

ARTICLE

AI-powered brainstorming tools and creative idea generation among university students: The role of creative self-efficacy and artificial intelligence literacy

Ahmad Adeel^{1*}, Samreen Batool², Sajid Mohy ul din³, Zain ul abdeen Madni⁴, and Ahmad Aziz Sheikh⁵¹Faculty of Business and Communications, INTI International University, Nilai, Negeri Sembilan, Malaysia²School of Management, Universiti Sains Malaysia, Minden, Penang, Malaysia³Department of Management and Economics, Universiti Pendidikan Sultan Idris, Tanjong Malim, Perak, Malaysia⁴Department of Business Administration, University of Layyah, Layyah, Punjab, Pakistan⁵Department of Business Education, The University of Chenab, Gujrat, Punjab, Pakistan***Corresponding author:**Ahmad Adeel
(adeelleads@yahoo.com)

Citation: Adeel, A., Batool S., Mohy ul din, S., Madni, Z. U. A., & Sheikh, A. A. (2026). AI-powered brainstorming tools and creative idea generation among university students: The role of creative self-efficacy and artificial intelligence literacy. *Int J Systematic Innovation*. 10(5): 026240149.
[https://doi.org/10.6977/IJoSI.202610_10\(5\).0004](https://doi.org/10.6977/IJoSI.202610_10(5).0004)

Received: June 12, 2026**Revised:** July 17, 2026**Accepted:** July 22, 2026**Published online:** October 21, 2026

Copyright: © 2026 Author(s). This is an Open-Access article distributed under the terms of the Creative Commons Attribution License, permitting distribution, and reproduction in any medium, provided the original work is properly cited.

Publisher's Note: AccScience Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract

AI-powered brainstorming tools are increasingly used in higher education, yet limited evidence explains how they shape students' creative idea generation or how individual capabilities, particularly AI literacy, influence these effects. The purpose of this research is to examine how artificial intelligence (AI)-powered brainstorming tools influence creative idea generation among undergraduate business students in Malaysia. Building on Social Cognitive Theory, we proposed a moderated mediation model in which AI-powered brainstorming tools enhance creative idea generation directly and indirectly through creative self-efficacy; however, AI literacy strengthens these relationships. Data for this research were collected from 293 undergraduate business students of a private university in Malaysia through a classroom-administered survey and analyzed using Mplus. Results show that AI-powered brainstorming tools were positively related to creative idea generation and creative self-efficacy. Creative self-efficacy positively affected creative idea generation and also partially mediated the relationship between AI-powered brainstorming tools and creative idea generation. AI literacy moderated the effect of AI-powered brainstorming tools on both creative self-efficacy and creative idea generation. Research contributions, limitations, and future research directions are also discussed.

Keywords: Artificial intelligence-powered brainstorming tools; Creative idea generation; Creative self-efficacy; Artificial intelligence literacy; Education; Process innovation

1. Introduction

Artificial intelligence (AI) has rapidly moved from being a specialized technological domain to becoming a visible part of students' everyday academic work (L. Chen *et al.*, 2020). In higher education, AI-powered tools are now used for searching information, drafting text, generating alternatives, refining ideas, solving problems, and supporting

early-stage brainstorming (Wang *et al.*, 2019). This shift is particularly important for creativity-related learning because universities are increasingly expected to prepare students not only to reproduce knowledge but also to generate original, useful, and contextually relevant ideas. Creative idea generation is therefore no longer limited to individual imagination; it increasingly occurs through interaction between students and digital systems that can provide prompts, examples, alternative perspectives, and rapid feedback (Tang *et al.*, 2022). Recent evidence suggests that generative AI can improve the perceived creativity of individual outputs, although it may also reduce the diversity of ideas when users rely too heavily on similar AI-generated suggestions (Doshi & Hauser, 2024). This makes AI-powered brainstorming tools a timely and theoretically important context for understanding how student creativity develops in AI-supported learning environments.

Creativity is conceptualized as the generation of novel and useful ideas within a particular task or social context (Amabile *et al.*, 1996; Runco & Jaeger, 2012). Creative idea generation is central for contemporary students, as they need creativity throughout their educational journey. However, students often struggle to generate creative ideas for assignments, regular entrepreneurship projects, end-of-course research proposals, routine design tasks, and problem-based learning activities (Richardson & Mishra, 2018). Researchers have found that a lack of confidence, limited exposure to alternative perspectives, fear of evaluation, or reliance on conventional thinking patterns can prevent individuals from producing required creative outputs (Adeel & Batool, 2025; Bilton, 2015). AI-powered brainstorming tools can help to address these barriers to creativity (Singh & Huang, 2025). These AI tools offer idea cues, divergent prompts, relevant examples, and alternative framings that stimulate students' thinking; they can interact conversationally, generate multiple possibilities, and respond to follow-up prompts, creating a more dynamic ideation environment (Geroimenko, 2025; Leung & Lo, 2024). Although AI-powered brainstorming tools may expand students' idea pool, they should not be assumed to automatically support the generation of students' creative ideas, because students may accept machine-generated suggestions without reflection, proper evaluation, or personal elaboration. Therefore, the central issue here is not to what extent students use AI-powered brainstorming tools, but how the use of such AI tools shapes the psychological conditions through which creativity emerges. Creative self-efficacy is the belief that an individual can produce creative outcomes (Tierney & Farmer, 2002). Prior research has found it to be a significant motivational foundation of creative performance because

when individuals believe they are creative, they are more engaged in exploratory thinking and persist in creative tasks (T. Chen *et al.*, 2025; Tierney & Farmer, 2002, 2011).

Social Cognitive Theory argues that the behavior of humans is shaped by their reciprocal interactions among environmental resources, personal beliefs, and behavioral outcomes (Bandura, 1986; Bandura & Wessels, 1997). From this perspective, AI-powered brainstorming tools can be treated as environmental enablers that may strengthen students' belief that they can generate creative ideas. When students receive multiple suggestions, alternative angles, and supportive prompts from AI tools, they may begin to perceive creative tasks as less uncertain and more manageable. This stronger belief in their creative capability can motivate them to invest greater cognitive effort, explore more possibilities, and persist when initial ideas appear weak. In this way, creative self-efficacy provides a theoretically meaningful bridge between exposure to AI-powered brainstorming tools and actual creative idea generation.

In an educational context, this belief is particularly relevant because students' creativity is often shaped by confidence, encouragement, feedback, and perceived task mastery (Shao *et al.*, 2024). However, it is unclear whether AI tools enhance creativity because they directly provide ideas or because they strengthen students' confidence in their own creative capacity. At the same time, students are unlikely to benefit from AI-powered brainstorming tools in the same way. AI literacy is a critical boundary condition because effective use of AI requires more than access to the technology. AI literacy is individuals' competencies for understanding, usage, evaluation, and engagement with AI systems (Long & Magerko, 2020; Ng *et al.*, 2021). Ng *et al.* (2021) conceptualized AI as the ability to understand, apply, evaluate, and create with it, while considering the ethical issues involved. Similarly, Wang *et al.* (2023) developed an AI literacy scale built around usage, awareness, evaluation, and consideration of ethical concerns, highlighting that AI literacy influences how individuals interact with AI technologies. These dimensions are highly relevant for brainstorming because students with higher levels of AI literacy are expected to formulate better prompts, critically assess AI-generated suggestions, identify weak or repetitive ideas, and combine AI input with their own reasoning. Students with lower AI literacy, by contrast, may either underuse AI tools or depend on them uncritically, which may weaken the creative value of AI-supported ideation.

Accordingly, this study aims to examine whether AI-powered brainstorming tools influence creative idea generation among university students through the mediation of creative self-efficacy, and whether AI

literacy moderates this process. The question is: How do AI-powered brainstorming tools affect creative idea generation among university students through creative self-efficacy, and under what conditions does AI literacy strengthen or weaken this relationship? By answering this question, the current research moves from a conventional technology-use perspective toward a more nuanced explanation of AI-supported creativity in higher education. This research offers several contributions. The primary contribution to the educational technology literature is shifting attention from AI adoption and usage intention to AI-enabled creative learning outcomes. Second, it extends creativity research by positioning a key psychological mechanism- creative self-efficacy that links AI-powered brainstorming tools with creative idea generation. Third, by showing that AI literacy can also shape the creative benefits of AI use, this research contributes to the emerging AI literacy literature. Finally, it has practical significance for universities and instructors seeking to integrate AI tools into teaching.

2. Literature review and hypotheses development

Creativity is the generation of novel and useful ideas in a given context (Amabile *et al.*, 1996; Runco & Jaeger, 2012). It has now become a central component of student learning because universities increasingly expect their students to move beyond memorization and towards the originality of their ideas (Amabile *et al.*, 1996; Anderson & Krathwohl, 2001; Pinar *et al.*, 2025). For university students, creativity is important as it is now expected in almost every learning task they perform during their regular and routine activities (Šliogerienė *et al.*, 2025).

