



OPEN Generative artificial intelligence in entrepreneurship education enhances entrepreneurial intention through self-efficacy and university support

Yingying Xie¹ & Shaofeng Wang²  

This study investigates how Generative Artificial Intelligence Supported Entrepreneurship Education (GAISEE) influences university students' entrepreneurial intentions through a quantitative analysis of Chinese higher education institutions. Using structural equation modeling with data from 346 university students, we demonstrate that GAISEE significantly enhances both entrepreneurial self-efficacy ($\beta = 0.523, p < 0.001$) and entrepreneurial intention ($\beta = 0.244, p < 0.001$). The research reveals that entrepreneurial self-efficacy mediates the relationship between GAISEE and entrepreneurial intention, while the university entrepreneurial environment moderates these relationships. Notably, an optimized university environment strengthens the positive effects of GAISEE on both entrepreneurial self-efficacy ($\beta = 0.333, p < 0.001$) and entrepreneurial intention ($\beta = 0.207, p < 0.001$). These findings provide empirical evidence for the effectiveness of integrating generative AI technology in entrepreneurship education and highlight the importance of supportive university ecosystems in fostering student entrepreneurship.

Keywords Generative artificial intelligence, Entrepreneurship education, Entrepreneurial intention, Entrepreneurial self-efficacy, University entrepreneurial environment

The integration of artificial intelligence (AI) in higher education, especially in entrepreneurship education, is undergoing a transformative shift, driven by advancements like generative AI^{1–4}. Generative AI, with its capacity to create novel content, including text, images, code, and even business simulations⁵ offers unprecedented opportunities to enhance the learning experience and foster entrepreneurial capabilities⁶. This evolution is crucial as entrepreneurship education must adapt to the rapidly changing demands of the modern business world, characterized by increasing complexity and the need for innovative solutions⁷. Therefore, Generative Artificial Intelligence Supported Entrepreneurship Education (GAISEE) has emerged as a focal point of research, with its potential to revolutionize educational practices and significantly impact students' entrepreneurial intention⁸.

Entrepreneurial intention is widely recognized as a critical precursor to entrepreneurial action⁹. While prior research has explored various factors influencing entrepreneurial intention, there remains a significant gap in understanding the specific role of GAISEE. Existing studies have predominantly focused on traditional entrepreneurship education methods. These methods, while valuable, may not fully leverage the potential of generative AI to personalize learning, simulate real-world entrepreneurial challenges, and provide immediate, tailored feedback^{5,10}. Our study directly addresses this gap by investigating whether GAISEE, with its unique capabilities, truly enhances students' entrepreneurial intention and how it interacts with the university entrepreneurial environment¹¹. We further explore the mediating role of entrepreneurial self-efficacy, a factor often overlooked in its interaction with AI-enhanced education, to provide a more nuanced understanding of the formation of entrepreneurial intention¹². By examining these relationships, this study offers both theoretical innovation and significant socio-economic value, guiding universities in formulating effective educational policies and optimizing the entrepreneurial education environment^{13,14}.

¹School of Innovation and Entrepreneurship, Zhejiang Wanli University, Ningbo 315100, China. ²International Business School, Fuzhou University of International Studies and Trade, Fuzhou 350202, China. ✉email: vipwhsl@hotmail.com

This study is situated within the context of Chinese higher education, a sector undergoing rapid transformation and facing unique challenges related to technological adoption and the cultivation of an entrepreneurial mindset. China's commitment to innovation-driven development has led to significant investments in AI and a growing emphasis on entrepreneurship education¹⁰. However, the adoption of AI in education is still in its nascent stages, and there are variations in technological infrastructure and pedagogical approaches across institutions¹⁰. Moreover, cultural factors, such as the strong emphasis on academic achievement and risk aversion, may influence students' entrepreneurial intentions¹⁵. For instance, parental and societal pressures to pursue stable career paths in established companies might dampen entrepreneurial aspirations. Additionally, while China has made strides in promoting entrepreneurship, the entrepreneurial ecosystem is still developing, and students may face challenges related to funding, mentorship, and navigating complex regulatory environments¹⁶. These contextual factors underscore the importance of investigating the effectiveness of GAISEE in the Chinese higher education landscape. This will help identify potential barriers and facilitators to fostering entrepreneurial intention among Chinese university students.

The application of generative AI in entrepreneurship education is a relatively new field, with limited research specifically examining its impact on students' entrepreneurial intention^{8,17,18}. Generative AI's ability to create new content, such as text, images, and code, is rapidly transforming various industries, including education⁶. In academic settings, generative AI tools are being used to personalize learning experiences, automate administrative tasks, and provide students with interactive and engaging learning environments^{5,10}. The global market for AI in education is projected to reach \$32 billion by 2030, growing at a CAGR of 31.2% from 2025 to 2030, showcasing its increasing adoption and perceived value in enhancing educational outcomes¹⁹. In entrepreneurship education, generative AI can simulate business scenarios, generate innovative ideas, and provide personalized feedback on students' entrepreneurial projects, potentially fostering their entrepreneurial intentions⁵. While existing research focuses on the relationship between traditional entrepreneurship education methods and entrepreneurial intention, there is a need to address how integrating advanced technologies like generative AI can enhance educational quality and outcomes. Furthermore, while the importance of the entrepreneurial context in stimulating students' entrepreneurial intention is recognized¹⁶ it is often overlooked in the literature, lacking sufficient theoretical support and empirical investigation, especially in the context of AI-enhanced education¹⁷.

This study aims to provide new perspectives for understanding and improving entrepreneurship education practices in higher education, offering potential theoretical innovation and significant socio-economic value¹². Building upon the Theory of Planned Behavior (TPB)¹³ we specifically investigate how GAISEE influences students' entrepreneurial intention. TPB posits that intention is a key determinant of behavior, and in the context of entrepreneurship, entrepreneurial intention is a crucial precursor to entrepreneurial action. We further integrate the concept of entrepreneurial self-efficacy, which aligns with TPB's perceived behavioral control, to explore its mediating role in the relationship between GAISEE and entrepreneurial intention. Entrepreneurial self-efficacy, defined as an individual's belief in their ability to successfully perform entrepreneurial tasks, has been shown to be a significant predictor of entrepreneurial intention. By providing interactive and engaging learning experiences, GAISEE can enhance students' entrepreneurial self-efficacy, thereby strengthening their entrepreneurial intention. Furthermore, we examine the moderating effect of the university entrepreneurial environment, recognizing that a supportive ecosystem can amplify the positive impact of both GAISEE and entrepreneurial self-efficacy on entrepreneurial intention¹⁴. To address these gaps and advance the understanding of GAISEE's impact on entrepreneurial intention, this study aims to answer the following research questions:

RQ1: How does GAISEE affect university students' entrepreneurial intention?

RQ2: What is the mediating role of entrepreneurial self-efficacy in the relationship between GAISEE and entrepreneurial intention?

RQ3: How does the university entrepreneurial environment moderate the relationship between GAISEE and entrepreneurial intention, as well as the relationship between entrepreneurial self-efficacy and entrepreneurial intention?

The remainder of this paper is structured as follows. Section 2 outlines the theoretical background underpinning our research, detailing the Theory of Planned Behavior, the concept of GAISEE, and the roles of entrepreneurial self-efficacy and university entrepreneurial environment, culminating in the development of our research hypotheses. Section 3 describes the research methodology, including data collection, measurement scales, and data analysis techniques. Section 4 presents the results of our empirical analysis. Section 5 discusses the findings, highlighting their theoretical and practical implications. Finally, Sects. 6 and 7 conclude the paper, acknowledging limitations and suggesting avenues for future research.

Theoretical background and hypothesis development

Theory of planned behavior

The Theory of Planned Behavior (TPB) provides a robust and widely validated framework for deciphering the antecedents of individual behavior, particularly within the domain of entrepreneurial intention^{13,20}. In its foundational form, TPB postulates that an individual's behavioral intention is the most proximal determinant of actual behavior, and this intention, in turn, is shaped by a confluence of three factors: attitudes toward the behavior, subjective norms, and perceived behavioral control¹⁵. When applied to the context of nascent entrepreneurship, these factors can be operationalized as an individual's personal evaluation of entrepreneurial activities, the perceived social pressure to engage in (or refrain from) such activities, and a self-assessment of one's capability to successfully execute the tasks inherent in launching and managing a new venture²¹.

However, while traditional applications of TPB have provided valuable insights into the formation of entrepreneurial intention²² the rapidly evolving landscape of higher education, particularly the advent of GAISEE, necessitates a more nuanced and expanded theoretical perspective. This study, therefore, extends the

traditional TPB model in two critical ways. First, it explicitly incorporates the construct of entrepreneurial self-efficacy, conceptualized as an individual's belief in their ability to successfully perform the multifaceted tasks associated with entrepreneurship²³. This is not merely a semantic adjustment; entrepreneurial self-efficacy aligns closely with TPB's perceived behavioral control but provides a more granular and domain-specific lens through which to examine the individual's perceived capabilities within the entrepreneurial context. As such, we posit that accurately measuring entrepreneurial self-efficacy enhances the predictive power of the model, particularly in a technology-infused educational setting. Second, recognizing the profound influence of the institutional context on student behavior, we introduce the university ecosystem as a critical moderating variable. This expansion acknowledges that the university environment, encompassing factors such as resource availability, programmatic support, and cultural norms, can significantly amplify or dampen the effects of both GAISEE and entrepreneurial self-efficacy on entrepreneurial intention. By integrating these elements, the study pushes beyond a purely individual-level analysis of entrepreneurial intention formation, acknowledging that intention is not formed in a vacuum but is instead deeply embedded within a broader socio-technical ecosystem²⁴. This expanded theoretical lens, therefore, underscores the novelty and adaptability of TPB to the exigencies of the new technological era, demonstrating its continued relevance in understanding the complex interplay between individual cognition, technological advancements, and institutional support in shaping entrepreneurial behavior. This new approach is important because it helps us understand how technology and support systems can work together to encourage more students to become entrepreneurs.

Generative artificial intelligence supported entrepreneurship education

GAISEE represents a fundamental departure from conventional pedagogical approaches, marking a paradigm shift in how entrepreneurship is taught and learned in higher education institutions^{11,25}. Unlike traditional entrepreneurship education, which often relies heavily on passive knowledge transfer through lectures and case studies, GAISEE leverages the unique capabilities of generative AI to create a dynamic, interactive, and highly personalized learning environment⁵. This is not merely an incremental improvement but a qualitative shift in educational methodology. The core innovation of GAISEE lies in its “generative” nature. Instead of pre-packaged content and predetermined learning pathways, students actively engage with AI tools that can generate realistic business simulations, create novel product ideas, simulate market scenarios, and provide tailored feedback on student-generated business plans²⁶.

This immersive and experiential approach fosters a deeper level of cognitive engagement, enabling students to not only learn theoretical concepts but also apply them in a simulated environment that closely mirrors the complexities of real-world entrepreneurship, moving from abstract concepts to concrete application. For example, students can use generative AI to develop and test marketing campaigns, analyze competitor strategies, and even simulate the process of securing funding. Such activities were rarely feasible with traditional methods and only available to a select few through internships or specialized programs. Furthermore, GAISEE's inherent adaptability, driven by continuous content generation and AI-powered feedback loops, allows for real-time adjustments in teaching strategies based on individual student progress and learning styles²⁷. This stands in stark contrast to the relatively static and uniform curricula characteristic of conventional entrepreneurship education. The flexibility afforded by GAISEE allows educators to personalize learning paths, catering to the unique needs and strengths of each student, thereby fostering a more inclusive and effective educational experience. This personalized approach accelerates learning and deepens understanding.

By providing these immersive, adaptive, and personalized learning experiences, GAISEE not only enhances students' technical knowledge of entrepreneurship but also cultivates their problem-solving skills, critical thinking abilities, and entrepreneurial mindset, preparing them to navigate the uncertainties and challenges of the modern business environment²⁸. This transformative potential of GAISEE, therefore, extends beyond simply improving existing educational practices; it opens up entirely new avenues for cultivating entrepreneurial intention and nurturing a new generation of entrepreneurs equipped with the skills and mindset to thrive in an increasingly complex and dynamic world¹⁴.

