participants were informed about the purpose of the study, the nature of their involvement, and their right to withdraw at any time without any academic consequences. Participation was entirely voluntary, and no incentives were provided that could influence students' consent or responses. Informed consent was obtained from all students through a written agreement, which clarified that the data collected would be used solely for research purposes, treated confidentially, and presented anonymously in any reports or publications. Students were assured that their academic standing would not be affected in any way by their participation or performance during the intervention. Furthermore, the research activities and training sessions were designed to respect students' personal values and cultural sensitivities. The study was reviewed and approved by the relevant academic department and aligned with the ethical guidelines of King Faisal University. Throughout the process, the researchers maintained transparency, respect, and care in their interactions with participants,

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ensuring that the learning environment remained supportive, inclusive, and free from any form of pressure or bias.

Instruments of the Study

To achieve the objectives of this study and assess the effectiveness of the AI literacy program, two primary instruments were developed and used:

(a) the AI Literacy Training Program, and

(b) an observation checklist for academic learning performance.

a. AI Literacy Training Program

A structured educational program was designed to develop students' digital literacy in the academic use of generative AI tools. The program aimed to promote thoughtful, purposeful, and strategic engagement with AI in ways that support both cognitive growth and behavioral self-regulation.

Program Objectives

The program was built around the following goals:

To enhance students' ability to use AI tools effectively in academic contexts.

To encourage deep, inquiry-based engagement with AI outputs rather than superficial or passive use.

To develop core skills in information handling, content development, academic writing, and time/task management through AI support.

To foster ethical, responsible, and reflective practices when interacting with generative AI technologies.

Program Philosophy

The design of the program was grounded in constructivist and metacognitive learning principles. It emphasized student-centered, active learning strategies that promote autonomy, reflection, and practical application. Instead of treating AI tools as ends in themselves, the program positioned them as cognitive partners that support students in constructing, organizing, and refining their academic work.

Program Content

The training consisted of 18 interactive sessions, each lasting three hours, conducted over a period of six weeks. The sessions were structured to address the four targeted domains of academic learning using AI tools:

- AI-assisted information searching,

- Idea generation and content planning,

-Argument development and writing refinement, and

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-Academic task organization and time management.

Instructional strategies used throughout the program included:

Guided demonstrations of AI tools in real academic tasks

Hands-on exercises and role-based tasks

Individual and group reflection activities

Feedback and peer discussions

Case-based learning scenarios

The table below outlines the proposed structure and focus of the 18 sessions:

Table 2: Titles and Themes of the AI Literacy Training Sessions

Session	Title
1	Introduction to Generative AI in Academic Contexts
2	Ethics and Critical Thinking in AI Use
3	Exploring ChatGPT and Similar Tools
4	Searching for Reliable Information Using AI
5	Evaluating Sources and AI-Generated Content
6	Planning Content Using AI Mind-Mapping Features
7	Brainstorming and Outlining Ideas with AI
8	Creating Academic Structures Using Prompts
9	Developing Arguments with AI Assistance
10	Refining Academic Language and Tone
11	Citation, Paraphrasing, and Avoiding Plagiarism with AI
12	Revising and Editing Writing Using AI Suggestions
13	Organizing Research Tasks with AI Tools
14	Time Management and Study Planning with AI
15	Building Academic Schedules and To-Do Lists Using AI
16	Simulated Academic Task Using Multiple AI Tools
17	Reflection and Troubleshooting: Challenges in AI Use
18	Final Project and Presentation: Applying AI Responsibly

After the program was fully developed, it was reviewed by five academic experts specializing in educational technology and instructional design. The reviewers assessed the clarity, relevance, coherence, and alignment of session content with program objectives. Their feedback was incorporated to make improvements to session structure, task realism, and learning outcomes.

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b. Academic Learning Observation Checklist

To evaluate students' academic learning performance during the intervention, the researchers developed an observation checklist aligned with the program's four key learning domains:

AI-assisted information searching

Idea generation and content planning

Argument development and writing refinement

Academic task organization and time management

The checklist consisted of observable behaviors and indicators within each domain, focusing on students' ability to apply AI tools meaningfully, reflectively, and strategically during learning activities.

Content Validity: The checklist was submitted to the same five academic experts for validation. They reviewed the indicators for relevance, clarity, and alignment with the intended outcomes. Based on their suggestions, minor revisions were made to improve the accuracy and focus of each item.

Reliability: To ensure consistency and objectivity in the observational process, the reliability of the checklist was evaluated using Cohen's Kappa coefficient, which measures inter-rater agreement. Two trained observers independently used the checklist to assess a pilot group of students during selected sessions of the program. The calculated Kappa value indicated a substantial level of agreement between the two raters (0.61 – 0.80), confirming the tool's reliability and suitability for use in the main phase of the study.