Brainstorming has long been understood as a structured approach to idea generation rather than a general act of thinking creatively. The technique is commonly traced to Osborn's work on applied imagination, where brainstorming was introduced as a method for encouraging the production of many ideas before evaluation or criticism occurs (Osborn, 1953). Subsequent research has treated brainstorming as a deliberate ideational process in which individuals or groups generate, combine, elaborate, and refine ideas in order to increase the quantity and potential novelty of creative outputs (Paulus & Brown, 2003; Paulus & Kenworthy, 2019). This distinction is important because creative idea generation is not merely the presence of creativity as an outcome; it is shaped by the process through which ideas are stimulated, varied, compared, and developed. Brainstorming is therefore central to the present study because AI-powered brainstorming tools are expected to influence students' creative idea generation by changing the conditions under which ideas are produced.

Artificial intelligence-powered brainstorming differs from ordinary AI use because it refers specifically to using AI tools for ideational purposes, including generating alternative ideas, expanding initial thoughts, suggesting different perspectives, comparing possible directions, and supporting the refinement of emerging ideas. Recent work on AI-assisted brainstorming argues that AI can enrich brainstorming by reducing some barriers associated with idea generation, such as limited perspective, hesitation, and difficulty in producing diverse alternatives, while also introducing new concerns related to overreliance, reduced originality, and weakened human ownership of ideas (Rowland & Grüning, 2025). Thus, AI-powered brainstorming should not be treated simply as "using AI." Rather, it reflects a more specific form of human AI interaction in which AI functions as an ideational partner that may stimulate students' thinking, but whose creative value depends on how actively and critically students engage with its suggestions.

In the present study, AI-powered brainstorming tools are therefore conceptualized as AI-based tools used specifically to support the ideation process rather than general AI use. This distinction matters because students may use AI for many academic purposes, including summarizing readings, correcting grammar, searching for explanations, or drafting text. Such uses may support learning, but they do not necessarily represent brainstorming. AI-powered brainstorming, by contrast, refers to AI-supported engagement with the early and developmental stages of idea production, where students ask AI tools to generate alternatives, extend initial ideas, compare possible directions, suggest different perspectives, or help refine emerging concepts.

Rowland and Grüning (2025) similarly show that AI-assisted brainstorming can support scenario thinking by expanding the range of possibilities considered, but they also caution that the value of AI depends on how users frame, evaluate, and work with AI-generated possibilities. Accordingly, this study treats AI-powered brainstorming tools as a specific ideational resource that may support creative idea generation when students use AI suggestions as inputs for further thinking rather than as finished substitutes for their own ideas.

Artificial intelligence-powered brainstorming tools are particularly relevant in this process because these AI tools can help students by providing a prompt response, an alternative perspective, relevant examples, and immediate and accurate feedback before any human, helping the student's cognitive search space (Adeel *et al.*, 2026). AI-powered brainstorming tools can help students generate, expand, compare, and refine their ideas. However,

a more nuanced view is needed because AI-supported brainstorming may not always strengthen students' creative confidence or agency. If students treat AI-generated ideas as substitutes for their own thinking, AI use may reduce their sense of ownership, weaken perceived personal contribution, and limit deeper engagement with the creative process. Recent evidence suggests that reliance on AI at work can reduce self-efficacy, ownership, and meaning, whereas active collaboration with AI can mitigate these negative effects (Lee *et al.*, 2026). This distinction is directly relevant to AI-powered brainstorming. When students use AI as a collaborator, they may interpret AI-generated suggestions as prompts for further thinking, comparison, and refinement. When they use AI as a substitute, however, the same tool may weaken creative agency by shifting the perceived source of the idea from the student to the technology. Therefore, the present study does not assume that AI-powered brainstorming is automatically beneficial; rather, it examines whether and when such tools are associated with students' creative self-efficacy and creative idea generation. AI-powered brainstorming tools differ from conventional digital tools and resources because they can respond interactively with students, generate multiple options, and help students refine vague thoughts into more structured possibilities. The researchers have recently found that generative AI can enhance individual creative output (Zhu & Zou, 2026), although it can also reduce the collective diversity of thoughts and ideas when users depend on similar AI-generated suggestions for their activities (Doshi & Hauser, 2024). These arguments suggest that AI-powered brainstorming tools may support creative idea generation when students use them as cognitive partners rather than as substitutes for their own thinking. Thus, we propose here:

- H1: AI-powered brainstorming tools are positively related to creative idea generation among university students.

Social Cognitive Theory argues that the interactions of environmental resources, personal cognitive beliefs, and actions shape individuals' behaviors (Bandura, 1986; Bandura & Wessels, 1997). From the perspective of social cognitive theory, AI-powered brainstorming tools represent the environmental resources that can influence students' beliefs about their creative capacity. The students receive idea cues about their academic tasks, alternative viewpoints, and language support for their academic activities that may reduce the perceived difficulty of creative tasks when the students interact with AI tools; this experience can strengthen their creative self-efficacy (Tierney & Farmer, 2002). Therefore, higher and stronger creative self-efficacy of the student is expected to help

students approach their academic tasks with confidence, explore unconventional possibilities, and persist when initial ideas are incomplete or uncertain for creative output in their routine activities. Therefore, we propose here that AI-powered brainstorming tools may not only provide ideas directly but also enhance the confidence of the students in their own abilities to generate creative ideas. Thus, we propose here:

- H2: AI-powered brainstorming tools are positively related to creative self-efficacy among university students.

Creative self-efficacy is an important motivational mechanism in creativity (T. Chen *et al.*, 2025; He & Zhang, 2025). Students who believe that they can be creative are more likely to invest cognitive effort, tolerate ambiguity, and experiment with alternative solutions (T. Chen *et al.*, 2025). Researchers have long presented creative self-efficacy as a distinct belief that predicts creative performance (Tierney & Farmer, 2002), while later work showed that such efficacy beliefs can develop over time and influence subsequent creative outcomes (Tierney & Farmer, 2011). Individuals often hold back creative ideas because of fear of rejection, uncertainty, or criticism (Adeel *et al.*, 2026). In the context of university students, this motivational mechanism is particularly important, as many students may initially hesitate to discuss and present novel and useful ideas because of fear of criticism, lack of experience, or uncertainty about what counts as creative. AI-supported brainstorming can reduce these uncertainty-related beliefs by offering starting points and encouraging students to revise, combine, and elaborate their creative ideas. However, the creative outcome depends on whether students internalize this support as confidence in their own creative ability. When students feel more capable of generating creative ideas, their engagement in the creative process is expected to increase rather than passively accept AI suggestions. Thus, we propose here:

- H3: Creative self-efficacy is positively related to creative idea generation among university students.

Creative self-efficacy as a mediator is important because it explains why AI-powered brainstorming tools may lead to stronger creative idea generation. The use of technology perspective assumes that access to technology is not enough (Adeel *et al.*, 2023). However, individuals with sufficient motivation may see AI as improving creativity because it provides more ideas. However, a social cognitive perspective explanation suggests that AI tools influence creativity by strengthening the beliefs of the students that they can think creatively (Baltà-Salvador *et al.*, 2025). This perspective and distinction is theoretically important, as it has been found that the same AI tool may

produce different outcomes for individuals depending on how the users interpret and use the AI tool. In the case of the students, those who use AI suggestions as scaffolding for their academic activities are more likely to be more confident and then subsequently generate more creative ideas. In contrast, students who treat AI as a replacement for their own thinking are more likely to produce outputs that appear complete but do not reflect genuine creative engagement in their routine activities. Therefore, creative self-efficacy is expected to serve as the psychological pathway through which AI-powered brainstorming tools enhance creative idea generation. Thus, we propose here:

- H4: Creative self-efficacy mediates the positive relationship between AI-powered brainstorming tools and creative idea generation among university students.

Artificial intelligence literacy is also expected to shape students' effectiveness of AI-powered brainstorming tools, as it is the application of knowledge, enhancement of skills, and evaluation capacity of the individuals that is required for the understanding, usage, assessment, and ethical engagement with AI systems (Long & Magerko, 2020; Ng *et al.*, 2021). Few researchers have further conceptualized AI literacy around usage, awareness, evaluation, and ethical boundaries, emphasizing that AI literacy reflects user competence in interacting with AI technologies (Wang *et al.*, 2023). In the context of brainstorming, students with higher AI literacy are better positioned to write effective prompts, evaluate the quality of creativity augmented by the AI tools they use, detect limitations of AI systems, understand biases, and combine AI suggestions with their own disciplinary knowledge. Conversely, students with lower AI literacy may not be able to evaluate AI-generated ideas and may either underuse AI-generated ideas and tools or rely on the ideas provided by those AI tools. Therefore, AI literacy may function as a boundary condition that determines whether AI-powered brainstorming tools translate into stronger creative confidence. Thus, we propose here:

- H5: AI literacy moderates the relationship between AI-powered brainstorming tools and creative self-efficacy, such that the relationship is stronger for students with higher AI literacy.