Generative artificial intelligence supported entrepreneurship education and entrepreneurial self-efficacy

The advent of GAISEE is reshaping the pedagogical landscape of higher education, offering a transformative approach to nurturing entrepreneurial competencies among students²⁷. By integrating the capabilities of generative AI, GAISEE transcends traditional didactic methods, creating a multifaceted learning ecosystem where students can actively engage with simulated entrepreneurial challenges⁶. This innovative educational model not only enriches the curriculum but also profoundly influences students' attitudes and confidence toward entrepreneurial endeavors². The adaptive and creative nature of generative AI provides a distinctive advantage for GAISEE in bolstering students' entrepreneurial self-efficacy. Grounded in social cognitive theory, which posits that self-efficacy significantly influences behavioral outcomes²⁹ GAISEE serves as a potent instrument for enhancing students' entrepreneurial knowledge, skills, and ultimately, their self-efficacy³⁰.

Moreover, heightened entrepreneurial self-efficacy, cultivated through GAISEE, signifies substantial advancements in students' mastery of entrepreneurial knowledge, their ability to apply this knowledge in practical scenarios, and their capacity for opportunity recognition²³. This comprehensive development lays a robust foundation for the formation of strong entrepreneurial intentions. Specifically, GAISEE facilitates immersive engagement with cutting-edge AI technologies and contemporary entrepreneurial theories. More critically, it enables students to solidify their understanding and skills through hands-on operation and project-based learning. As students navigate complex problem-solving tasks, identify viable entrepreneurial opportunities, and develop comprehensive business plans, their self-efficacy is continuously challenged and enhanced^{23,31}. Through practical applications such as using AI to simulate market scenarios or generate innovative product

ideas⁵ students gain a deeper understanding of entrepreneurial processes. For example, utilizing generative AI resources, including hardware, data, software tools, an innovative culture, and skilled personnel, can significantly enhance entrepreneurial performance by fostering internal integration and external collaboration¹⁰. This experiential learning approach allows students to see the tangible results of their efforts, reinforcing their belief in their abilities to succeed as entrepreneurs. This process elevates entrepreneurship education beyond mere knowledge transfer, transforming it into an active, engaging, and self-empowering journey. Consequently, based on these enriched educational experiences, this study posits the following hypothesis:

H1: Generative artificial intelligence supported entrepreneurship education positively influences entrepreneurial self-efficacy.

Generative artificial intelligence supported entrepreneurship education and entrepreneurial intention

GAISEE, characterized by its interactive and immersive features, presents a novel and dynamic learning platform for students, significantly influencing their entrepreneurial intentions¹¹. In alignment with the Theory of Planned Behavior, which underscores that behavioral intentions are direct precursors to actual behavior, GAISEE exerts a substantial influence on students' attitudes, subjective norms, and perceived behavioral control regarding entrepreneurship²¹. Through GAISEE courses, students are afforded the opportunity to engage in realistic business simulations, thereby enhancing their problem-solving and decision-making capabilities and fostering greater confidence in their ability to succeed in entrepreneurial ventures²⁷. For instance, students can use generative AI tools to develop and refine business models, simulate market entry strategies, and even practice pitching their ideas to virtual investors, receiving immediate, tailored feedback⁵. This hands-on experience not only equips them with practical skills but also reinforces their belief in their entrepreneurial potential. The design of these courses aligns with the latest understanding of generative learning principles, encouraging students to actively explore, experiment, and learn through a self-directed process²⁸. The application of AI to enhance experiential learning and authentic assessment through realistic scenarios and feedback mechanisms further improves the relevance of the educational content for students²⁶.

Furthermore, interaction with AI technology within the GAISEE framework enables students to better perceive and assess the risks and opportunities inherent in the entrepreneurial process, thereby cultivating a more positive and proactive entrepreneurial attitude²⁸. According to social cognitive theory, such a positive attitude is a critical driver of entrepreneurial behavior²⁹. The implementation of GAISEE also reinforces subjective norms; students often collaborate in teams within simulated environments, which enhances their teamwork skills and creates a perception of social support for entrepreneurial actions through peer interactions and mentorship from experienced entrepreneurs facilitated by the platform⁷. Consequently, students may feel recognized and encouraged by their peers and mentors to pursue entrepreneurial paths, further bolstering their entrepreneurial intention. From the perspective of perceived behavioral control, the AI components within GAISEE courses deliver real-time feedback and personalized assistance, empowering students to effectively address entrepreneurial challenges and mitigating self-doubt about their ability to execute entrepreneurial activities successfully²⁶. This targeted support enhances students' self-perception of possessing the necessary skills and resources to undertake and complete entrepreneurial tasks, thus strengthening their control over entrepreneurial behavior. As an innovative and transformative approach to entrepreneurship education, GAISEE significantly enhances students' entrepreneurial intention by positively influencing the psychological factors associated with entrepreneurship¹⁴. Therefore, this study proposes the following hypothesis:

H2: Generative artificial intelligence supported entrepreneurship education positively influences entrepreneurial intention.

Entrepreneurial self-efficacy and entrepreneurial intention

Entrepreneurial self-efficacy stands as a cornerstone in the formation of an individual's entrepreneurial intention, reflecting a robust belief in one's own capabilities to successfully navigate the entrepreneurial landscape³². Within the framework of the Theory of Planned Behavior, entrepreneurial self-efficacy aligns closely with the concept of perceived behavioral control, which is a critical determinant of behavioral intention^{21,23}. A strong sense of entrepreneurial self-efficacy has been empirically demonstrated to exert a positive influence on an individual's entrepreneurial intention³³. This is because heightened confidence in one's entrepreneurial abilities enhances the motivation and resolve to engage in entrepreneurial activities. Individuals with high entrepreneurial self-efficacy are more likely to perceive entrepreneurial challenges as surmountable and view entrepreneurship as a viable and attractive career path¹⁵.

Conversely, a deficiency in entrepreneurial self-efficacy can significantly dampen one's entrepreneurial aspirations and intentions. A primary objective of effective entrepreneurship education is to cultivate and strengthen students' entrepreneurial self-efficacy, thereby building their confidence and fostering positive expectations regarding their entrepreneurial capabilities³⁴. GAISEE plays a crucial role in this process by providing students with simulated entrepreneurial experiences and personalized feedback, which effectively raise their entrepreneurial self-efficacy³⁵. Through these immersive and interactive learning experiences, students gain practical insights and develop a stronger belief in their ability to succeed, which in turn, strengthens their desire and plans to pursue entrepreneurial activities in the future. For instance, by engaging in AI-simulated business challenges, students can test their decision-making skills and receive immediate feedback on their performance, reinforcing their confidence in their entrepreneurial abilities. Therefore, this study proposes the following hypothesis:

H3: Entrepreneurial self-efficacy positively influences entrepreneurial intention.

The mediating effect of entrepreneurial self-efficacy

The relationship between GAISEE and entrepreneurial intention cannot overlook the concept of entrepreneurial self-efficacy, which is the confidence in one's ability to execute entrepreneurial activities^{35,36}. Entrepreneurial self-efficacy plays a crucial role in the formation of entrepreneurial intention³⁵ and is considered a psychological state reflecting an individual's self-assessment of their ability to identify opportunities, mobilize resources, and apply strategies for effective entrepreneurship²³. While the foundational Theory of Planned Behavior (TPB) introduced Perceived Behavioral Control (PBC) – a construct closely related to self-efficacy – as a direct antecedent of intention¹³ and some recent discussions have explored its potential moderating influences, the specific role of entrepreneurial self-efficacy in the context of educational interventions is strongly supported in the literature as a mediator. Educational programs, particularly innovative approaches like GAISEE, are designed to directly build and enhance specific competencies and the belief in one's ability to perform related tasks^{5,27}. In this vein, GAISEE provides students with simulated entrepreneurial experiences, personalized feedback, and opportunities to apply generative AI tools, all of which are posited to directly enhance their entrepreneurial self-efficacy²⁸. This newly acquired or strengthened entrepreneurial self-efficacy then serves as a critical psychological mechanism that translates the educational experience into a heightened entrepreneurial intention. Numerous contemporary studies within entrepreneurship education empirically support this mediational pathway. For instance, Al-Qadasi et al.²³ and Amani et al.²⁵ found that entrepreneurial self-efficacy significantly mediates the relationship between entrepreneurship education and entrepreneurial intentions. Similarly, Wang et al.³⁶ and Taneja et al.²⁴ demonstrated the mediating effect of entrepreneurial self-efficacy in linking educational or experiential inputs to entrepreneurial outcomes. Bachmann et al.¹¹ also highlighted entrepreneurial self-efficacy as a key mediator in the process through which digital competencies translate into entrepreneurial intention. Therefore, conceptualizing entrepreneurial self-efficacy as a mediator aligns with the logic that GAISEE fosters a belief in one's capabilities (entrepreneurial self-efficacy), which subsequently fuels the intention to pursue entrepreneurial endeavors. This psychological mechanism enables GAISEE to stimulate and enhance students' entrepreneurial intention by improving their self-efficacy. Based on the theoretical and practical understanding of entrepreneurial self-efficacy, this study proposes:

H4: Entrepreneurial self-efficacy mediates the relationship between generative artificial intelligence supported entrepreneurship education and entrepreneurial intention.

The moderating effect of university entrepreneurial environment

A supportive university entrepreneurial environment plays a critical role in amplifying the effectiveness of entrepreneurship education and catalyzing students' entrepreneurial potential by providing essential resources, mentorship, and a nurturing culture²⁵. The optimization of the university ecosystem, encompassing factors such as a vibrant entrepreneurial atmosphere, supportive policies, and strategic resource allocation, significantly enhances students' engagement with GAISEE. This, in turn, deepens their understanding of entrepreneurial concepts and cultivates their ability to apply these concepts in practical settings³⁷. By fostering a positive learning atmosphere and offering ample opportunities for hands-on experience, a strengthened entrepreneurial context enables GAISEE to more effectively nurture students' entrepreneurial self-efficacy³⁸. Functioning as an external catalyst in generative AI-based education, the entrepreneurial environment provides students with increased access to enterprise collaborations, mentorship opportunities, and crucial resources³¹. These supportive measures facilitate students' mastery of entrepreneurial knowledge and significantly boost their confidence in applying this knowledge to real-world entrepreneurial practice.

When universities actively encourage entrepreneurial activities, provide necessary resources, and foster collaborations with businesses, students are more inclined to transform the knowledge and skills acquired through GAISEE into concrete entrepreneurial motivations and actionable plans³⁹. The entrepreneurial context not only offers educational resources and cultivates an entrepreneurial culture, thereby enriching and practicalizing the entrepreneurship education process, but it also provides valuable networks and platforms that promote the integration of students' innovative thinking with their practical abilities³⁸. This integration is crucial for helping students develop a clearer and more robust entrepreneurial intention. A supportive university ecosystem can significantly enhance the educational impact of GAISEE, ensuring that the experiences and learning gained in the course have a more profound and lasting influence on students' future entrepreneurial decisions³⁹. Moreover, an exemplary university entrepreneurial environment can inspire students to actively participate in entrepreneurial competitions, workshops, and other extracurricular activities, which further strengthens the entrepreneurial knowledge and skills obtained through GAISEE and paves the way for their future entrepreneurial endeavors⁴⁰.

The university entrepreneurial environment exerts a direct influence on students' perceptions of entrepreneurial behavior and indirectly impacts the development of their entrepreneurial capabilities and the formation of their entrepreneurial intention by providing essential resources and support⁴¹. Key supportive aspects of the university ecosystem include fostering an encouraging entrepreneurial spirit on campus, providing readily available entrepreneurial resources and guidance, and establishing close ties with business practices³⁸. These elements collectively create a robust ecosystem that reinforces students' entrepreneurial experiences and skill development, enabling entrepreneurship education to achieve superior practical outcomes²¹. An optimized environment facilitates the effective transformation of entrepreneurial self-efficacy into entrepreneurial intention, increasing the likelihood that students will put the entrepreneurial skills and mindsets they have learned into practice³⁸. In a positive entrepreneurial context, the entrepreneurial support and confidence students perceive are more likely to translate into actual entrepreneurial action intentions²⁵. Therefore, this study posits:

H5: University entrepreneurial environment positively moderates the relationship between generative artificial intelligence supported entrepreneurship education and entrepreneurial self-efficacy.

H6: University entrepreneurial environment positively moderates the relationship between generative artificial intelligence supported entrepreneurship education and entrepreneurial intention.

H7: University entrepreneurial environment positively moderates the relationship between entrepreneurial self-efficacy and entrepreneurial intention.