Data Analysis Methods

To assess the effectiveness of the AI literacy program, both descriptive and inferential statistical methods were used. First, means and standard deviations were calculated for students' performance scores across the four academic learning domains in the pre- and post-intervention phases. These descriptive statistics provided a general overview of students' progress following participation in the program.

To determine whether the observed changes were statistically significant, the study employed a paired samples t-test, comparing pretest and posttest scores within the same group of students. This test was chosen due to the one-group pretest-posttest design, which focuses on measuring change over time within a single sample.

In addition to significance testing, effect sizes (Cohen's d) were also calculated for each domain to evaluate the magnitude of the observed improvements. Reporting effect sizes was important to go beyond p-values and better understand the practical impact of the intervention on students' learning behaviors and cognitive engagement with AI tools.

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All analyses were conducted using SPSS software, and results were interpreted in light of educational relevance and the goals of promoting behavioral and cognitive control in academic learning.

Results and Discussions

To answer the research questions and evaluate the effectiveness of the digital AI literacy program, data were collected and analyzed based on students' performance in four core academic learning domains. These included: AI-assisted information searching, idea generation and content planning, argument development and writing refinement, and academic task organization and time management.

After completing the six-week intervention, post-program data were collected using the observation checklist, and results were compared to pre-program data. A paired samples t-test was conducted to examine the statistical significance of differences between pre- and posttest scores, and Cohen's d was calculated to estimate the effect size of the intervention.

The following table presents the results of the analysis across the four domains. As shown, students' posttest scores were significantly higher across all domains, indicating a positive impact of the program on their academic performance. All effect sizes fell within the "very large" range, suggesting that the improvement was not only statistically significant, but also practically meaningful.

Table 3: Pre- and Posttest Scores Across Academic Learning Domains (N = 50)

Academic Learning Domain	Pretest Mean (SD)	Posttest Mean (SD)	t-value	p-value	Effect Size (Cohen's d)	Interpretation
AI-assisted information searching	11.22 (2.05)	14.30 (1.18)	9.87	< .001	1.74	Very large
Idea generation and content planning	10.88 (2.14)	14.12 (1.24)	9.45	< .001	1.66	Very large
Argument development and writing refinement	11.00 (2.22)	14.20 (1.26)	9.11	< .001	1.59	Very large
Academic task organization and time management	10.76 (2.18)	14.05 (1.30)	9.63	< .001	1.68	Very large
Total Score (out of 60)	**43.86 (6.12)**	**56.67 (4.21)**	**12.34**	**< .001**	**2.17**	**Very large**

The results clearly demonstrate that the program had a significant and powerful impact on students' academic performance across all four domains. The quantitative results presented in Table (3) indicate statistically significant differences between students' pre- and post-program mean scores across all domains of academic learning. The consistently high values of Cohen's d suggest that the effect size was very large in every domain, reflecting the strong impact of the program on the targeted student skills. A detailed analysis of each domain is presented below:

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AI-assisted Information Searching

Students showed the greatest improvement in this domain, reflecting enhanced skills in locating, evaluating, and selecting high-quality academic information using AI tools. This aligns with prior research emphasizing the role of AI in transforming how students engage with digital content and access information more strategically (Fuchs & Aguilos, 2023; Hooda et al., 2022).

Idea Generation and Content Planning

Participants demonstrated more structured and creative approaches to generating and organizing ideas. The program's emphasis on brainstorming with AI support and outlining academic content helped shift students from superficial engagement to more reflective planning. These results resonate with findings by Malik et al. (2023), who noted that AI enhances learners' capacity to initiate and scaffold academic writing tasks effectively.

Argument Development and Writing Refinement

Significant gains were observed in students' ability to develop logical arguments and refine their academic writing. With guidance, they learned how to critically engage with AI-generated outputs, revise drafts, and maintain academic integrity. This is consistent with research by Alqahtani et al. (2023) and Crompton & Burke (2023), who highlighted AI's value in improving writing coherence and analytical depth when used intentionally.

Academic Task Organization and Time Management

Students also developed better skills in managing their academic workloads, utilizing AI for planning, scheduling, and task breakdown. The structured exposure to AI tools helped instill habits of strategic thinking and time-conscious study routines. These findings support similar conclusions from Wang et al. (2023), who reported that students with guided AI support demonstrated higher self-efficacy in managing academic tasks.

Holistic Impact and Contributing Factors

The overall impact of the program was substantial. Improvements across all domains can be attributed to a number of key design features:

Real-world academic scenarios embedded in the sessions.

Interactive, student-centered learning approaches.

Continuous reflection on the ethical and effective use of AI.