Artificial intelligence literacy may also condition the broader AI-powered brainstorming tools and creativity relationship. Although AI tools can generate multiple novel ideas quickly, the creative value of those ideas depends on the student's ability to evaluate them, adapt them, and transform them into contextually meaningful outputs. Students with high AI literacy can use AI as a reflective thinking partner and an expert with whom they discuss

their ideas, rather than as a mechanical answer provider. Students with elevated AI literacy are expected to evaluate AI-generated ideas by challenging assumptions, requesting alternatives, combining suggestions, and refining them to meet task requirements. Conversely, lower levels of AI literacy unintentionally encourage superficial use, where students accept AI-generated responses without sufficient evaluation or personal contribution. This perspective and distinction are important, as research on AI and creativity suggests that AI can improve individual creative performance while also creating risks of similarity and reduced diversity in individuals' outputs (Doshi & Hauser, 2024). Therefore, the positive influence of AI-powered brainstorming tools on creative idea generation is expected to be stronger when students possess higher AI literacy. Thus, we propose here:

- H6: AI literacy moderates the relationship between AI-powered brainstorming tools and creative idea generation, such that the relationship is stronger for students with higher AI literacy.

Finally, the proposed model suggests that the indirect effect of AI-powered brainstorming tools on the generation of creative ideas through creative self-efficacy is moderated by AI literacy, a moderated mediation process of this model. The proposal is that AI-powered brainstorming tools are most likely to enhance students' creative idea generation when students not only have access to these AI tools, but also possess the relevant literacy required to use them critically and effectively. Higher levels of AI literacy may help students engage with AI-generated outputs more logically, which may increase their own creative confidence, and this confidence may further explain and improve their own ability to produce creativity. However, when AI literacy is low, the students may struggle to transform these AI interactions into creative self-beliefs and creative outputs. This argument aligns with Social Cognitive Theory because environmental support influences behavior more effectively when individuals have the personal capabilities needed to interpret and use that support productively (Bandura, 1986; Bandura & Wessels, 1997). Thus, we propose here:

- H7: AI literacy moderates the indirect relationship between AI-powered brainstorming tools and creative idea generation through creative self-efficacy, such that the indirect effect is stronger for students with higher AI literacy.

The proposed relationships are presented in [Figure 1](#).

3. Methodology

This study was approved by the Ethical Committee—INTI International University; Reference no.: INTI/

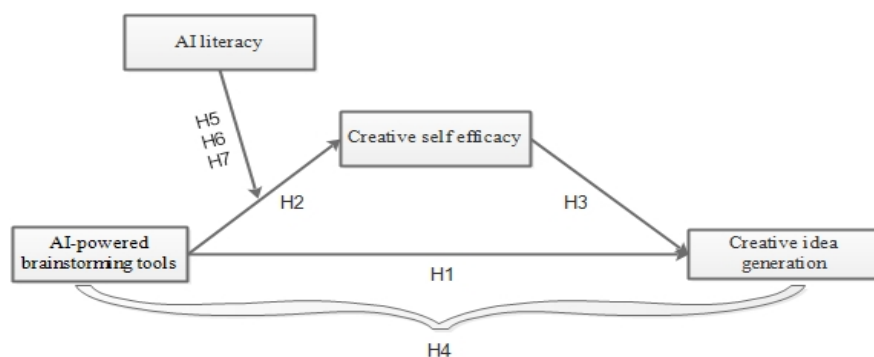


Figure 1. Hypothesized moderated mediation model linking artificial intelligence (AI)-powered brainstorming tools, creative self-efficacy, AI literacy, and creative idea generation

UEC/2026/003. This research used a quantitative, cross-sectional survey design for data collection and the examination of the relationship between AI-powered brainstorming tools and creative idea generation among undergraduate students in the business domain. The population of interest for this research consisted of the undergraduate business students enrolled in a private sector university in Malaysia. This research design was appropriate because this research aimed to capture students' perceptions of AI-powered brainstorming tools, AI literacy, creative self-efficacy, and creative idea generation at the individual level.

Data were collected through a classroom-administered, paper-based questionnaire designed specifically for this study. The study was not a secondary analysis of data collected for another purpose. After regular lectures, one author visited undergraduate business classes, briefly explained the academic purpose of the study, and invited students to participate voluntarily. Students completed the questionnaire in class and returned it directly to the researcher. The questionnaire included items measuring AI-powered brainstorming tools, AI literacy, creative self-efficacy, creative idea generation, and demographic/control variables. No specific AI tool was assigned to students during the survey. Instead, students reported their perceptions and prior use of AI tools for brainstorming-related academic activities, such as generating, expanding, refining, and comparing ideas. The survey took approximately 10–15 minutes to complete. Participants received no financial reward, course credit, or other incentive for participating. Students were informed that participation was voluntary, their responses would remain confidential, and the data would be used only for academic research purposes.

To clarify the context of AI use, the study did not assign a specific AI tool to participants during data collection. Rather, students responded based on their prior use of

commonly available AI tools for academic work, such as generative AI chatbots and related AI-supported writing or ideation tools. The questionnaire focused specifically on AI use for brainstorming-related academic activities rather than general AI use. Students reported the extent to which AI tools helped them generate, expand, compare, and refine ideas for academic tasks. These tasks were comparable in the sense that they were situated within undergraduate business coursework and commonly involved assignments, presentations, case analyses, project work, entrepreneurship-related idea development, and problem-solving activities. Prior AI use and weekly AI usage hours were included as control variables to account for students' general familiarity and exposure to AI tools; however, the focal AI-powered brainstorming tools measure captured students' perceived use of AI specifically for ideation-related academic work.

We also informed students that participation was voluntary and that their individual responses would be treated confidentially and used only for research purposes. Across all visits, 387 agreed to participate, and 324 completed questionnaires were returned, for a response rate of approximately 83.7%. After deleting data with missing values and incomplete response patterns, we retained 293 valid responses from undergraduate students enrolled in business-related programs as the final sample, which we used for all analyses. This represented 90.4% of the returned questionnaires and 75.7% of the students who initially agreed to participate. In our final qualified sample, 58% of the respondents were female; 69% were Chinese, while the remaining respondents included Malay, Indian, Vietnamese, Laotian, and Thai students.

3.1. Measures

The study variables were measured with a five-point Likert scale (1: Strongly disagree; 5: Strongly agree). AI-powered brainstorming tools were measured with five study-specific

items developed for this research to capture AI-supported ideational use rather than general AI use. The items were conceptually derived from prior literature on generative AI-supported creativity, AI-assisted ideation, and AI literacy (Doshi & Hauser, 2024; Hinkin, 1998; Long & Magerko, 2020; MacKenzie *et al.*, 2011; Wang *et al.*, 2023). The items captured how students used AI tools to generate, expand, refine, and compare ideas during academic tasks. No specific AI tool was assigned to students during the survey. Instead, students reported their perceptions and prior use of AI tools for brainstorming-related academic activities. Sample items included “AI tools help me generate multiple ideas for academic tasks” and “AI tools help me think about problems from different perspectives” ($\alpha = 0.90$). Confirmatory factor analysis results further supported the construct’s reliability, convergent validity, and discriminant validity. Creative self-efficacy was measured with four adapted items (Tierney & Farmer, 2002). The construct captured students’ confidence in their ability to produce creative and useful ideas. Sample items included “I am confident in my ability to generate creative ideas” and “I believe I can develop novel solutions for academic tasks” ($\alpha = 0.88$). AI literacy was measured with eight items adapted from the conceptualization of AI literacy (Long & Magerko, 2020; Ng *et al.*, 2021; Wang *et al.*, 2023). The items reflected students’ perceived ability to use AI tools effectively, assess AI-generated content, recognize limitations in AI outputs, and apply AI responsibly in academic work. Sample items included “I can evaluate whether AI-generated suggestions are useful for my task” and “I understand that AI-generated outputs may contain errors or bias” ($\alpha = 0.92$). Creative idea generation was measured using five items adapted from creativity and idea generation research (Zhou & George, 2001). The items captured students’ tendency to produce novel, useful, and diverse ideas in academic tasks. Sample items included “I generate original ideas for academic assignments” and “I develop useful ideas that improve the

quality of my academic work” ($\alpha = 0.89$). The measurement properties of the four substantive constructs were assessed through confirmatory factor analysis, internal consistency reliability, composite reliability, and average variance extracted. The results are reported in [Tables 1](#) and [2](#). The complete list of measurement items is provided in [Appendix A](#).

3.2. Control variables

Demographic characteristics, academic stage, academic performance, and prior familiarity with AI may influence both students’ use of AI-powered brainstorming tools and their creative outcomes (He & Wong, 2021; Laupichler *et al.*, 2022; Stöhr *et al.*, 2024; Tierney & Farmer, 2002; Wang *et al.*, 2023). To reduce the chances of alternative explanations, we included several control variables. These controls included gender, age, ethnic background, year of study, cumulative grade point average, prior AI use, and weekly AI usage hours.