Research model

The research model constructed in this study aims to explore the mechanisms through which GAISEE affects university students' entrepreneurial intention and the moderating role of the university entrepreneurial environment. Figure 1 presents an integrated model that includes independent, dependent, mediating, moderating, and control variables, striving to comprehensively reveal how GAISEE influences students' entrepreneurial intention through entrepreneurial self-efficacy and examines how university entrepreneurial environment optimizes this process. To account for potential confounding factors and enhance the robustness of our findings, we included several control variables in our analysis: gender, age, academic discipline, and family background in entrepreneurship. The inclusion of these variables was based on existing literature suggesting their potential influence on entrepreneurial intentions and related constructs. Prior research has indicated that gender differences may exist in entrepreneurial intentions, self-efficacy, and perceptions of the entrepreneurial environment¹⁰. Including gender as a control variable allows us to isolate the effects of GAISEE while accounting for potential gender-based variations. Age has also been identified as a factor that can influence entrepreneurial intentions, with younger individuals often exhibiting higher levels of entrepreneurial aspiration. Controlling for age helps ensure that the observed effects are not merely due to age-related differences. Students from different academic disciplines may have varying levels of exposure to entrepreneurship concepts and varying predispositions toward entrepreneurial careers⁴². For instance, business students might inherently possess higher entrepreneurial intentions compared to those from other fields. Controlling for academic discipline allows us to account for these potential differences. Prior exposure to entrepreneurship through family businesses can significantly influence an individual's entrepreneurial intentions and self-efficacy. Individuals with a family background in entrepreneurship may have different motivations, resources, and support systems compared to those without such a background. Controlling for this variable helps isolate the unique impact of GAISEE⁴³.

Methodology

Data collection

We employed a purposive sampling method to recruit participants for this study, specifically targeting Chinese university students who had participated in GAISEE⁴³. While acknowledging that random sampling is often preferred for generalizability, we opted for purposive sampling due to the nascent nature of GAISEE adoption in Chinese higher education. This approach allowed us to specifically target the population of interest—students with direct experience in this innovative educational model. We initially aimed for a representative sample of universities offering GAISEE. However, given the limited number of institutions implementing GAISEE at the time of data collection, we collaborated with entrepreneurship associations at several leading universities known for their pioneering efforts in integrating AI into entrepreneurship education. These associations facilitated the distribution of our survey within their online student communities. However, we believe this approach was the most feasible and appropriate given the exploratory nature of our study and the specific population we aimed to investigate. To further mitigate potential biases associated with this sampling strategy, we ensured diversity within our sample by reaching out to multiple universities and encouraging participation across

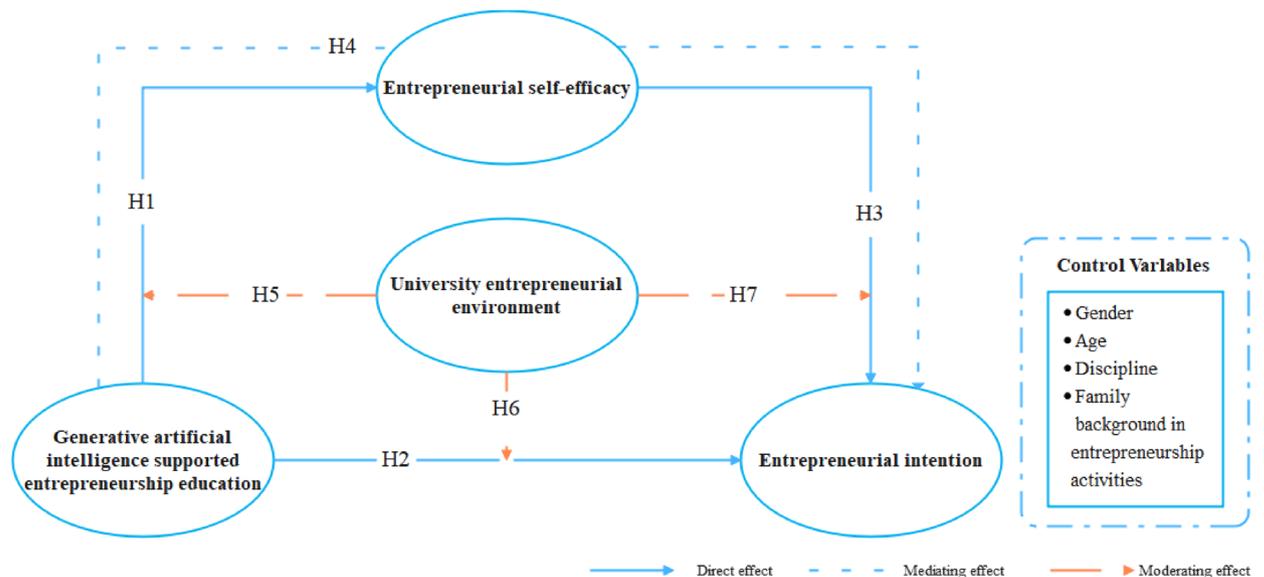


Fig. 1. Research model.

various disciplines (see Table 1). The adoption of this method can also increase the response rate of potential participants to a certain degree.

All methods employed in this study were carried out in accordance with relevant guidelines and regulations, including the Declaration of Helsinki for research involving human subjects. The survey-based data collection methodology adhered to international standards for ethical research conduct in educational settings. Confirmation that informed consent has been obtained from all subjects. The Ethics Committee of the Student Affairs Department, Zhejiang Wanli University reviewed the experimental protocols for this survey research, given the nature of this educational research, which involved anonymous surveys about entrepreneurial intentions and educational experiences without collecting sensitive personal data or involving vulnerable populations. The Ethics Committee of the Student Affairs Department, Zhejiang Wanli University (Institutional Review Board), Ningbo, Zhejiang Province, China, has reviewed this study and granted an exemption from requiring formal written ethical approval (Review Reference: ZWU2024XYY). This exemption decision (Review Reference: ZWU2024XYY) was based on the minimal-risk nature of the study and its compliance with institutional guidelines for educational research.

The survey was meticulously constructed to include independent, dependent, mediating, moderating, and control variables based on the theoretical framework and research hypotheses. A seven-point Likert scale was used, allowing respondents to rate a series of statements from “strongly disagree” to “strongly agree” based on their views and experiences¹⁴. A pilot test was conducted with 29 university students to ensure the survey’s validity and operability. The pilot test feedback led to wording and structure adjustments to enhance comprehension and efficiency³³. The formal data collection was facilitated by university entrepreneurship associations in China, which distributed the survey through online student communities, ensuring a diverse sample coverage. Participation criteria were clearly defined, and only students who had undergone GAISEE were eligible for the survey. Incentives, such as the opportunity to participate in a raffle, were offered to improve response rates and data quality. Data collection spanned from February to April 2024, with the research team ensuring respondent anonymity and information confidentiality, encouraging candid responses, and ensuring data quality and credibility¹⁴. After excluding 39 incomplete or non-compliant surveys, 346 valid responses were obtained (Table 1 for respondent information), providing a solid foundation for subsequent data analysis and conclusions. In addition to obtaining ethical approval, we took several measures to mitigate potential biases:

- **Social Desirability Bias:** To minimize social desirability bias, where participants might provide responses they perceive as socially acceptable rather than their true beliefs, we emphasized the anonymity and confidentiality of the survey in the introductory statement and consent form. Participants were assured that their responses would be used for research purposes only and would not be linked to their identities. The online survey format also helped reduce potential interviewer effects that could contribute to social desirability bias.
- **Non-Response Bias:** To address potential non-response bias, which could arise if those who chose to participate differed systematically from those who did not, we employed several strategies. First, we used a clear and concise survey instrument to minimize participant burden and encourage completion. Second, we collaborated with university entrepreneurship associations to promote the survey within their networks, leveraging their credibility and influence to increase participation rates. Third, we offered a small incentive (the opportunity to participate in a raffle) to further motivate responses. While we cannot completely eliminate non-response bias, these measures were implemented to maximize participation and minimize potential differences between respondents and non-respondents.

Measurement scales

To accurately measure the constructs in the research model, validated scales were adapted to fit the study’s needs²³. These scales, derived from existing research and theoretical frameworks, ensured reliability and validity³³.

The GAISEE scale was refined based on expert reviews and a pilot test²⁵. It measures students’ perceptions and experiences with this innovative educational method, including understanding entrepreneurship, recognizing new opportunities, enhancing innovation and entrepreneurial capabilities, reducing risks and uncertainties, and analyzing business models and market trends.

Variables	Characteristic	Frequency	%
Gender	Male	231	66.8
	Female	115	33.2
Age	≤20	50	14.5
	20~23	239	69.0
	≥24	57	16.5
Discipline	Business	269	77.7
	Non-business	77	22.3
Family background in entrepreneurship activities	Yes	125	36.1
	No	221	63.9

Table 1. Participants profiles.

The entrepreneurial self-efficacy scale was adapted from Al-Qadasi et al.³⁵ incorporating aspects relevant to the entrepreneurial field. It covers individuals' confidence in identifying business opportunities, creating products or services, using innovative thinking to solve problems, commercializing ideas, and managing entrepreneurial challenges.

The entrepreneurial intention scale, based on Ajzen's¹³ Theory of Planned Behavior and Martín-Navarro et al.³³ assesses individuals' motivation and plans to become entrepreneurs. It includes the desire to be an entrepreneur, the intention to pursue entrepreneurship, and perseverance in facing challenges.

The university entrepreneurial environment scale focuses on the university's performance in encouraging student entrepreneurship, providing education and resources, fostering an entrepreneurial culture, and offering guidance and practical opportunities²⁵. These items help us understand the potential impact of the university environment on students' entrepreneurial intentions and efficacy.

The pilot test not only refined the scale items but also provided evidence for the scales' reliability and validity¹⁴. This rigorous design and testing process ensures that the scales reliably capture the key variables in the research model, laying the groundwork for structural model analysis.

Data analysis

The study utilized Partial Least Squares Structural Equation Modeling (PLS-SEM) as the primary tool for data analysis to reveal the effects of GAISEE, entrepreneurial self-efficacy, and university entrepreneurial environment on entrepreneurial intention. PLS-SEM is particularly advantageous for exploratory research and initial model development, especially when dealing with small sample sizes and models that do not assume multivariate normality²⁵. Given the complexity of the theoretical model involving multiple mediators and moderators, PLS-SEM's flexibility was well-suited for the study's analytical needs⁴³.

The analysis began with validating the measurement scales to ensure the accuracy and stability of variable measurements²³. Both internal and external models were assessed, with the internal model including path coefficients, R-squared values, and adjusted R-squared values. In contrast, the external model assessment covered indicator loadings, cross-loadings, and Average Variance Extracted (AVE) to ensure good discriminant validity. Variance Inflation Factor (VIF) was used to assess potential multicollinearity issues within the model. These steps were crucial to ensure the reliability and validity of the subsequent structural equation model estimates. Bootstrap resampling was employed to obtain standard errors and statistical significance for path coefficients, aiding in accurately estimating the strength and direction of relationships. The study further utilized effect size analysis (f^2) to evaluate the impact of relationships between variables and redundancy analysis (Q^2) to assess the model's predictive power for data variance. Combined with importance-performance map analysis (IPMA), this method not only revealed the relative importance of variables to the target construct (Entrepreneurial Intention) but also provided their performance levels in the sample, deepening the understanding of model effects³³. Applying PLS-SEM deepened the understanding of the relationships between GAISEE, entrepreneurial self-efficacy, entrepreneurial intention, and university entrepreneurial environment and provided a robust analytical tool for future research.

Common method variance, normality and multicollinearity

Common Method Variance (CMV) refers to systematic error in variable correlations due to measurement method commonality, which can lead to over- or underestimation of variable correlations. In this study, several measures were taken to assess and control for potential CMV^{23,25}. An anonymous survey was conducted to minimize potential response biases, and questions were designed to be clear and concise to reduce confusion and misinterpretation. Harman's single-factor test was employed, where all items were entered into an exploratory factor analysis to check if a single factor accounted for the majority of the variance. The results indicated that no single factor explained a majority of the variance, suggesting that CMV was not a significant issue in this study. Additionally, the unmeasured latent variable technique proposed by Podsakoff et al. was used by including a method factor in the model to assess its impact on the measurement variables. The method factor's path coefficients were insignificant ($P > 0.05$), confirming that CMV did not significantly affect the study results. The preventive and testing measures indicated that CMV's impact on the study's conclusions is limited, providing additional confidence in the findings and enabling a more reliable interpretation of the relationship between GAISEE and entrepreneurial intentions among university students.

While PLS-SEM does not have strict distributional assumptions like covariance-based SEM. Although PLS-SEM is less sensitive to non-normality than covariance-based SEM⁴⁴ we assessed the data for deviations from normality using skewness and kurtosis values. The results indicated that while some variables showed slight deviations, they were within acceptable ranges for PLS-SEM analysis⁴⁴. We assessed multicollinearity using the Variance Inflation Factor (VIF). As reported in Table 2, all VIF values were below the commonly accepted threshold of 5, indicating that multicollinearity was not a concern in our model⁴⁴. This provides further confidence in the stability and reliability of our parameter estimates. By addressing these considerations, we aim to provide a more transparent and rigorous analysis using PLS-SEM.