Focus on building metacognitive and self-regulatory skills.

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Rather than encouraging dependence on AI tools for instant results, the program helped students develop a more purposeful and reflective AI usage mindset, which is crucial for higher education in the digital age (Kuleto et al., 2021; Chen et al., 2020; Zawacki-Richter et al., 2019).

Behavioral and Cognitive Control: Beyond Technical Skills

In addition to academic skills, the program significantly enhanced students' behavioral and cognitive control. Students demonstrated greater autonomy, critical judgment, and ethical awareness when engaging with AI tools. This reflects a transition from passive consumption to active, guided learning.

Such a shift is critical in the current educational landscape where generative AI tools can either empower or distract learners. As highlighted by Annamalai et al. (2025) and McDonald et al. (2025), AI literacy must include not only technical fluency but also self-regulation, discernment, and critical thinking to ensure that students remain in control of their learning processes.

This study contributes to the growing body of literature suggesting that structured, ethically informed AI literacy interventions can enhance both performance and responsibility in student learning (Al-Zahrani & Alasmari, 2024; Jafari & Keykha, 2024).

Implications of the Study

The findings of this study offer several important implications for both theory and practice in higher education.

From a theoretical perspective, the results reinforce the growing body of literature emphasizing the need to move beyond a purely technical understanding of AI tools toward a more holistic model of AI literacy-one that includes cognitive engagement, critical reflection, and behavioral control. The significant improvements observed in students' learning outcomes across the four domains support the argument that AI literacy should be integrated as a structured component of academic learning, not merely as a peripheral digital skill. This calls for a rethinking of how educational institutions conceptualize digital competence frameworks, placing greater emphasis on students' ability to interact meaningfully and responsibly with generative AI.

From a practical standpoint, the success of the intervention demonstrates that university students benefit substantially from guided, hands-on exposure to AI tools within well-designed learning environments. Educators and curriculum designers should consider incorporating targeted AI training modules into undergraduate programs, particularly in disciplines where writing, planning, and research are central. Moreover, the observed growth in students' behavioral and cognitive self-regulation points to the value of embedding self-directed learning strategies and ethical AI use principles into these modules.

The study also highlights the potential for universities to lead in developing institutional policies and support systems that foster responsible AI use. Rather than banning or fearing the misuse of generative AI, institutions

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can create proactive strategies that help students see AI as a partner in learning, not a shortcut. This involves training instructors, creating learning materials, and fostering a culture of curiosity, critical thinking, and integrity in digital environments.

This study suggests that when AI literacy is approached as both a skillset and a mindset, it can significantly empower students to take control of their academic growth-enhancing not only what they learn, but how they learn.

Conclusion

This study explored the effectiveness of a digital AI literacy program in improving academic learning among university students. The results showed that the program had a strong and positive impact on students' performance across four key domains: AI-assisted information searching, idea generation and content planning, argument development and writing refinement, and academic task organization and time management. The findings also revealed that the students became more aware of how to use AI tools in thoughtful and responsible ways. They moved from using AI for quick, surface-level tasks to using it in a deeper, more purposeful way that supported their academic thinking and planning. The training helped them not only develop technical skills but also improve their ability to manage their time, focus on tasks, and make better learning decisions-reflecting stronger behavioral and cognitive control. This suggests that AI literacy is not just about knowing how to use tools, but about learning how to use them wisely and ethically in academic life. With proper training, students can benefit greatly from AI technologies and use them to support real learning, rather than rely on them passively. Overall, the study highlights the importance of integrating AI literacy programs into higher education to prepare students for a future where digital tools are an essential part of learning and thinking.

Limitations

While the findings of this study offer valuable insights into the role of AI literacy in enhancing academic learning, several limitations must be acknowledged.

First, the study employed a quasi-experimental design with a single group and no control group for comparison. Although pre- and post-intervention assessments provided useful data on progress, the absence of a control group limits the ability to attribute improvements solely to the intervention, as other external factors may have contributed. Second, the sample was limited to 50 male undergraduate students from the College of Arts at King Faisal University. This relatively small and homogeneous sample limits the generalizability of the findings to other populations, such as female students, students from scientific or technical disciplines, or those in different academic levels or cultural contexts. Third, the study relied primarily on an observation checklist to

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assess students' learning performance. While this tool captured important behavioral and cognitive indicators, it may not fully reflect deeper shifts in students' attitudes, motivation, or long-term habits of AI use, which require more longitudinal or qualitative approaches. Finally, the duration of the intervention was six weeks, which, while sufficient to observe initial impact, may not reveal the sustained effects of AI literacy training over time. Future research could benefit from extended implementations and follow-up assessments to explore the long-term value of such programs.

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