4. Analyses and results

Data for this research were analyzed using Mplus (Version 8, Muthén & Muthén, USA) following a regression-based moderated mediation approach. Before hypothesis testing, descriptive statistics and reliabilities were examined ([Table 3](#)), providing initial support for the proposed theoretical logic. The first model revealed the total effect of AI-powered brainstorming tools on creative idea generation, controlling for gender, age, ethnic background, year of study, cumulative grade point average, prior AI use, and weekly AI usage hours. The model was significant, with $R^2 = 0.145$ ([Table 4](#)). AI-powered brainstorming tools had a positive and significant relationship with creative idea generation, $\beta = 0.359$, standard error (SE) = 0.056, 95% confidence interval (CI) [0.249, 0.469], $p < 0.001$, indicating that students with greater use of AI-powered brainstorming are linked with higher levels of creative idea generation. Therefore, H1 is supported.

Table 1. Confirmatory factor analysis

Model	χ^2	Df	χ^2/df	CFI	TLI	RMSEA	SRMR
Four-factor model	339.928	203	1.675	0.964	0.959	0.048	0.046
One-factor model	4061.991	231	17.584	0.000	0.000	0.182	0.161

Notes: $n = 293$; standardized factor loadings are reported for the measurement items. Higher factor loadings indicate stronger item representation of the respective latent construct; the hypothesized four-factor model was assessed using confirmatory factor analysis and compared to alternative measurement models to establish discriminant validity; better model fit is indicated by higher CFI and TLI values and lower RMSEA and SRMR values. Abbreviations: CFI: Comparative fit index; RMSEA: Root mean square error of approximation; SRMR: Standardized root mean square residual; TLI: Tucker–Lewis index.

Table 2. Construct reliability and convergent validity

Construct	Item	Factor loading	α	CR	AVE
AI-powered brainstorming tools	AIBT1	0.840	0.901	0.927	0.717
	AIBT2	0.828			
	AIBT3	0.869			
	AIBT4	0.850			
	AIBT5	0.846			
AI literacy	AIL1	0.830	0.922	0.936	0.648
	AIL2	0.832			
	AIL3	0.789			
	AIL4	0.796			
	AIL5	0.804			
	AIL6	0.800			
	AIL7	0.802			
	AIL8	0.786			
Creative self-efficacy	CSE1	0.868	0.882	0.919	0.740
	CSE2	0.856			
	CSE3	0.855			
	CSE4	0.862			
Creative idea generation	CIG1	0.806	0.892	0.920	0.698
	CIG2	0.832			
	CIG3	0.838			
	CIG4	0.861			
	CIG5	0.841			

Notes: $n = 293$; standardized factor loadings are reported for the measurement items; higher factor loadings indicate stronger item representation of the respective latent construct; values of CR above 0.70 and AVE above 0.50 indicate acceptable reliability and convergent validity.

Abbreviations: AI: Artificial intelligence; AIBT: Artificial intelligence-powered brainstorming tools; AIL: Artificial intelligence literacy; AVE: Average variance extracted; CIG: Creative idea generation; CR: Composite reliability; CSE: Creative self-efficacy.

The second model tested the effect of AI-powered brainstorming tools on creative self-efficacy and examined the moderating role of AI literacy. This model explains 29.9% of the variance in creative self-efficacy, with $R^2 = 0.299$ (Table 5). AI-powered brainstorming tools had a positive impact on creative self-efficacy, $\beta = 0.408$, $SE = 0.053$, 95% CI [0.304, 0.512], $p < 0.001$. The relationship between AI literacy and creative self-efficacy was also positive, $\beta = 0.224$, $SE = 0.058$, 95% CI [0.111, 0.338], $p < 0.001$. More importantly, the interaction between

AI-powered brainstorming tools and AI literacy was significant, $\beta = 0.134$, $SE = 0.053$, 95% CI [0.031, 0.237], $p = 0.008$. Simple slope analysis results confirm that the impact of AI-powered brainstorming tools on creative self-efficacy was positive at low AI literacy, $\beta = 0.274$, $SE = 0.068$, 95% CI [0.140, 0.408], $p < 0.001$, but stronger at high AI literacy, $\beta = 0.542$, $SE = 0.076$, 95% CI [0.392, 0.691], $p < 0.001$ (Figure 2). These findings support H2 and H5.

The third model examined creative idea generation as the dependent variable and included AI-powered

Table 3. Descriptive statistics and correlations

Variable	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. Gender	0.58	0.49	–										
2. Age	21.04	1.30	0.01	–									
3. Ethnic background	0.69	0.46	0.03	–0.02	–								
4. Year of study	2.47	1.07	–0.04	0.44***	0.01	–							
5. CGPA	3.17	0.35	–0.06	0.18**	–0.07	0.30***	–						
6. Prior AI use	0.73	0.44	0.03	–0.07	0.02	–0.04	0.04	–					
7. Weekly AI usage hours	5.77	3.18	–0.06	–0.01	–0.03	–0.01	0.10	0.10	–				
8. AI-powered brainstorming tools	2.95	1.03	0.05	0.02	0.02	0.03	–0.02	0.17**	0.01	–			
9. AI literacy	2.91	0.97	0.06	0.19**	–0.03	0.21***	0.18**	0.07	–0.10	0.22***	–		
10. Creative self-efficacy	2.91	1.05	0.06	0.02	0.02	0.14*	0.16**	0.10	–0.01	0.44***	0.33***	–	
11. Creative idea generation	2.87	1.03	0.02	0.05	0.03	0.13*	0.05	–0.01	0.02	0.35***	0.28***	0.55***	–

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; $n = 293$; gender was coded as 1 = female and 0 = male; ethnic background was coded as 1 = Chinese and 0 = other ethnic/national group; prior AI use was coded as 1 = yes and 0 = no; reliability coefficients (Cronbach's alpha) for multi-item constructs are reported in parentheses on the diagonal; control variables do not have reliability coefficients.
Abbreviations: CGPA: Cumulative grade point average; M: Mean; SD: Standard deviation.

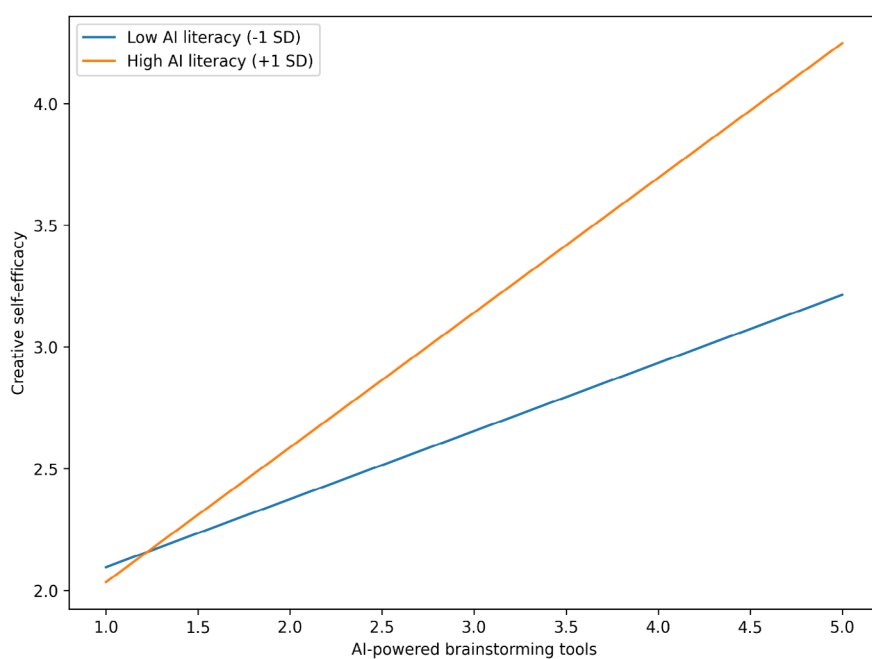


Figure 2. Moderating role of artificial intelligence (AI) literacy in the relationship between AI-powered brainstorming tools and creative self-efficacy

Table 4. Regression results for simple mediation

Variables	Model 1: CIG (total effect)			Model 2: CSE			Model 3: CIG (direct effect)		
Predictor	β	SE	95% CI	β	SE	95% CI	β	SE	95% CI
Gender (female)	0.022	0.115	[−0.203, 0.247]	0.093	0.106	[−0.116, 0.301]	−0.024	0.101	[−0.223, 0.174]
Age	−0.017	0.057	[−0.129, 0.095]	−0.067	0.056	[−0.177, 0.043]	0.016	0.052	[−0.086, 0.119]
Ethnic background	0.064	0.118	[−0.167, 0.296]	0.032	0.117	[−0.197, 0.260]	0.049	0.107	[−0.160, 0.257]
Year of study	0.119	0.067	[−0.012, 0.251]	0.106	0.061	[−0.012, 0.225]	0.066	0.059	[−0.049, 0.182]
CGPA	0.026	0.056	[−0.084, 0.137]	0.161**	0.054	[0.056, 0.266]	−0.054	0.049	[−0.150, 0.043]
Prior AI use	−0.156	0.118	[−0.387, 0.075]	0.058	0.122	[−0.181, 0.297]	−0.185	0.106	[−0.392, 0.022]
Weekly AI usage hours	0.024	0.056	[−0.085, 0.134]	−0.036	0.054	[−0.141, 0.069]	0.042	0.049	[−0.053, 0.137]
AI-powered brainstorming tools	0.359***	0.056	[0.249, 0.469]	0.437***	0.054	[0.331, 0.543]	0.141*	0.057	[0.030, 0.253]
Creative self-efficacy	–	–	–	–	–	–	0.498***	0.054	[0.392, 0.603]
R^2	0.145	–	–	0.239	–	–	0.366	–	–
Indirect effect (AIBT → CSE → CIG)	–	–	–	–	–	–	0.217	–	[0.152, 0.292]

Notes: * $p < 0.05$; ** $p < 0.01$, *** $p < 0.001$; $n = 293$; standardized regression coefficients are reported; Model 1 estimates the total effect of AI-powered brainstorming tools on creative idea generation after including all control variables; Model 2 estimates the path from AI-powered brainstorming tools to creative self-efficacy; Model 3 estimates the direct effect of AI-powered brainstorming tools on creative idea generation after creative self-efficacy is included; control variables include gender, age, ethnic background, year of study, CGPA, prior AI use, and weekly AI usage hours; CIs are 95%.