Results

Measurement model

The assessment of the measurement model indicates that the scales used in this study exhibit high reliability and validity, effectively reflecting the theoretical constructs of GAISEE, entrepreneurial self-efficacy, entrepreneurial intention, and university entrepreneurial environment^{25,33}. The scales demonstrate high internal consistency, with Cronbach's alpha (α) and Composite Reliability (CR) values exceeding the recommended threshold of 0.7 (Table 2). Specifically, the α value for GAISEE is 0.909, and the CR is 0.899, indicating excellent reliability in measuring students' perceptions of the entrepreneurship education course. In terms of validity, the Average

Scales	VIF	λ	α	CR	AVE
Generative artificial intelligence supported entrepreneurship education (GAISEE)					
Participation in GAISEE deepens my understanding of entrepreneurship.	2.531	0.854	0.909	0.899	0.663
The content of GAISEE courses has made me aware of new opportunities that may arise during the entrepreneurial process.	2.139	0.816			
I believe using generative artificial intelligence technology in entrepreneurship education enhances my innovation and entrepreneurial capabilities.	2.239	0.829			
I trust that the generative artificial intelligence tools provided in the entrepreneurship education course will assist in reducing risks and uncertainties in future entrepreneurial endeavors.	2.265	0.826			
The artificial intelligence models used in the course offer valuable insights for analyzing business models and market trends.	2.432	0.837			
Through learning in the entrepreneurship education course, I am convinced that I can employ artificial intelligence support to develop effective entrepreneurial strategies.	2.180	0.815			
Entrepreneurial self-efficacy (EE)					
I am confident in identifying new business opportunities.	2.195	0.817	0.899	0.922	0.716
I can create innovative products or services.	2.196	0.826			
I am good at using innovative thinking to solve problems.	2.140	0.809			
I can commercialize a creative idea or invention.	2.181	0.819			
I can effectively manage the various challenges in the entrepreneurial process.	2.160	0.814			
I believe I can successfully establish an enterprise.	2.067	0.801			
Entrepreneurial intention (EI)					
I plan to establish my enterprise within five years of graduating.	2.621	0.851	0.92	0.911	0.688
I aspire to be an entrepreneur.	2.390	0.834			
People important to me support my entrepreneurial ambition.	2.067	0.801			
Compared to other career choices, I prefer entrepreneurship.	3.670	0.904			
Even if I may encounter setbacks in the entrepreneurial process, I will keep trying.	2.509	0.848			
Becoming an entrepreneur is my career goal.	2.454	0.836			
University entrepreneurial environment (UEE)					
My university strongly encourages student entrepreneurship.	2.294	0.830	0.914	0.917	0.698
My university provides good entrepreneurship education for students to start their businesses.	2.261	0.830			
My university provided the resources I needed to start a business.	2.273	0.811			
My university has created a supportive campus culture for entrepreneurship.	2.395	0.836			
I can easily find guidance for entrepreneurship at my university.	2.558	0.856			
My university collaborates closely with enterprises to offer practical opportunities for student entrepreneurs.	2.522	0.849			

Table 2. Measurements, reliability and variance inflation factor.

	EE	EI	GAISEE	UEE
Fornell-Larcker criterion				
EE	0.814			
EI	0.644	0.846		
GAISEE	0.567	0.525	0.830	
UEE	0.326	0.310	0.356	0.836
HTMT matrix				
EE				
EI	0.707			
GAISEE	0.624	0.572		
UEE	0.358	0.335	0.386	

Table 3. Discriminant validity. The bold value indicates $\sqrt{\text{AVE}}$.

Variance Extracted (AVE) values surpass the standard of 0.5, confirming good convergent validity. The AVE for entrepreneurial self-efficacy is 0.716, well above the acceptance criterion, suggesting that the scale accurately reflects the construct of entrepreneurial self-efficacy. Discriminant validity is further confirmed through the Fornell-Larcker criterion and the Heterotrait-Monotrait (HTMT) matrix (Table 3), ensuring no excessive overlap between constructs. The results of the cross-loadings (Table 4) also support the discriminant validity of the scales. Variance Inflation Factor (VIF) results indicate no multicollinearity issues, with all scale items having VIF values below 5, ensuring the accuracy of model estimates. The VIF values for entrepreneurial self-efficacy items range from 2.067 to 2.196, supporting the assumption of variable independence within the model. Evaluating

	EE	EI	GAISEE	UEE
EE1	0.817	0.528	0.466	0.307
EE2	0.826	0.526	0.535	0.287
EE3	0.809	0.514	0.420	0.254
EE4	0.819	0.542	0.458	0.226
EE5	0.814	0.518	0.467	0.294
EE6	0.801	0.517	0.417	0.222
EI1	0.529	0.851	0.424	0.198
EI2	0.541	0.834	0.448	0.256
EI3	0.514	0.801	0.409	0.272
EI4	0.586	0.904	0.472	0.284
EI5	0.577	0.848	0.432	0.236
EI6	0.517	0.836	0.476	0.329
GAISEE1	0.512	0.471	0.854	0.299
GAISEE2	0.470	0.435	0.816	0.259
GAISEE3	0.490	0.449	0.829	0.338
GAISEE4	0.476	0.406	0.826	0.328
GAISEE5	0.436	0.424	0.837	0.237
GAISEE6	0.433	0.422	0.815	0.306
UEE1	0.282	0.265	0.305	0.830
UEE2	0.265	0.281	0.279	0.830
UEE3	0.250	0.187	0.217	0.811
UEE4	0.279	0.242	0.320	0.836
UEE5	0.296	0.283	0.338	0.856
UEE6	0.259	0.283	0.308	0.849

Table 4. Cross loadings. Significant values are in bold.

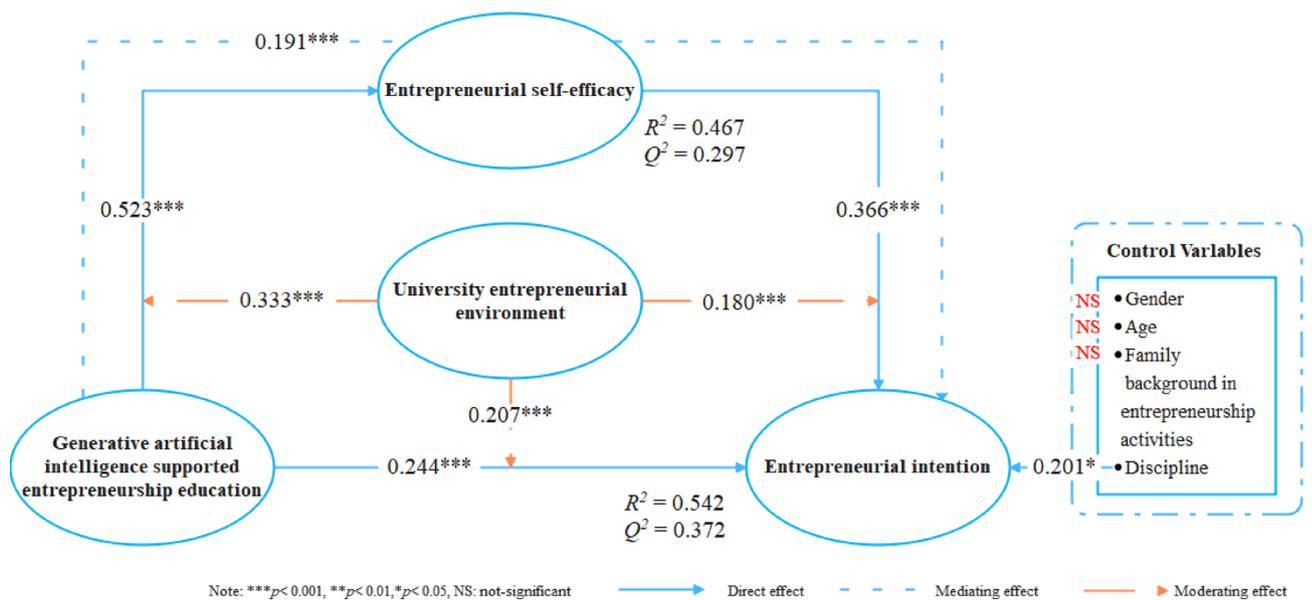


Fig. 2. Structural model.

the measurement model provides a solid foundation for the study, ensuring the reliability and effectiveness of the subsequent structural model analysis.

Structural model

As illustrated in Fig. 2, the structural model demonstrates the significant relationships between GAISEE, entrepreneurial self-efficacy, entrepreneurial intention, and the moderating role of the university entrepreneurial environment^{23,43}. The significant positive effect of entrepreneurial self-efficacy on entrepreneurial intention

($\beta = 0.366, p < 0.001$) supports Hypothesis H3, implying that students who believe in their abilities to perform entrepreneurial tasks are more likely to intend to become entrepreneurs. This finding underscores the importance of designing educational interventions that bolster students' confidence in their entrepreneurial capabilities⁴⁴. The positive influence of GAISEE on entrepreneurial self-efficacy ($\beta = 0.523, p < 0.001$) is also significant, confirming Hypothesis H1. This suggests that the integration of generative AI tools in entrepreneurship education enhances students' belief in their ability to identify opportunities, innovate, and manage entrepreneurial challenges. For example, GAISEE can provide personalized feedback and simulations that allow students to practice and refine their entrepreneurial skills in a low-risk environment, thereby increasing their self-efficacy⁵.

The data supports the direct positive effect of GAISEE on entrepreneurial intention ($\beta = 0.244, p < 0.001$), validating Hypothesis H2. This suggests that exposure to generative AI in entrepreneurship education not only enhances students' skills but also directly increases their desire to pursue entrepreneurial ventures. This may be due to the innovative nature of AI tools, which can inspire students to think creatively and explore new entrepreneurial possibilities¹. The mediating role of entrepreneurial self-efficacy between GAISEE and entrepreneurial intention aligns with Hypothesis H4 (Table 5), indicating entrepreneurial self-efficacy's bridging role. This means that the positive effects of GAISEE on entrepreneurial intention are partially explained by the increase in students' self-efficacy. In practical terms, GAISEE's ability to enhance students' confidence in their entrepreneurial skills acts as a catalyst for their entrepreneurial intentions^{23,27}.

The moderating effect analysis shows that the university entrepreneurial environment positively moderates the relationship between GAISEE and entrepreneurial self-efficacy ($\beta = 0.333, p < 0.001$), supporting Hypothesis H5. This implies that a supportive university environment, characterized by resources, mentorship, and an encouraging culture, can amplify the positive impact of GAISEE on students' self-efficacy. Universities that invest in creating such environments are likely to see greater returns on their investment in AI-enhanced entrepreneurship education^{9,25}. Similarly, the university entrepreneurial environment positively moderates the relationship between GAISEE and entrepreneurial intention ($\beta = 0.207, p < 0.001$), supporting Hypothesis H6. This suggests that the positive impact of GAISEE on entrepreneurial intention is stronger in universities that actively promote entrepreneurship. For example, universities that provide incubator programs, seed funding, and networking opportunities can enhance the effectiveness of GAISEE in fostering entrepreneurial intentions^{38,40}.

Furthermore, the university entrepreneurial environment also strengthens the relationship between entrepreneurial self-efficacy and entrepreneurial intention ($\beta = 0.180, p < 0.001$), further confirming Hypothesis H7. This finding highlights the synergistic effect of a supportive environment in translating students' confidence into actual entrepreneurial intentions. When students believe in their abilities and are supported by a conducive university environment, they are more likely to take concrete steps toward starting their own ventures^{21,39}. The effect size (f^2) of GAISEE on entrepreneurial self-efficacy ($f^2 = 0.442$) indicates a substantial impact, highlighting the critical role of GAISEE in enhancing students' entrepreneurial self-efficacy. This substantial effect size suggests that GAISEE is a powerful tool for entrepreneurship education, capable of significantly boosting students' confidence in their entrepreneurial abilities, which, in turn, can lead to higher entrepreneurial intentions and actions⁴⁵. These structural model analyzes not only validate the theoretical model's hypotheses but also provide empirical evidence for understanding the potential of GAISEE in enhancing university students' entrepreneurial intentions.