Abbreviations: AI: Artificial intelligence; AIBT: Artificial intelligence-powered brainstorming tools; CGPA: Cumulative grade point average; CI: Confidence interval; CIG: Creative idea generation; CSE: Creative self-efficacy; SE: Standard error.

brainstorming tools, creative self-efficacy, AI literacy, the interaction term, and all control variables ($R^2 = 0.361$) (Table 5). The model explained 36.1% of the variance in creative idea generation. Creative self-efficacy was significantly associated with creative idea generation, $\beta = 0.445$, $SE = 0.057$, 95% CI [0.332, 0.557], $p < 0.001$; this finding supports H3. AI-powered brainstorming tools remained positively related to creative idea generation after including creative self-efficacy, $\beta = 0.157$, $SE = 0.055$, 95% CI [0.048, 0.265], $p = 0.005$, indicating partial mediation. AI literacy was also significant, $\beta = 0.120$, $SE = 0.053$, 95% CI [0.016, 0.224], $p = 0.024$.

The moderating role of AI literacy in the interaction between AI-powered brainstorming tools and AI literacy was significant in predicting creative idea generation, $\beta = 0.135$, $SE = 0.048$, 95% CI [0.040, 0.230], $p = 0.006$ (Table 5). Simple slope analysis showed the direct impact of AI-powered brainstorming tools on creative idea

generation; the results confirmed that the impact was not significant at low AI literacy, $\beta = 0.022$, $SE = 0.067$, 95% CI [−0.109, 0.154], $p = 0.742$. However, the relationship became significant and stronger when AI literacy was high, $\beta = 0.291$, $SE = 0.079$, 95% CI [0.136, 0.447], $p < 0.001$ (Figure 3). This suggests that students benefit more creatively from AI-powered brainstorming tools when they possess stronger AI literacy, supporting H6. The mediation hypothesis was tested using 5,000 bootstrap resamples. The indirect impact of AI-powered brainstorming tools on creative idea generation through the mediation of creative self-efficacy was confirmed by the results. As shown in Table 4, the indirect effect (0.217; 95% bootstrap CI [0.152, 0.292]) was significant. Since the confidence interval did not include zero, H4 was supported. This result suggests that AI-powered brainstorming tools are associated with creative idea generation partly because they strengthen students' confidence in their own creative ability.

Table 5. Hierarchical regression analysis results for moderated mediation

Outcome	Predictor	B	SE	95% CI
CSE	Gender (female)	0.073	0.103	[−0.128, 0.274]
CSE	Age	−0.086	0.053	[−0.190, 0.017]
CSE	Ethnic background	0.062	0.111	[−0.157, 0.280]
CSE	Year of study	0.072	0.060	[−0.046, 0.190]
CSE	CGPA	0.136*	0.054	[0.031, 0.241]
CSE	Prior AI use	0.010	0.117	[−0.219, 0.240]
CSE	Weekly AI usage hours	−0.012	0.051	[−0.112, 0.087]
CSE	AI-powered brainstorming tools	0.408***	0.053	[0.304, 0.512]
CSE	AI literacy	0.224***	0.058	[0.111, 0.338]
CSE	AI brainstorming × AI literacy	0.134**	0.053	[0.031, 0.237]
CSE	R ²	0.299		
CIG	Gender (female)	−0.027	0.099	[−0.221, 0.167]
CIG	Age	0.005	0.054	[−0.100, 0.110]
CIG	Ethnic background	0.073	0.106	[−0.135, 0.282]
CIG	Year of study	0.049	0.060	[−0.068, 0.167]
CIG	CGPA	−0.055	0.050	[−0.153, 0.043]
CIG	Prior AI use	−0.216*	0.103	[−0.419, −0.013]
CIG	Weekly AI usage hours	0.051	0.049	[−0.045, 0.147]
CIG	AI-powered brainstorming tools	0.157**	0.057	[0.046, 0.268]
CIG	AI literacy	0.120*	0.055	[0.012, 0.228]
CIG	AI brainstorming × AI literacy	0.135**	0.048	[0.041, 0.228]
CIG	Creative self-efficacy	0.445***	0.058	[0.331, 0.558]
CIG	R ²	0.361		

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; $n = 293$; standardized beta coefficients are reported, with standard errors presented in separate columns; the interaction term was created by multiplying AI-powered brainstorming tools and AI literacy after standardizing the continuous variables; control variables include gender, age, ethnicity, year of study, CGPA, prior AI use, and weekly AI usage hours; a significant interaction term indicates that the strength of the relationship differs across levels of AI literacy.

Abbreviations: AI: Artificial intelligence; CI: Confidence interval; CIG: Creative idea generation; CSE: Creative self-efficacy; SE: Standard error.

Finally, the moderated mediation analysis results confirmed the indirect effect differed across levels of AI literacy. At low AI literacy, the indirect effect was significant but weaker, with indirect effect = 0.123, 95% bootstrap CI [0.066, 0.187]. At high AI literacy, the indirect effect became stronger, with indirect effect = 0.241, 95% bootstrap CI [0.153, 0.342]. The index of moderated mediation was significant (0.059; 95% bootstrap CI

[0.013, 0.108]) (Table 6). Because the confidence interval excluded zero, the results support H7. This indicates that AI literacy strengthens the indirect effect of AI-powered brainstorming tools on creative idea generation through creative self-efficacy.

Overall, the findings support the proposed moderated mediation model. AI-powered brainstorming tools were positively associated with creative idea generation and

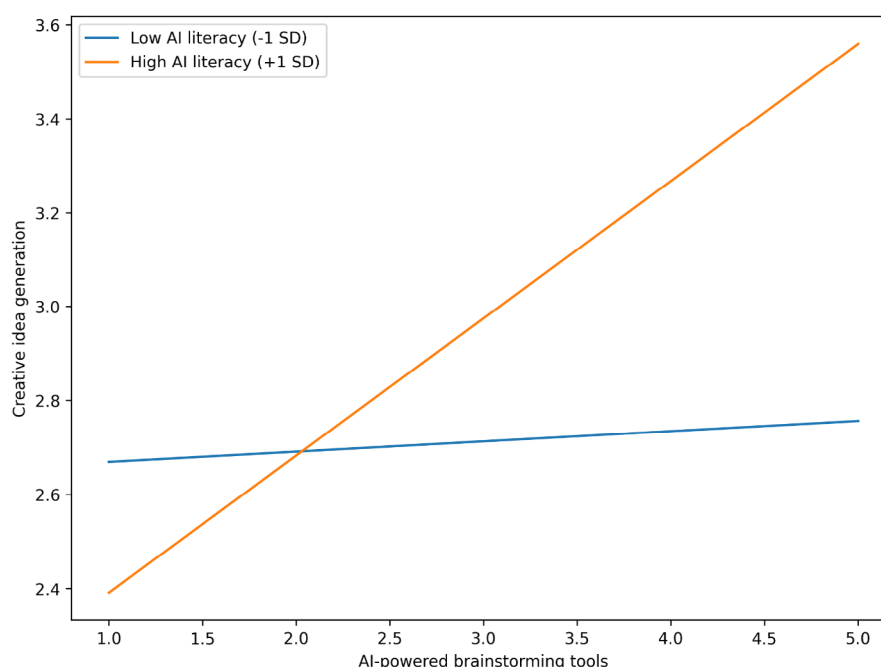


Figure 3. Moderating role of artificial intelligence (AI) literacy in the relationship between AI-powered brainstorming tools and creative idea generation

Table 6. Conditional indirect effect of AI-powered brainstorming tools on creative idea generation via creative self-efficacy at different levels of AI literacy

Level of AI literacy	Indirect effect	Boot LL 95% CI	Boot UL 95% CI	Decision
Low AI literacy (mean – 1 SD)	0.123	0.066	0.187	Significant
High AI literacy (mean + 1 SD)	0.241	0.153	0.342	Significant
Index of moderated mediation	0.059	0.013	0.108	Significant

Notes: $n = 293$; low AI literacy represents one SD below the mean, while high AI literacy represents one SD above the mean; conditional indirect effects were estimated using 5,000 bootstrap resamples; the conditional indirect effect is significant when the confidence interval does not include zero. Abbreviations: AI: Artificial intelligence; CI: Confidence interval; LL: Lower limit; SD: Standard deviation; UL: Upper limit.

were also indirectly related to creative idea generation through creative self-efficacy. However, these relationships were stronger among students with higher AI literacy. This pattern suggests that AI tools alone may not be sufficient to maximize student creativity; students must also possess the literacy required to evaluate, refine, and meaningfully use AI-generated suggestions (Tables 4–7).