Moderating effect of university entrepreneurial environment

The university entrepreneurial environment significantly moderates the relationship between GAISEE and entrepreneurial self-efficacy⁴³. Figure 3 visually depicts the moderating effect of the university entrepreneurial environment on the relationship between GAISEE and entrepreneurial self-efficacy, as discussed earlier. This visual representation complements the statistical results presented in Table 5 ($\beta = 0.333, p < 0.001$) and provides a clearer understanding of how a supportive environment amplifies the positive impact of GAISEE. Similarly, Figs. 4

Hypotheses	Original sample (O)	STDEV	T statistics (O/STDEV)	p	f ²
EE → EI	0.366	0.051	7.175	0.000	0.160
GAISEE → EE	0.523	0.039	13.440	0.000	0.442
GAISEE → EI	0.244	0.049	5.017	0.000	0.071
Age → EE	0.060	0.036	1.668	0.095	
Gender → EE	0.039	0.087	0.446	0.656	
Family background in entrepreneurship activities → EE	-0.110	0.081	1.371	0.170	
Discipline → EE	0.201	0.094	2.142	0.032	
Mediating effects					
GAISEE → EI	0.244	0.049	5.017	0.000	
GAISEE → EE → EI	0.191	0.032	6.054	0.000	
Moderating effects					
UEE x GAISEE → EE	0.333	0.038	8.706	0.000	0.191
UEE x GAISEE → EI	0.207	0.047	4.387	0.000	0.059
UEE x EE → EI	0.180	0.047	3.806	0.000	0.045

Table 5. Path coefficients for the structural model.

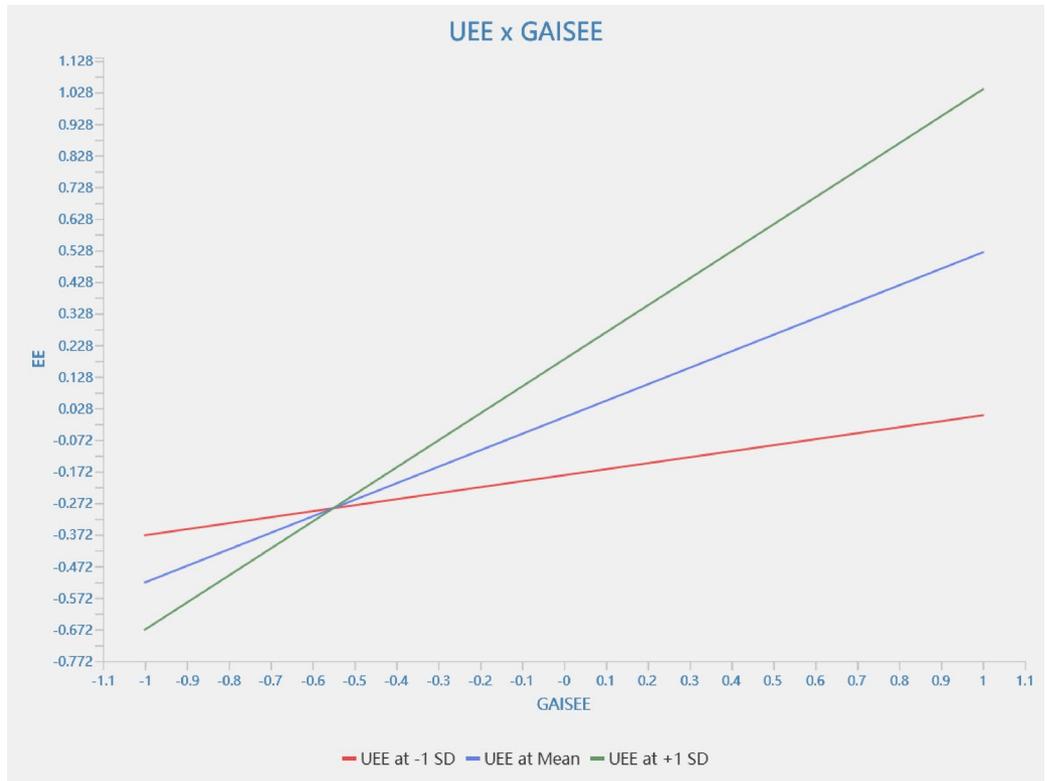


Fig. 3. Moderating effect of university entrepreneurial environment on the relationship between GAISEE and entrepreneurial self-efficacy.

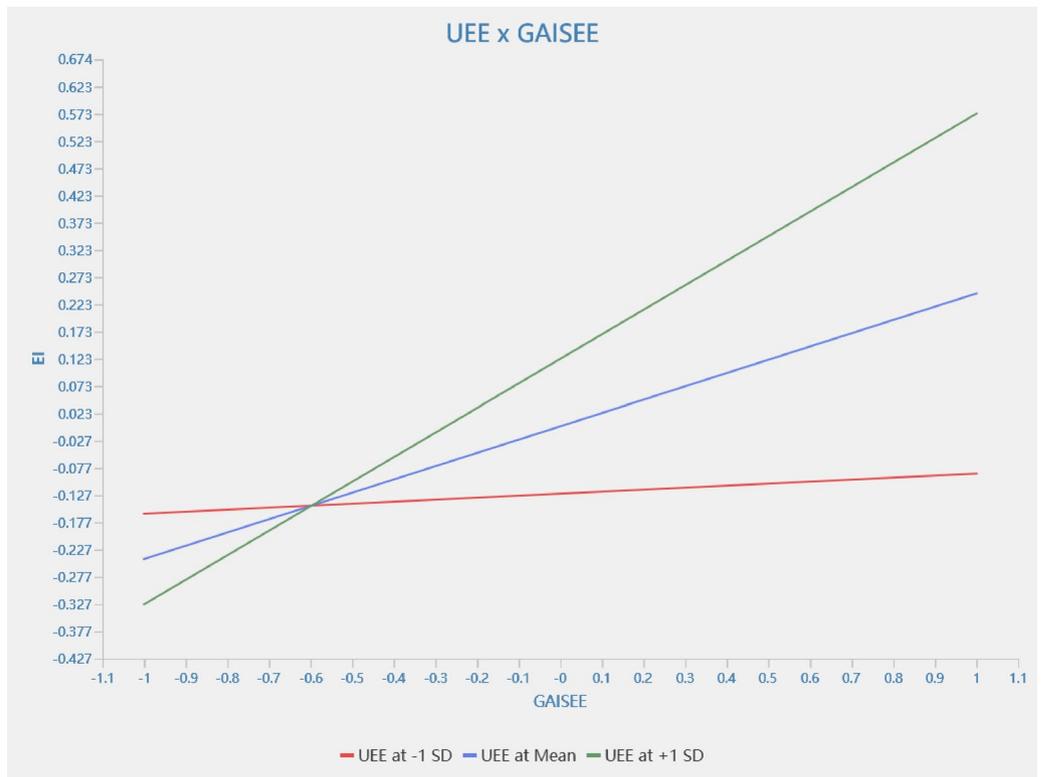


Fig. 4. Moderating effect of university entrepreneurial environment on the relationship between GAISEE and entrepreneurial intention.

and 5 illustrate the moderating effects on the relationships between GAISEE and entrepreneurial intention, as well as entrepreneurial self-efficacy and entrepreneurial intention. These figures, in conjunction with the data in Table 5, provide a comprehensive overview of the moderating role of the university entrepreneurial environment. When the university entrepreneurial environment is more encouraging and supportive, the positive influence of GAISEE on students' entrepreneurial intention is strengthened, validating Hypothesis H6. This highlights the pivotal role of university entrepreneurial environment in fostering students' entrepreneurial intention, especially when employing emerging technologies in entrepreneurship education. Figure 5 further reveals the moderating effect of university entrepreneurial environment on the relationship between entrepreneurial self-efficacy and entrepreneurial intention. An optimized university entrepreneurial environment strengthens the positive influence of entrepreneurial self-efficacy on entrepreneurial intention, aligning with Hypothesis H7. In a vibrant and resource-rich university entrepreneurial environment, students' entrepreneurial self-efficacy is more effectively translated into motivation for entrepreneurial action. The moderating role of university entrepreneurial environment is significant, enhancing the effects of GAISEE and providing a conducive backdrop for the relationship between entrepreneurial self-efficacy and entrepreneurial intention.

Interestingly, Figs. 3 and 4 suggest that at very low levels of GAISEE, students in a high-support UEE report marginally lower entrepreneurial self-efficacy and intention compared to those in a low-support UEE. A similar pattern is observed in Fig. 5 for entrepreneurial self-efficacy and entrepreneurial intention. As depicted in Fig. 3, the positive relationship between GAISEE and entrepreneurial self-efficacy is significantly stronger when the university entrepreneurial environment (UEE) is high (UEE at +1 SD). However, the plot also reveals a conditional effect: this strengthening influence of a high UEE becomes particularly evident as levels of GAISEE increase. At very low levels of GAISEE, the lines for high and low UEE are much closer, and the pronounced divergence, indicating a stronger positive slope for the high UEE condition, emerges as GAISEE surpasses a certain threshold. "Similar nuanced interpretations have been incorporated for Fig. 4 (UEE x GAISEE → EI) and Fig. 5 (UEE x EE → EI), emphasizing that the amplification effect of a supportive university environment is most prominent at moderate to high levels of the predictor variable (GAISEE or EE).

Importance-performance map analysis (IPMA)

Importance-performance map analysis (IPMA) offers unique insights into the importance and actual performance of variables related to entrepreneurial intention³³. The IPMA, presented in Fig. 6, further elaborates on the relative importance and performance of the key constructs. This figure provides a visual comparison of the constructs' contributions to entrepreneurial intention, enhancing the interpretation of the structural model results. IPMA demonstrates the importance and performance levels of entrepreneurial self-efficacy, GAISEE, and university entrepreneurial environment in influencing students' entrepreneurial intention. The IPMA results, depicted in Fig. 6, indicate that although the importance of entrepreneurial self-efficacy (0.368) is slightly lower

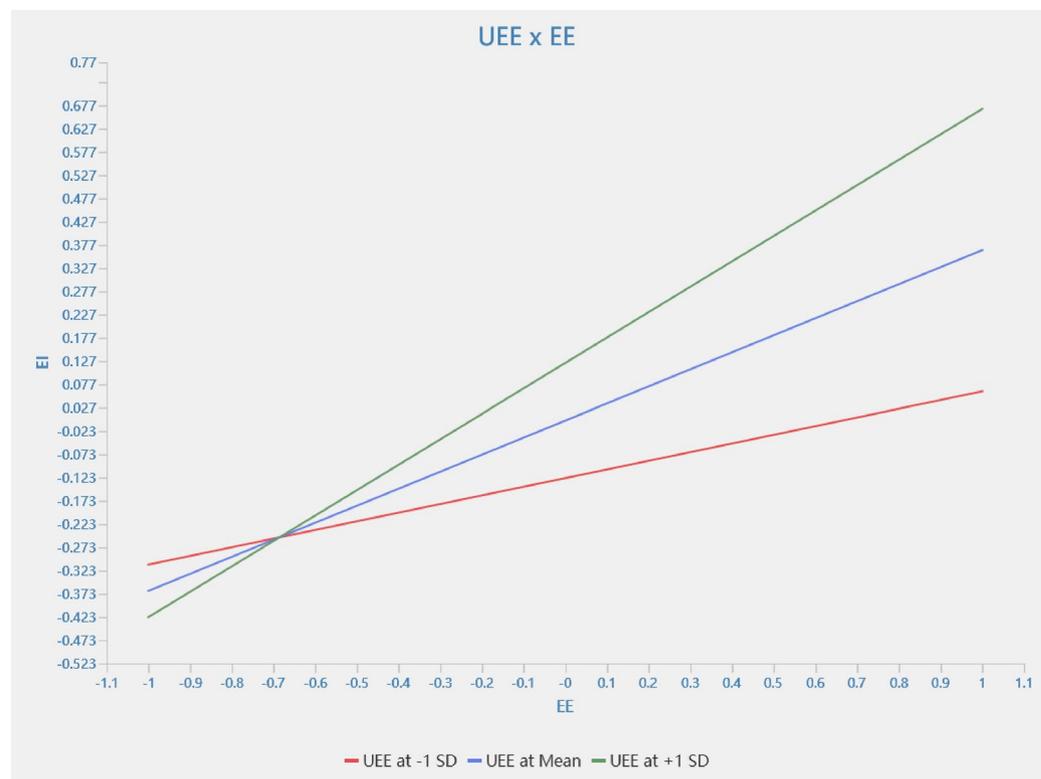


Fig. 5. Moderating effect of university entrepreneurial environment on the relationship between entrepreneurial self-efficacy and entrepreneurial intention.