5. Discussion

Our findings show that AI-powered brainstorming tools played an important role in enhancing creative idea generation of undergraduate business students. The results suggest that AI-supported brainstorming can help students think differently by exploring alternative perspectives, expanding their idea pool, and overcoming the initial

barrier in creative academic tasks. This interpretation aligns with the view that brainstorming supports creativity by expanding the number, variety, and elaboration of ideas before evaluation occurs (Osborn, 1953; Paulus & Brown, 2003; Rowland & Grüning, 2025). It was also confirmed by the results of this research that creative self-efficacy explains the underlying mechanism that links the relationship between AI-powered brainstorming and creative idea generation, indicating that the AI tools enhance students' creativity not only by providing the needed suggestions, but also by strengthening the confidence of the students in their own ability and capacity. At the same time, this finding should be interpreted carefully. The positive association between AI-powered brainstorming tools and creative self-efficacy does not

imply that all forms of AI use strengthen students' creative agency. Recent evidence suggests that reliance on AI can reduce self-efficacy, ownership, and meaning when users experience AI as replacing rather than supporting their own contribution (Lee *et al.*, 2026). The present findings are more consistent with a collaborative interpretation: AI-powered brainstorming appears to support creative self-efficacy when students use AI-generated suggestions as prompts for further thinking, refinement, and idea development. This also helps explain why AI literacy plays a strengthening role in the model, as students with higher AI literacy may be better able to use AI as an ideational partner rather than as a substitute for their own creative effort. The findings further show that AI literacy enhanced the impact of AI-powered brainstorming tools on students' creative self-efficacy and their generation of creative ideas. Students with higher AI literacy are better positioned to use AI-generated suggestions critically, refine outputs, and translate AI support into meaningful creative output. The results suggest that access to technology alone is not enough for creative potential; rather, it is students' ability to use AI thoughtfully and responsibly, indicating that AI-powered brainstorming tools can contribute to students' creativity when combined with creative confidence and adequate AI literacy.

5.1. Theoretical contributions

This research offers several theoretical contributions. First, our study shifts the conventional focus from general AI adoption to AI-enabled creativity. Much current research on AI adoption and students' creativity has emphasized academic writing, learning efficiency, assessment concerns, and the ethical risks associated with AI use and creativity. While the findings are important for the literature, they

do not fully explain how AI tools may support students' creative thinking. In this study, we examined creative idea generation as an outcome; doing so, we have positioned AI-powered brainstorming tools as potential cognitive resources for creative learning.

Second, our study also extends the literature on creative idea generation (Ahmad *et al.*, 2023; Amoozegar *et al.*, 2025; Song *et al.*, 2025) by identifying creative self-efficacy as the underlying mediating mechanism for the relationship between AI-powered brainstorming tools and creative idea generation. Prior research on creative idea generation has shown that creative self-efficacy predicts creative behavior and performance (Tierney & Farmer, 2002, 2011). However, little is known about how AI-based learning resources shape creative self-efficacy among students. Our study addressed this gap by showing that AI-powered brainstorming tools can enhance creative self-beliefs, which then support creative idea generation. This contributes to a more psychologically grounded understanding of AI-supported creativity.

Third, our study also contributes to social cognitive theory by applying it to AI-assisted learning and creativity. Our findings supported the assumptions of social exchange theory that external environmental resources influence behavior through personal cognitive mechanisms (Bandura, 1986; Bandura & Wessels, 1997). In our study, AI-powered brainstorming tools serve as environmental supports, creative self-efficacy as a personal belief mechanism, and creative idea generation as the behavioral outcome. Adding AI literacy further enriched the model by showing that individual capability shapes the extent to which environmental resources affect individuals' personal beliefs and behaviors.

Table 7. Summary of direct, indirect, and conditional effects

Effect	Estimate	SE	95% CI	Decision
Direct effect: AI brainstorming → creative idea generation	0.157	0.057	[0.046, 0.268]	Supported
Indirect effect through creative self-efficacy	0.217		[0.152, 0.292]	Supported
Interaction: AI brainstorming × AI literacy → creative self-efficacy	0.134	0.053	[0.031, 0.237]	Supported
Interaction: AI brainstorming × AI literacy → creative idea generation	0.135	0.048	[0.041, 0.228]	Supported
Conditional indirect effect at low AI literacy	0.123	–	[0.066, 0.187]	Supported
Conditional indirect effect at high AI literacy	0.241	–	[0.153, 0.342]	Supported
Index of moderated mediation	0.059	–	[0.013, 0.108]	Supported

Notes: $n = 293$; this table summarizes the direct, indirect, moderating, and moderated mediation effects tested in the proposed model; direct effects represent the regression paths among the main study variables; indirect effects represent the mediating role of creative self-efficacy; conditional effects indicate whether the strength of the relationship changes across low and high levels of AI literacy; the index of moderated mediation is significant when its bootstrap confidence interval does not include zero.

Abbreviations: AI: Artificial intelligence; CI: Confidence interval; SE: Standard error.

Finally, our study positions AI literacy as more than a technical skill. AI literacy is considered to be understanding AI systems, using AI tools, evaluating outputs, and recognizing ethical issues (Long & Magerko, 2020; Ng *et al.*, 2021; Wang *et al.*, 2023). The findings of this research further extend the literature by showing that AI literacy also has motivational and creative implications. Students with better AI literacy are better able to convert AI tool use into creative confidence and creative output. Therefore, AI literacy should be understood as a strategic capability that shapes learning quality, not merely as a functional skill for operating AI tools.

5.2. Practical contributions

The findings also offer important implications for universities, instructors, and curriculum designers. First, universities should understand that AI-powered brainstorming tools available to university students can support students' creativity when integrated into learning activities responsibly. This aligns with brainstorming research, which emphasizes separating idea generation from early evaluation and encouraging the production of multiple alternatives before selecting final solutions (Osborn, 1953; Paulus & Brown, 2003). Universities should not just discourage AI use; academicians should design student assignments that require students to use AI tools to explore, compare, and refine their creative ideas. These assignments can help students to develop more active and reflective forms of AI-supported creativity.

Second, the findings also suggested that academicians should encourage students and focus more on building their creative self-efficacy. Students may benefit from classroom activities designed to develop and strengthen creative self-efficacy, generate multiple ideas, revise weak ideas, and reflect on how AI suggestions helped them think differently, since creative self-efficacy is an important predictor of creative performance (Tierney & Farmer, 2002, 2011). Tutors and instructors can ask students to write down their AI interaction process and explain it to other students, including how they evaluated AI-generated suggestions for their own creative ideas. Such initiatives can reinforce students' understanding and confidence in their own abilities, showing that creative ideas come from their own thinking process rather than from AI-generated content alone.

Third, universities should also design training programs for awareness of AI literacy. The results also highlighted that students with higher levels of AI literacy can benefit more from AI-powered brainstorming tools. Prior research conceptualizes AI literacy as the ability to understand, use, evaluate, and ethically engage with AI

systems (Long & Magerko, 2020; Ng *et al.*, 2021; Wang *et al.*, 2023). Such specifically designed training programs and awareness initiatives should include prompt formulation, output evaluation, bias recognition, ethical use, academic integrity, and responsible citation of AI-assisted work. It is also important that AI literacy should not be taught to students only as a technical workshop; it should be embedded in discipline-specific courses so students can use AI meaningfully in their own academic and professional contexts. Additionally, business students are now expected to engage in innovation, entrepreneurship, market analysis, strategic problem solving, and digital transformation. Recent evidence suggests that active collaboration with AI can mitigate some of the negative psychological effects associated with AI reliance (Lee *et al.*, 2026). AI-powered brainstorming tools can support these learning outcomes by helping students generate business ideas, evaluate alternatives, develop campaign concepts, analyze cases, and propose solutions. The instructors of business schools should train their students to use AI as a partner in ideation while maintaining originality, judgment, and contextual awareness.