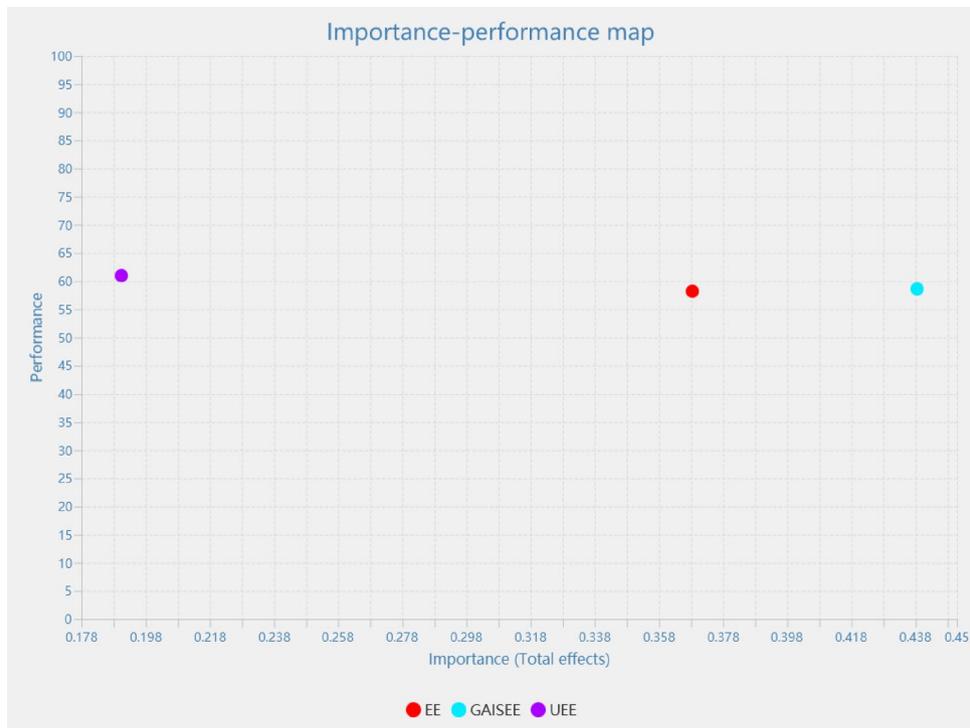


Fig. 6. IPMA (Entrepreneurial intention).

than that of GAISEE (0.438), its performance level is slightly lower (58.196 compared to 58.625), suggesting that entrepreneurial self-efficacy plays a crucial role in practically promoting entrepreneurial intention. Despite university entrepreneurial environment having the lowest importance score (0.190) in this analysis, it scores the highest in performance (60.975), implying that the quality of university entrepreneurial environment is relatively good in the current sample and significantly impacts entrepreneurial intention. This phenomenon points to the importance of strengthening university entrepreneurial environment, particularly when combined with GAISEE, as it may have a more profound positive effect on students' entrepreneurial intention.

Discussion

This study's findings indicate that GAISEE significantly enhances both students' entrepreneurial self-efficacy and their entrepreneurial intention. Crucially, we found that entrepreneurial self-efficacy serves as a pivotal mediator in the GAISEE-EI relationship. These results resonate with and extend the Theory of Planned Behavior (TPB)^{13,46} by situating it within the rapidly evolving context of AI-driven entrepreneurship education, a domain experiencing burgeoning scholarly interest⁴⁷. While traditional applications of TPB have long informed our understanding of entrepreneurial intention, the advent of sophisticated technologies like generative AI necessitates a re-examination of how its core constructs—attitudes, subjective norms, and perceived behavioral control (PBC)—are shaped and interact^{6,48}. Our research aligns with prior work underscoring the power of innovative educational methodologies in bolstering entrepreneurial confidence^{23,49} and the direct positive effect of GAISEE on entrepreneurial intention supports the argument that engagement with advanced technologies can indeed ignite entrepreneurial aspirations among students⁷. However, the integration of GAISEE is not merely an incremental enhancement; it represents a qualitative shift, suggesting that the very nature of PBC, as reflected in entrepreneurial self-efficacy, may be transformed when students learn to leverage AI as a cognitive and operational partner.

The mediating role of entrepreneurial self-efficacy offers a more granular understanding of how GAISEE influences students' career trajectories towards entrepreneurship, building upon established research that identifies entrepreneurial self-efficacy as a cornerstone of entrepreneurial intention^{32,35}. Our distinct contribution lies in empirically demonstrating that a generative AI-enriched learning environment—characterized by its capacity for personalized learning pathways, dynamic content generation, and interactive simulations^{5,26}—acts as a potent catalyst for entrepreneurial self-efficacy. This AI-driven enhancement of entrepreneurial self-efficacy, in turn, fuels students' intentions to pursue entrepreneurial ventures. For instance, GAISEE can empower students to develop and test marketing campaigns or simulate funding processes, activities that build tangible skills and, more importantly, the conviction in their ability to navigate complex entrepreneurial tasks^{10,27}. This aligns with recent work by Somia and Vecchiarini⁵⁰ who found that tools like ChatGPT enhance specific entrepreneurial competencies such as opportunity spotting and creativity, which are foundational to entrepreneurial self-efficacy. The experiential learning fostered by GAISEE allows students to not only apply concepts but also to witness the outcomes of their AI-assisted efforts, thereby reinforcing their belief in their entrepreneurial capabilities²⁴ and potentially cultivating a unique, digitally-augmented form of entrepreneurial self-efficacy.

Our research further illuminates the critical moderating influence of the university entrepreneurial environment on the relationships between GAISEE, entrepreneurial self-efficacy, and entrepreneurial intention. An optimized university entrepreneurial environment—rich in resources, mentorship, and a supportive culture—significantly amplifies GAISEE’s positive impacts. This finding concurs with studies emphasizing the enabling role of supportive ecosystems in entrepreneurial endeavors^{9,38} and extends this understanding to the context of AI-enhanced education. A conducive university entrepreneurial environment does more than just provide resources; it fosters a milieu where the skills and confidence gained through GAISEE can be more effectively translated into actionable entrepreneurial intent. As universities evolve into sustainable entrepreneurial hubs³⁹ their role in providing robust digital infrastructure^{47,51} and ethical guidance for AI use becomes paramount. This suggests that the interplay between advanced pedagogy like GAISEE and a nurturing university entrepreneurial environment is synergistic, creating an environment where technological potential and human aspiration can converge to foster a new generation of entrepreneurs. The efficacy of university offerings in translating intention to action is also noted by Lyu et al.⁴⁰ underscoring the importance of a well-structured university entrepreneurial environment.

An intriguing and somewhat counterintuitive pattern emerged from our moderation analyses (Figs. 3, 4 and 5). Specifically, at very low levels of GAISEE (or entrepreneurial self-efficacy in the case of its interaction with university entrepreneurial environment on entrepreneurial intention), a highly supportive university entrepreneurial environment was associated with slightly lower, rather than higher, entrepreneurial self-efficacy and intention. While our study did not pre-emptively hypothesize this, several potential explanations could be considered. It is plausible that in a high-support environment, students with very limited GAISEE exposure (or low initial self-efficacy) might become more acutely aware of the entrepreneurial standards, resources, and expectations, which could paradoxically temper their immediate self-assessment or intentions if they perceive a significant gap between their current standing and the perceived requirements^{52,53}. Alternatively, the nature of support in high-university entrepreneurial environment settings might be tailored to individuals who already possess a baseline level of engagement or skill, potentially making these resources seem less relevant or even overwhelming for those at the very nascent stages of GAISEE exposure. This could lead to a temporary discouragement or a more cautious articulation of intentions or self-efficacy.

The IPMA complements our structural model by offering a pragmatic lens on the relative leverage of GAISEE, entrepreneurial self-efficacy, and university entrepreneurial environment in fostering entrepreneurial intention³³. While both GAISEE and entrepreneurial self-efficacy are identified as highly important, the IPMA may also reveal nuances in their current performance levels within the sampled institutions. For instance, a high importance yet moderate performance for GAISEE could suggest that while its potential is recognized, its implementation could be further optimized. The university entrepreneurial environment’s strong performance in our sample, despite a comparatively lower direct importance score for entrepreneurial intention in the IPMA, underscores its foundational role in enabling the translation of educational impacts into tangible entrepreneurial outcomes, aligning with findings by Suguna et al.⁴ who highlight incubators and partnerships as key drivers. This reinforces the necessity for a holistic strategy that not only deploys innovative educational tools like GAISEE but also meticulously cultivates individual entrepreneurial self-efficacy and the broader supportive university entrepreneurial environment.

Situating our findings within the broader discourse on AI-enabled entrepreneurship education, this study responds to urgent calls for more empirical investigations into how generative AI is reshaping this field^{31,54}. While the potential of AI in education is widely discussed²⁸ and conceptual frameworks for AI integration are emerging^{5,17} our work provides specific empirical evidence on the cognitive (entrepreneurial self-efficacy) and environmental (university entrepreneurial environment) pathways through which GAISEE influences entrepreneurial intention. This is particularly salient given the rapid proliferation of GenAI tools and the need for educators to understand their pedagogical implications⁵⁵. We move beyond general discussions of AI in entrepreneurial self-efficacy by focusing on generative AI’s unique affordances, such as content creation and simulation, which differentiate GAISEE from earlier forms of technology-enhanced learning. However, the embrace of GAISEE is not without its complexities. We must critically consider potential downsides, such as the risk of AI dependency if students do not develop critical evaluation skills alongside AI tool usage⁵³. As Weng et al.⁵⁶ articulate in their SWOT analysis, while AI-empowered entrepreneurial self-efficacy offers strengths like personalized learning and efficiency, it also presents weaknesses such as potential for imprecise information and threats including over-reliance and ethical concerns. Effective GAISEE pedagogy, therefore, must actively foster critical thinking and digital literacy to mitigate these risks, ensuring AI serves as an empowerment tool rather than a crutch.

Our study also contributes to understanding the cognitive architecture of entrepreneurial development in an AI era. The enhancement of entrepreneurial self-efficacy through GAISEE aligns with socio-cognitive theory²⁹ suggesting that GAISEE provides mastery experiences and vicarious learning opportunities that are potent sources of self-efficacy. The capacity of generative AI to generate novel scenarios and provide tailored feedback²⁶ offers students a unique “practice field” for complex entrepreneurial tasks like opportunity recognition and strategic planning. This experiential learning, augmented by AI, can reinforce critical cognitive skills. For example, the creative potential of GenAI, as highlighted by Hubert et al.¹ can be directly leveraged within GAISEE for ideation exercises, pushing students beyond conventional thinking. However, it is also important to consider findings from studies like Nguyen and Nguyen²¹ whose research on digital entrepreneurship education in Vietnam showed an inverse effect of digital entrepreneurship education on the PBC-DEI relationship. While our findings on GAISEE’s positive impact (mediated by entrepreneurial self-efficacy, which is conceptually close to PBC) appear to differ, this could be attributed to the specific nature of GAISEE—which is highly interactive and generative—compared to broader digital entrepreneurship education, or due to distinct socio-cultural and institutional contexts between China and Vietnam. Such discrepancies underscore the need for

further contextualized research into how specific AI applications interact with diverse learner populations and educational settings, including considering factors like parental psychological control prevalent in the Chinese context which might interact with GAISEE's impact³.

Finally, the effective deployment of GAISEE is inextricably linked to the availability and quality of digital infrastructure and the broader AI ecosystem. As prior research indicates, inadequate digital infrastructure can severely hamper the benefits of digital entrepreneurship and innovation^{45,47,51}. The promise of GAISEE to personalize learning and provide sophisticated simulations hinges on students having reliable access to these AI tools and the requisite digital literacy to engage with them. This not only impacts the direct efficacy of GAISEE but also has equity implications, as unequal access can exacerbate existing digital divides⁵⁶. Moreover, the broader AI talent ecosystem, including the availability of AI-savvy educators and the potential “brain drain” of AI talent from universities⁷ could influence the sustainable implementation of GAISEE programs. This calls for strategic investment in both technological and human capital within universities, ensuring that GAISEE initiatives are both cutting-edge and inclusively implemented. The ethical integration of GAI, as advocated by Celik¹⁸ through an “Intelligent-TPACK” framework, also becomes a critical consideration for institutions, ensuring that GAISEE promotes responsible entrepreneurship. Furthermore, GAISEE may play a role in developing skills pertinent to entrepreneurial resilience, a critical asset in today's turbulent markets where GenAI is already being used by SMEs to cope with crises⁵⁷.