5.3. Limitations and future research

This research also has several limitations and directions for future research. First, data for this research were collected using a cross-sectional survey design. Although we have strong theoretical reasons to propose that AI-powered brainstorming tools influence creative self-efficacy and creative idea generation, due to the cross-sectional design, there is a risk of strong causal interpretations, such that creative students can develop creative self-efficacy over time and ultimately affect the use of AI-powered brainstorming tools. Future research may use a true longitudinal or experimental design to examine how students' AI use affects creative self-efficacy and creative performance over time. Additionally, although the AI-powered brainstorming tools scale demonstrated satisfactory reliability and validity, the measure was developed specifically for this research. Future studies should further validate the scale through expert review, content validity indexing, pilot testing across diverse student populations, and replication in different educational contexts (Hinkin, 1998; MacKenzie *et al.*, 2011).

Second, this study used self-reported measures. Self-reported measures were appropriate for capturing perceptions of AI use, AI literacy, and creative self-efficacy. However, these self-reported measures may introduce common method bias or social desirability. Future research may use objective indicators of AI literacy, instructor ratings of creativity, peer evaluations, or task-based creative performance scores. Experimental studies may also

compare AI-assisted and non-AI-assisted brainstorming tasks to confirm whether AI use improves actual creative outcomes. Third, we collected data from undergraduate business students at a private-sector university in Malaysia. The university context and sample were appropriate because business students frequently engage in idea-based academic tasks. To improve the generalizability of these findings, future research may collect data from students in public universities, postgraduate programs, non-business disciplines, or different national contexts. Comparative research may also explore whether AI literacy and creative self-efficacy operate differently across different cultures, disciplines, and educational systems. Finally, future research may extend this model by considering additional mediators such as cognitive flexibility, creative process engagement, intrinsic motivation, epistemic curiosity, or perceived autonomy. Future studies may also examine other moderators, including academic integrity climate, instructor support, digital learning readiness, prior creative experience, or ethical awareness of AI use. These extensions will provide a more comprehensive understanding of how AI tools influence student creativity in universities.

6. Conclusion

This study examined how AI-powered brainstorming tools relate to creative idea generation among undergraduate business students in Malaysia. The findings show that AI-powered brainstorming tools are positively related to creative idea generation, and that creative self-efficacy partly explains this relationship. The results also show that AI literacy strengthens both the direct and indirect effects of AI-powered brainstorming tools. These findings suggest that AI-supported creativity depends not only on access to AI tools but also on students' confidence in their own creative ability and their capacity to use AI-generated suggestions critically.

The broader implication of the study is that AI should not be understood simply as a productivity tool or a replacement for human thinking. In educational contexts, AI-powered brainstorming can be valuable when it helps students generate alternatives, question assumptions, compare ideas, and refine their own thinking. However, the same technology may be less beneficial if students use it passively or treat AI-generated ideas as final answers. The distinction between AI as a collaborator and AI as a substitute is therefore central. AI appears most likely to strengthen students' creative confidence when students remain active participants in the ideation process and possess the literacy needed to evaluate and adapt AI-generated suggestions.

These findings also matter beyond university classrooms. As AI becomes increasingly embedded in

workplaces and everyday decision-making, students will enter professional and civic environments where AI-mediated cognition is normal. Future employees should consider AI while maintaining judgment, ownership, and responsibility for their ideas. Similarly, citizens will need to evaluate AI-generated information and resist overreliance on automated outputs. The present study therefore suggests that higher education has a responsibility not only to provide access to AI tools but also to cultivate creative self-efficacy and AI literacy. Under these conditions, AI-powered brainstorming may support human creativity rather than displace it.

Acknowledgments

The authors would like to thank all participants and the organization for providing support during data collection.

Funding

No external funding was received for this research; the study was conducted without financial support from any funding agency or organization.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions

Conceptualization: Ahmad Adeel

Data curation: Ahmad Adeel, Samreen Batool

Formal analysis: Ahmad Adeel

Investigation: Ahmad Adeel, Sajid Mohy ul din, Zain ul abdeen Madni, Ahmad Aziz Sheikh

Methodology: Ahmad Adeel

Project administration: Ahmad Adeel

Resources: Sajid Mohy ul din, Ahmad Aziz Sheikh

Software: Samreen Batool

Supervision: Ahmad Adeel

Validation: Ahmad Adeel, Samreen Batool, Sajid Mohy ul din, Zain ul abdeen Madni

Writing—original draft: Ahmad Adeel

Writing—review & editing: Ahmad Adeel

Ethics approval and consent to participate

This study was approved by the Ethics Committee, INTI International University; Ref: INTI/UEC/2026/003. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Verbal informed consent was obtained from all

participants, which was documented and approved by the relevant ethics committee. No identifiable personal data or images are disclosed in this publication.

Availability of data

The data supporting the findings of this study are available from the corresponding author upon reasonable request. To support transparency and replicability, simulated replication datasets that mirror the statistical properties of the empirical data have been generated and are available for verification and methodological purposes. Due to ethical considerations and confidentiality agreements with the participating organization, the original raw survey data is not publicly available.

References

- Adeel, A., & Batool, S. (2025). Too close for creativity? How employee risk-taking shapes the LMX-creativity relationship in Asian businesses. *International Journal of Organization Theory & Behavior*, 1-16.
<https://doi.org/10.1108/IJOTB-10-2024-0199>
- Adeel, A., Batool, S., Kee, D. M. H., & Madni, Z.-u.-A. (2023). Why cognitive absorption is not enough: the role of knowledge absorption capacity and technological opportunity for individual learning. *Asian Academy of Management Journal*, 28(2), 239-274.
<https://doi.org/10.21315/aamj2023.28.2.9>
- Adeel, A., Mohy-ud-din, S., Ahmed, K., & Dhay, K. (2026). Emotional Culture, Communication Climate, and Creative Idea Withholding: A Curvilinear Perspective. *Journal of Intercultural Communication*, 26(2), 39-51.
<https://doi.org/10.36923/jicc.v26i2.1441>
- Ahmad, I., Thurasamy, R., Adeel, A., & Alam, B. (2023). Promotive voice, leader-member exchange, and creativity endorsement: the role of supervisor-attributed motives. *Journal of Intercultural Communication*, 23(3), 1-13.
<https://doi.org/10.36923/jicc.v23i3.121>
- Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the work environment for creativity. *Academy of Management Journal*, 39(5), 1154-1184.
<https://doi.org/10.2307/256995>
- Amoozegar, A., Elsiddig, B. M. H., Falahat, M., Ikram, M., Ismaeil, A. A. R. M., & Krishnasamy, H. N. (2025). An examination of the role of big five personality traits on employee creativity in Sudanese public universities: a gender-based approach. *Frontiers in Psychology*, 16, 1556637.
<https://doi.org/10.3389/fpsyg.2025.1556637>
- Anderson, L. W., & Krathwohl, D. R. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives: complete edition*. London, UK: Addison Wesley Longman, Inc.
- Baltà-Salvador, R., El-Madafri, I., Brasó-Vives, E., & Peña, M. (2025). Empowering engineering students through artificial intelligence (AI): blended human-AI creative ideation processes with ChatGPT. *Computer Applications in Engineering Education*, 33(1), e22817.
<https://doi.org/10.1002/cae.22817>
- Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ, 1986(23-28), 2.
- Bandura, A., & Wessels, S. (1997). *Self-efficacy* (Vol. 10). Cambridge, United Kingdom: Cambridge University Press.
- Bilton, C. (2015). Uncreativity: The shadow side of creativity. *International Journal of Cultural Policy*, 21(2), 153-167.
<https://doi.org/10.1080/10286632.2014.892933>
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access*, 8, 75264-75278.
<https://doi.org/10.1109/ACCESS.2020.2988510>
- Chen, T., Kim, T. Y., Gong, Y., & Liang, Y. (2025). Competence drives interest or vice versa? Untangling the bidirectional relationships between creative self-efficacy and intrinsic motivation for creativity in shaping employee creativity. *Journal of Management Studies*, 62(2), 775-811.
<https://doi.org/10.1111/joms.13072>
- Doshi, A. R., & Hauser, O. P. (2024). Generative AI enhances individual creativity but reduces the collective diversity of novel content. *Science advances*, 10(28), eadn5290.
<https://doi.org/10.1126/sciadv.adn5290>
- Geroimenko, V. (2025). Enhancing AI's Cognitive Abilities: Optimising AI's Reasoning, Creativity, and Knowledge Application. In *Beyond and After Prompt Engineering: The Future of AI Communication* Cham, Switzerland: Springer. (pp. 259-288).
https://doi.org/10.1007/978-3-032-04569-0_13
- He, W. J., & Wong, W. C. (2021). Gender differences in creative self-efficacy: Findings of mean and variability analyses. *Thinking Skills and Creativity*, 42, 100955.
<https://doi.org/10.1016/j.tsc.2021.100955>
- He, W. J., & Zhang, K. (2025). From Perceived School Climate to Creativity Performance: The Serial Multiple Mediation of Creative Self-Efficacy and Creativity Motivation. *The Journal of Creative Behavior*, 59(3), e70045.
<https://doi.org/10.1002/jocb.70045>
- Hinkin, T. R. (1998). A brief tutorial on the development of measures for use in survey questionnaires. *Organizational Research Methods*, 1(1), 104-121.
<https://doi.org/10.1177/109442819800100106>
- Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial intelligence literacy in higher and adult education:

- A scoping literature review. *Computers and Education: Artificial Intelligence*, 3, 100101.
<https://doi.org/10.1016/j.caeai.2022.100101>
- Lee, E. H., Yin, Y., Jia, N., & Wakslak, C. J. (2026). Relying on AI at work reduces self-efficacy, ownership, and meaning while active collaboration mitigates the effects. *Scientific Reports*, 16, 13583.
<https://doi.org/10.1038/s41598-026-42312-6>
- Leung, R., & Lo, I. S. (2024). Can ChatGPT Inspire Me? Evaluate Students' Questioning Techniques on AI Tool for Overcoming Fixation. In: Berezina, K., Nixon, L., Tuomi, A. (eds) *Information and Communication Technologies in Tourism 2024*. Cham, Switzerland: Springer.
https://doi.org/10.1007/978-3-031-58839-6_9
- Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In: *Proceedings of the 2020 CHI conference on human factors in computing systems*. New York, NY: ACM Digital Library.
<https://doi.org/10.1145/3313831.3376727>
- MacKenzie, S. B., Podsakoff, P. M., & Podsakoff, N. P. (2011). Construct measurement and validation procedures in MIS and behavioral research: Integrating new and existing techniques. *MIS quarterly*, 35(2), 293-A5.
<https://doi.org/10.2307/23044045>
- Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, 2, 100041.
<https://doi.org/10.1016/j.caeai.2021.100041>
- Osborn, A. (1953). *Applied Imagination: Principles and Procedures of Creative Thinking*. New York, NY: Charles Scribner Sons; 1956.
- Paulus, P. B., & Brown, V. R. (2003). Enhancing ideational creativity in groups. *Group creativity: Innovation through collaboration*, 110-136.
<https://doi.org/10.1093/acprof:oso/9780195147308.003.0006>
- Paulus, P. B., & Kenworthy, J. B. (2019). 17 Effective Brainstorming. *The Oxford handbook of group creativity and innovation*, 286-305.
<https://doi.org/10.1093/oxfordhb/9780190648077.013.17>
- Pinar, F. I. L., Panergayo, A. A. E., Sagcal, R. R., Acut, D. P., Roleda, L. S., & Prudente, M. S. (2025). Fostering scientific creativity in science education through scientific problem-solving approaches and STEM contexts: a meta-analysis. *Disciplinary and Interdisciplinary Science Education Research*, 7(1), 18.
<https://doi.org/10.1186/s43031-025-00137-9>
- Richardson, C., & Mishra, P. (2018). Learning environments that support student creativity: Developing the SCALE. *Thinking Skills and Creativity*, 27, 45-54.
<https://doi.org/10.1016/j.tsc.2017.11.004>
- Rowland, N. J., & Grüning, D. J. (2025). AI-assisted brainstorming for scenario thinking. *Futures*, 172, 103644.
<https://doi.org/10.1016/j.futures.2025.103644>
- Runco, M. A., & Jaeger, G. J. (2012). The standard definition of creativity. *Creativity Research Journal*, 24(1), 92-96.
<https://doi.org/10.1080/10400419.2012.650092>
- Shao, Y., Liu, Q., Dong, Y., & Liu, J. (2024). Perceived formative assessment practices in homework and creativity competence: The mediating effects of self-confidence in learning and intrinsic motivation. *Studies in Educational Evaluation*, 83, 101376.
<https://doi.org/10.1016/j.stueduc.2024.101376>
- Singh, P., & Huang, L. (2025). AI meets brainstorming: Enhancing creativity and collaboration in marketing education. *Marketing Education Review*, 35(4), 271-279.
<https://doi.org/10.1080/10528008.2025.2501790>
- Šliogerienė, J., Darginavičienė, I., Suchanova, J., Gulbinskienė, D., & Jakučionytė, V. (2025). Problem-based learning in developing students' communicative skills and creativity in teaching English for specific purposes. *Creativity Studies*, 18(1), 30-42.
<https://doi.org/10.3846/cs.2025.22343>
- Song, G., Nabi, M. N., Gazi, M. A. I., Amin, M. B., Senathirajah, A. R. B. S., Rahaman, M. A., & Min, Z. (2025). Participative leadership effects on followers' radical creativity: the role of psychological safety and collaborative relationship. *BMC psychology*, 13(1), 604.
<https://doi.org/10.1186/s40359-025-02950-3>
- Stöhr, C., Ou, A. W., & Malmström, H. (2024). Perceptions and usage of AI chatbots among students in higher education across genders, academic levels and fields of study. *Computers and Education: Artificial Intelligence*, 7, 100259.
<https://doi.org/10.1016/j.caeai.2024.100259>
- Tang, C., Mao, S., Naumann, S. E., & Xing, Z. (2022). Improving student creativity through digital technology products: A literature review. *Thinking Skills and Creativity*, 44, 101032.
<https://doi.org/10.1016/j.tsc.2022.101032>
- Tierney, P., & Farmer, S. M. (2002). Creative self-efficacy: Its potential antecedents and relationship to creative performance. *Academy of Management Journal*, 45(6), 1137-1148.
<https://doi.org/10.2307/3069429>
- Tierney, P., & Farmer, S. M. (2011). Creative self-efficacy development and creative performance over time. *Journal of Applied Psychology*, 96(2), 277.
<https://doi.org/10.1037/a0020952>

Wang, B., Liu, H., An, P., Li, Q., Li, K., Chen, L., Zhang, Q., Zhang, J., Zhang, X., & Gu, S. (2019). Artificial intelligence and education. In: *Reconstructing our orders: Artificial intelligence and human society*. Cham, Switzerland: Springer. (pp. 129-161).

https://doi.org/10.1007/978-981-13-2209-9_5

Wang, B., Rau, P.-L. P., & Yuan, T. (2023). Measuring user competence in using artificial intelligence: validity and reliability of artificial intelligence literacy scale. *Behaviour & Information Technology*, 42(9), 1324-1337.

<https://doi.org/10.1080/0144929X.2022.2072768>

Zhou, J., & George, J. M. (2001). When job dissatisfaction leads to creativity: Encouraging the expression of voice. *Academy of Management Journal*, 44(4), 682-696.

<https://doi.org/10.2307/3069410>

Zhu, F., & Zou, W. (2026). Generative AI adoption in human creative tasks: Experimental evidence. *Journal of Economic Behavior & Organization*, 242, 107414.

<https://doi.org/10.1016/j.jebo.2026.107414>

Appendix A. Measurement items

All substantive constructs were measured using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

AI-powered brainstorming tools (AIBT):

AIBT1. AI tools help me generate multiple ideas for academic tasks.

AIBT2. AI tools help me expand my initial ideas into more developed ideas.

AIBT3. AI tools help me think about problems from different perspectives.

AIBT4. AI tools help me compare different possible ideas before choosing one.

AIBT5. AI tools help me refine and improve my ideas for academic tasks.

AI literacy (AIL):

AIL1. I understand the basic functions of AI tools used for academic tasks.

AIL2. I know how to use AI tools to support my learning activities.

AIL3. I can write effective prompts to obtain useful responses from AI tools.

AIL4. I can evaluate whether AI-generated suggestions are useful for my task.

AIL5. I can identify limitations in AI-generated outputs.

AIL6. I understand that AI-generated outputs may contain errors or bias.

AIL7. I know how to use AI tools responsibly in academic work.

AIL8. I can combine AI-generated suggestions with my own ideas.

Creative self-efficacy (CSE):

CSE1. I am confident in my ability to generate creative ideas.

CSE2. I believe I can develop novel solutions for academic tasks.

CSE3. I have confidence in my ability to solve problems creatively.

CSE4. I believe I can produce useful and original ideas when required.

Creative idea generation (CIG):

CIG1. I generate original ideas for academic assignments.

CIG2. I develop useful ideas that improve the quality of my academic work.

CIG3. I often suggest new ways of approaching academic tasks.

CIG4. I generate diverse ideas when working on assignments or projects.

CIG5. I produce ideas that are both novel and useful in my academic work.

Appendix B. Control variable coding

Gender was measured via student self-report and coded as 1 = female and 0 = male. Age was measured in years. Ethnic/national background was measured using student self-report. Reported categories included Chinese, Malay, Indian, Vietnamese, Laotian, and Thai. For the regression analyses, ethnic/national background was represented by a Chinese dummy variable because Chinese students formed the largest group in the sample. Chinese students were coded as 1, while all other ethnic/national groups were coded as 0. Year of study was measured according to the student's current undergraduate year of study. Cumulative grade point average was measured using students' reported cumulative grade point average based on the university's grading scale. Prior AI use was measured by asking whether students had previously used AI tools. Responses were coded as 1 = yes and 0 = no. Weekly AI usage hours were measured by asking students to report the approximate number of hours they used AI tools in a typical week.