Theoretical implications

This study offers several theoretical contributions to the entrepreneurship education literature, particularly at the intersection of technology, pedagogy, and cognitive psychology. Firstly, we extend the Theory of Planned Behavior (TPB)^{13,46} by empirically examining its applicability and nuances in the context of GAISEE. While TPB provides a robust framework for understanding intention formation, our findings illustrate how a technologically advanced educational intervention like GAISEE directly influences entrepreneurial intention and, more significantly, enhances entrepreneurial self-efficacy – a key proxy for perceived behavioral control within the TPB model^{20,23}. This integration of a specific, AI-driven pedagogical approach (GAISEE) into the TPB framework provides a more contemporary understanding of how antecedents to entrepreneurial intention are shaped in an era of intelligent technologies, responding to calls for research that explore technology's role in TPB dynamics⁶.

Secondly, our research illuminates the mediating mechanism of entrepreneurial self-efficacy in the GAISEE-EI nexus. By demonstrating that GAISEE enhances entrepreneurial intention through the cultivation of entrepreneurial self-efficacy, we provide empirical weight to the argument that advanced educational technologies can foster the psychological prerequisites for entrepreneurship^{18,36}. This responds to calls for a deeper understanding of how entrepreneurship education translates into entrepreneurial intention by specifying a critical cognitive pathway¹⁷. GAISEE, with its interactive and generative capabilities, appears uniquely positioned to provide the mastery experiences that Bandura identified as central to self-efficacy development, thereby offering a novel theoretical lens on how entrepreneurial self-efficacy is cultivated in digital learning environments. This deepens our understanding beyond general entrepreneurship education effects^{14,25} by specifying the role of a particular technological intervention.

Thirdly, the study contributes by empirically validating the multi-faceted moderating role of the university entrepreneurial environment. We demonstrate that the university entrepreneurial environment does not just independently influence entrepreneurial intention but also conditions the effectiveness of GAISEE on both entrepreneurial self-efficacy and entrepreneurial intention, and the entrepreneurial self-efficacy–entrepreneurial intention link itself. This finding underscores the theoretical importance of considering the interplay between pedagogical innovations and their contextual embeddedness^{9,37}. It suggests that theories of entrepreneurship education must account for the synergistic effects that arise when advanced educational tools are deployed within supportive and resource-rich ecosystems. This nuanced understanding of moderation enriches TPB by highlighting how environmental factors can amplify or dampen the cognitive processes leading to entrepreneurial action, especially when these processes are themselves being shaped by new technologies.

Finally, through the use of IPMA, this study offers a methodological extension that provides nuanced insights into the practical leverage of different theoretical constructs^{16,33}. While SEM identifies significant pathways, IPMA allows for a more strategic interpretation of which factors (GAISEE, entrepreneurial self-efficacy, university entrepreneurial environment) offer the most impactful intervention points relative to their current performance. This contributes to a more actionable theoretical understanding, bridging the gap between identifying significant relationships and prioritizing them for practical application in fostering future entrepreneurs through the integration of generative AI in education.

Practical implications

The empirical findings of this study carry significant practical implications for higher education institutions, educators, and policymakers aiming to cultivate entrepreneurial talent in the age of generative AI. Our results underscore GAISEE's transformative potential in fostering both entrepreneurial self-efficacy and intention, offering a data-driven roadmap for designing more effective entrepreneurship education programs.

Firstly, the demonstrated capacity of GAISEE to significantly enhance entrepreneurial self-efficacy offers crucial guidance for educators. Rather than treating AI as a mere supplementary tool, we recommend the active integration of specific generative AI applications (e.g., ChatGPT for ideation and business plan drafting, Synthesia for pitch development, Jasper for marketing content creation) into the core curriculum^{5,8}. Curriculum modules should be explicitly designed around the application of generative AI in diverse entrepreneurial scenarios, such as market analysis, financial projection, and competitive strategy development²⁷. These hands-on, AI-augmented experiences are vital for bridging the theory-practice gap. Moreover, fostering a collaborative

learning environment where students experiment with AI tools and engage in peer-assisted learning can amplify GAISEE's benefits²⁸. However, this integration must be coupled with pedagogical strategies that promote critical thinking and ethical AI use, mitigating risks like AI dependency or the uncritical acceptance of AI-generated content^{53,56}. Continuous professional development for educators is therefore essential, equipping them not only with technical skills but also with the pedagogical knowledge to guide students in the responsible and effective use of these evolving tools^{18,58}.

Secondly, the pivotal role of the university entrepreneurial environment in amplifying GAISEE's positive effects necessitates a holistic institutional strategy. University administrators should prioritize the creation of a vibrant entrepreneurial ecosystem that extends beyond formal coursework. This involves establishing robust university-industry partnerships for real-world data access, mentorship, and potential seed funding⁷. Developing university incubators and accelerators with dedicated resources, co-working spaces, and specialized training tailored to student startups is also crucial⁴⁰. These initiatives must be embedded within a campus culture that actively celebrates entrepreneurial pursuits and provides strong support networks⁹. Critically, a modern university entrepreneurial environment must also ensure robust digital infrastructure, including high-speed internet, access to AI platforms, and technical support, to ensure equitable access to GAISEE for all students^{47,59,51}.

Thirdly, from a policy perspective, our findings advocate for increased investment in the digital transformation of higher education institutions, specifically to support GAISEE. Policymakers should champion funding for technological infrastructure and AI software access, alongside comprehensive technical and pedagogical support for educators and students^{6,59,51}. It is equally crucial to develop clear guidelines and ethical frameworks for the responsible use of generative AI in educational settings, addressing concerns such as data privacy, algorithmic bias, academic integrity, and the societal impact of AI-driven innovations^{18,56}. Fostering collaborations between universities, industry, and ethics experts can help establish best practices, ensuring GAISEE is implemented effectively and responsibly. Given the diverse institutional landscape, policies should also encourage flexible, adaptable GAISEE implementation strategies tailored to institutional resources and student demographics⁴².

Finally, the insights from our IPMA offer a quantitative basis for the continuous improvement of entrepreneurship education. Universities should regularly assess their GAISEE programs, evaluating not only student outcomes (entrepreneurial self-efficacy, entrepreneurial intention) but also the performance of key enabling factors like the quality of GAISEE implementation and the supportiveness of the university entrepreneurial environment. This data-driven approach facilitates timely adjustments and strategic resource allocation, ensuring that programs remain effective and responsive to evolving student needs and technological advancements⁶⁰. By embracing a culture of continuous evaluation and improvement, incorporating feedback from students, educators, and industry partners, universities can maximize the socio-economic benefits of GAISEE, contributing to a more innovative and entrepreneurial workforce^{4,17}. This includes monitoring for and mitigating unintended negative consequences, ensuring GAISEE truly empowers students.

Conclusions

This research provides new theoretical and empirical support for the field of entrepreneurship education by examining the influence of GAISEE on university students' entrepreneurial intention and the moderating role of the university entrepreneurial environment. The findings demonstrate that GAISEE significantly improves students' entrepreneurial self-efficacy and entrepreneurial intention, with entrepreneurial self-efficacy acting as a mediator between GAISEE and entrepreneurial intention. Additionally, an optimized university entrepreneurial environment significantly enhances the positive effects of GAISEE on both entrepreneurial self-efficacy and entrepreneurial intention. These insights enrich the application of the Theory of Planned Behavior in the context of entrepreneurship education and provide valuable guidance for higher education institutions in designing entrepreneurship courses. This study makes a significant contribution to the field by being among the first to empirically investigate the impact of GAISEE on entrepreneurial intention. It extends the existing literature on entrepreneurship education by highlighting the potential of generative AI as a powerful tool for enhancing students' entrepreneurial self-efficacy and intention. Furthermore, it underscores the importance of a supportive university entrepreneurial environment in maximizing the effectiveness of GAISEE, offering a nuanced understanding of the interplay between technology, education, and the broader institutional context. The study highlights the importance of integrating generative AI technology into entrepreneurship education to enhance students' entrepreneurial skills, market insights, and confidence. Policymakers are encouraged to optimize the university entrepreneurial environment to foster students' entrepreneurial aspirations, suggesting policy support and funding to promote collaboration between universities and industry, providing rich entrepreneurial resources and practical opportunities. Engaging in GAISEE can enhance students' entrepreneurial skills and unleash their entrepreneurial potential, laying a solid foundation for their future entrepreneurial path. This study offers new perspectives for theoretical research and concrete recommendations for entrepreneurship education practice.

Limitations and future agenda

Despite the insights provided, this study has limitations that present directions for future research. Firstly, the cross-sectional survey data used needs to capture the long-term impact of GAISEE on changes in entrepreneurial intention. Future research could employ a longitudinal study design to track the entrepreneurial process of respondents over time, observing the long-term effects of entrepreneurship education interventions on entrepreneurial behavior and intention. Secondly, the limited sample scope, focused on university students in China, restricts the generalizability of the findings. While the focus on a Chinese context provides valuable in-depth insights, we acknowledge the need to consider the implications of our findings for non-Eastern and non-Chinese institutions. Although the core principles of integrating generative AI into education and fostering

a supportive entrepreneurial environment are likely to be universally beneficial, the specific implementation strategies may need to be adapted to different cultural and institutional contexts. For example, Western institutions might place a greater emphasis on individualistic entrepreneurial pursuits, while Eastern institutions might prioritize collective or collaborative entrepreneurial models. The availability and acceptance of AI technologies, as well as the structure of support systems for entrepreneurship within universities, may also vary across regions, necessitating tailored approaches. To enhance the external validity of the conclusions, future studies could expand the sample to include students from different countries and cultural backgrounds, exploring the role of cultural diversity in GAISEE. Thirdly, this research focused on the rational aspect of entrepreneurial intention, and future studies could incorporate emotional factors into the theoretical model. Investigating the relationship between students' emotional states, such as passion, fear, and optimism, and their entrepreneurial intention and behavior could provide a more comprehensive understanding of entrepreneurial intention. Building a more holistic theoretical model of entrepreneurial intention will also offer richer guidance for designing and implementing entrepreneurship education. These suggestions deepen the field's theoretical understanding while advancing entrepreneurship education's development and guiding future educational reforms. The counterintuitive finding that a high-support university environment might be associated with slightly lower self-efficacy and intention at very low levels of GAISEE warrants more in-depth investigation. Future research could employ qualitative methods or more granular quantitative measures to explore the psychological mechanisms behind this observation, such as perceived pressure, resource misalignment, or heightened awareness of competency gaps in high-support environments for individuals with minimal initial exposure or efficacy.

Another important limitation of this study concerns the potential causal ambiguity between GAISEE and the university entrepreneurial environment. While our current model positions the university entrepreneurial environment as a moderator, we acknowledge that the relationship between these constructs may be more complex and bidirectional. Universities with stronger entrepreneurial environments may be more likely to adopt innovative educational approaches like GAISEE, while the implementation of GAISEE may simultaneously contribute to strengthening the university's entrepreneurial ecosystem. Future research could explore alternative model specifications, such as testing the interaction effect of GAISEE in the relationship between university support and entrepreneurial intention. This reverse moderation approach would provide valuable insights into whether GAISEE amplifies the impact of existing university support structures on student entrepreneurial outcomes. Additionally, longitudinal studies could help disentangle the temporal dynamics and potential reciprocal relationships between GAISEE implementation and the evolution of university entrepreneurial environments. We acknowledge a potential conceptual overlap between our GAISEE construct and the university entrepreneurial environment measurement. Specifically, the university entrepreneurial environment scale includes an item related to entrepreneurship education ('My university provides good entrepreneurship education for students to start their businesses'), which could be perceived as overlapping with GAISEE, as GAISEE represents a specific form of entrepreneurship education. While we maintained these as separate constructs based on their distinct theoretical foundations—with GAISEE focusing specifically on AI-enhanced pedagogical approaches and the university entrepreneurial environment encompassing broader institutional support systems—future research should consider developing more refined measurement instruments that clearly delineate between specific educational interventions and general institutional support. This limitation does not invalidate our findings, as discriminant validity tests confirmed the empirical distinctiveness of these constructs (see Table 3), but it highlights an area for methodological improvement in future studies.

Our study has primarily conceptualized and tested entrepreneurial self-efficacy as a mediating variable between GAISEE and entrepreneurial intention. This approach is well-grounded in a substantial body of entrepreneurship education literature which emphasizes the role of educational interventions in building efficacy, which, in turn, drives intentions, regarding Ajzen's⁴⁶ discussion on the potential for Perceived Behavioral Control (and by extension, domain-specific self-efficacy like entrepreneurial self-efficacy) to also function as a moderator within the TPB framework. While our focus was on the efficacy-building nature of GAISEE, future research could fruitfully explore a more complex model that simultaneously investigates the dual roles of entrepreneurial self-efficacy – both as a mediator and a moderator. This could provide an even more nuanced understanding of how individual self-perceptions of capability interact with educational inputs to shape entrepreneurial intentions, particularly in the context of rapidly evolving AI-augmented learning environments. Such investigations could further refine the application of TPB in predicting entrepreneurial outcomes stemming from technology-enhanced education.

Data availability

The datasets used or analysed during the current study are available from the corresponding author (Shaofeng Wang: vipwhsl@hotmail.com) on reasonable request.

Received: 5 January 2025; Accepted: 27 June 2025

Published online: 05 July 2025

References

1. Hubert, K. F., Awa, K. N. & Zabelina, D. L. The current state of artificial intelligence generative Language models is more creative than humans on divergent thinking tasks. *Sci. Rep.* **14** (1), 3440 (2024).
2. Fang, J. & Jia, W. Applying information mining technology in online entrepreneurship training course. *Sci. Rep.* **14** (1), 22740 (2024).
3. Gao, Y. & Lu, J. Entrepreneurship education and self-efficacy among Chinese college students mediated by harmonious passion and moderated by parental psychological control. *Scientific Reports.* **14** (1), 31892 (2024).
4. Suguna, M. et al. Entrepreneurial education and its role in fostering sustainable communities. *Sci. Rep.* **14** (1), 7588 (2024).

5. Bell, R. & Bell, H. Entrepreneurship education in the era of generative artificial intelligence. *Entrepreneurship Educ.* **6** (3), 229–244 (2023).
6. Ivanov, S., Soliman, M., Tuomi, A., Alkathiri, N. A. & Al-Alawi, A. N. Drivers of generative AI adoption in higher education through the lens of the theory of planned behaviour. *Technol. Soc.* 102521. (2024).
7. Gofman, M. & Jin, Z. Artificial intelligence, education, and entrepreneurship. *J. Finance.* **79** (1), 631–667 (2024).
8. Sitaridis, I. & Kitsios, F. Digital entrepreneurship and entrepreneurship education: a review of the literature. *Int. J. Entrepreneurial Behav. Res.* **30** (2/3), 277–304 (2024).
9. Batista-Canino, R. M., Santana-Hernández, L. & Medina-Brito, P. A holistic literature review on entrepreneurial intention: A scientometric approach. *J. Bus. Res.* **174**, 114480 (2024).
10. Liu, A. & Wang, S. Generative artificial intelligence (GenAI) and entrepreneurial performance: implications for entrepreneurs. *J. Technol. Transf.* **49** (6), 2389–2412 (2024).
11. Bachmann, N., Rose, R., Maul, V. & Hölzle, K. What makes for future entrepreneurs? The role of digital competencies for entrepreneurial intention. *J. Bus. Res.* **174**, 114481 (2024).
12. Hagenauer, W. & Zipko, H. T. The relationship between entrepreneurial personality patterns linked to risk, innovation and gender across industrial sectors. *Sci. Rep.* **14** (1), 20864 (2024).
13. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* **50** (2), 179–211 (1991).
14. Adeel, S., Daniel, A. D. & Botelho, A. The effect of entrepreneurship education on the determinants of entrepreneurial behaviour among higher education students: A multi-group analysis. *J. Innov. Knowl.* **8** (1), 100324 (2023).
15. Wang, S., Esperança, J. P., Yang, W. & Zhang, J. Z. Investigating the determinants of new technology entrepreneurial performance: an empirical study with PLS-SEM and MGA. *J. Knowl. Econ.* **15** (2), 6617–6642 (2024).
16. Wang, S. & Zhang, H. Green entrepreneurship success in the age of generative artificial intelligence: the interplay of technology adoption, knowledge management, and government support. *Technol. Soc.* **79**, 102744 (2024).
17. Chen, L., Ifenthaler, D., Yau, J. Y. K. & Sun, W. Artificial intelligence in entrepreneurship education: a scoping review. *Educ. + Train.* <https://doi.org/10.1108/ET-05-2023-0169> (2024).
18. Celik, I. Towards Intelligent-TPACK: an empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education. *Comput. Hum. Behav.* **138**, 107468 (2023).
19. Grand View Research, Inc. AI in education market size to reach \$32.27 billion by 2030. <https://www.grandviewresearch.com/press-release/global-artificial-intelligence-ai-education-market> (2024).
20. Lyu, X., Al Mamun, A., Yang, Q. & Aziz, N. A. Social entrepreneurial intention among university students in China. *Sci. Rep.* **14** (1), 7362 (2024).
21. Nguyen, P. N. D. & Nguyen, H. H. Unveiling the link between digital entrepreneurship education and intention among university students in an emerging economy. *Technological Forecast. Social Change.* **203**, 123330 (2024).
22. Yuan, R., Chen, Y. & Zheng, Y. The impact of deep learning based-psychological capital with ideological and political education on entrepreneurial intentions. *Sci. Rep.* **14** (1), 18132 (2024).
23. Al-Qadasi, N., Zhang, G., Al-Jubari, I., Al-Awlaqi, M. A. & Aamer, A. M. Entrepreneurship education and entrepreneurial behaviour: do self-efficacy and attitude matter? *Int. J. Manage. Educ.* **22** (1), 100945 (2024).
24. Taneja, M., Kiran, R. & Bose, S. C. Assessing entrepreneurial intentions through experiential learning, entrepreneurial self-efficacy, and entrepreneurial attitude. *Stud. High. Educ.* **49** (1), 98–118 (2024).
25. Amani, D., Ismail, I. J., Makona, A., Chagalima, I. A. & Kazungu, I. Extending the mediation role of entrepreneurial self-efficacy on enhancing students' entrepreneurial intentions: A moderated mediation model. *Int. J. Manage. Educ.* **22** (1), 100915 (2024).
26. Salinas-Navarro, D. E., Vilalta-Perdomo, E., Michel-Villarreal, R. & Montesinos, L. Using generative artificial intelligence tools to explain and enhance experiential learning for authentic assessment. *Educ. Sci.* **14** (1), 83 (2024).
27. Vecchiari, M. & Somià, T. Redefining entrepreneurship education in the age of artificial intelligence: an explorative analysis. *Int. J. Manage. Educ.* **21** (3), 100879 (2023).
28. Kumar, S., Rao, P., Singhania, S., Verma, S. & Kheterpal, M. Will artificial intelligence drive the advancements in higher education? A tri-phased exploration. *Technol. Forecast. Soc. Chang.* **201**, 123258 (2024).
29. Christensen, B. T., Arendt, K. M., McElheron, P. & Ball, L. J. The design entrepreneur: how adaptive cognition and formal design training create entrepreneurial self-efficacy and entrepreneurial intention. *Des. Stud.* **86**, 101181 (2023).
30. Jia, X. H. & Tu, J. C. Towards a new conceptual model of AI-Enhanced learning for college students: the roles of artificial intelligence capabilities, general Self-Efficacy, learning motivation, and critical thinking awareness. *Systems* **12** (3), 74 (2024).
31. Winkler, C., Hammada, B., Noyes, E. & Van Gelderen, M. Entrepreneurship education at the dawn of generative artificial intelligence. *Entrepreneurship Educ. Pedagogy.* **6** (4), 579–589 (2023).
32. Caliendo, M., Kritikos, A. S., Rodriguez, D. & Stier, C. Self-efficacy and entrepreneurial performance of start-ups. *Small Bus. Econ.* **61** (3), 1027–1051 (2023).
33. Martín-Navarro, A., Velicia-Martín, F., Medina-Garrido, J. A. & Palos-Sánchez, P. R. Impact of effectual propensity on entrepreneurial intention. *J. Bus. Res.* **157**, 113604 (2023).
34. Porfirio, J. A., Felício, J. A., Carrilho, T. & Jardim, J. Promoting entrepreneurial intentions from adolescence: the influence of entrepreneurial culture and education. *J. Bus. Res.* **156**, 113521 (2023).
35. Al-Qadasi, N., Zhang, G., Al-Awlaqi, M. A., Alshebami, A. S. & Aamer, A. Factors influencing entrepreneurial intention of university students in yemen: the mediating role of entrepreneurial self-efficacy. *Front. Psychol.* **14**, 1111934 (2023).
36. Wang, X. H. et al. The effect of entrepreneurship education on entrepreneurial intention: mediation of entrepreneurial self-efficacy and moderating model of psychological capital. *Sustainability* **15** (3), 2562 (2023).
37. Ozen, C., Owaishiz, A., Dabic, M. & Daim, T. Exploring entrepreneurship in the academic environment. *Technol. Soc.* **72**, 102168 (2023).
38. Karan, A., Singh, M. & Rana, N. P. Does entrepreneurial motivation influence entrepreneurial intention? Exploring the moderating role of perceived supportive institutional environment on Indian university students. *Int. Entrepreneurship Manage. J.* **20** (1), 215–229 (2024).
39. Cai, Y. & Ahmad, I. From an entrepreneurial university to a sustainable entrepreneurial university: conceptualization and evidence in the contexts of European university reforms. *High. Educ. Policy.* **36** (1), 20–52 (2023).
40. Lyu, J., Shepherd, D. & Lee, K. From intentional to nascent student entrepreneurs: the moderating role of university entrepreneurial offerings. *J. Innov. Knowl.* **8** (1), 100305 (2023).
41. Sadeghi, M. & Malekinia, E. University student's assessment of entrepreneurial environments and its relationship with entrepreneurial intention. *Q. J. Res. Plann. High. Educ.* **17** (1), 69–89 (2023).
42. Morales-Alonso, G., Blanco-Serrano, J. A., Núñez Guerrero, Y., Grijalvo, M. & Blanco Jimenez, F. J. Theory of planned behavior and GEM framework—how can cognitive traits for entrepreneurship be used by incubators and accelerators? *Eur. J. Innov. Manage.* **27** (3), 922–943 (2024).
43. Dayan, M., Ng, P. Y., Husain, Z. & Zacca, R. Effects of constructive politics and market turbulence on entrepreneurial Orientation-Performance relationship: A moderated mediation model. *Eur. Manag. J.* **41** (3), 385–394 (2023).
44. Hair, J. F., Hult, G. T. M., Ringle, C. M. & Sarstedt, M. A *Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)* 3rd Ed. (Sage, 2022).
45. Saeedikiya, M., Salunke, S. & Kowalkiewicz, M. The nexus of digital transformation and innovation: A multilevel framework and research agenda. *J. Innov. Knowl.* **10** (1), 100640 (2025).

46. Ajzen, I. *Theory of Planned Behavior*. <http://people.umass.edu/ajzen/tpb.html> (2019).
47. Orlandi, L. B., Zardini, A. & Rossignoli, C. Highway to hell: cultural propensity and digital infrastructure gap as recipe to entrepreneurial death. *J. Bus. Res.* **123**, 188–195 (2021).
48. Wang, S. & Zhang, H. Leveraging generative artificial intelligence for sustainable business model innovation in production systems. *Int. J. Prod. Res.* 1–26. (2025).
49. Marchena Sekli, G. & Portuguez-Castro, M. Fostering entrepreneurial success from the classroom: unleashing the potential of generative AI through technology-to-performance chain. A multi-case study approach. *Educ. Inform. Technol.* 1–29. (2025).
50. Somia, T. & Vecchiarini, M. Navigating the new frontier: the impact of artificial intelligence on students' entrepreneurial competencies. *Int. J. Entrepreneurial Behav. Res.* **30** (11), 236–260 (2024).
51. Saeedikiya, M., Salamzadeh, A., Salamzadeh, Y. & Aeeni, Z. Cognitions affecting innovation among generation Z entrepreneurs: the external enablement of digital infrastructure. *Int. J. Entrepreneurial Behav. Res.* **30** (2/3), 572–608 (2024).
52. Bohlayer, C. & Gielnik, M. M. S) training experiences: toward Understanding decreases in entrepreneurial self-efficacy during action-oriented entrepreneurship training. *Journal Bus. Venturing.* **38** (1), 106259 (2023).
53. Zhang, S., Zhao, X., Zhou, T. & Kim, J. H. Do you have AI dependency? The roles of academic self-efficacy, academic stress, and performance expectations on problematic AI usage behavior. *Int. J. Educational Technol. High. Educ.* **21** (1), 34 (2024).
54. Obschonka, M. et al. Artificial intelligence and entrepreneurship: a call for research to prospect and Establish the scholarly AI frontiers. *Entrepreneurship Theory Pract.* **49** (3), 620–641 (2025).
55. Ferrati, F., Kim, P. H. & Muffatto, M. Generative AI in entrepreneurship research: principles and practical guidance for intelligence augmentation. *Found. Trends® Entrepreneurship.* **20** (3), 245–383 (2024).
56. Weng, X., Gu, M. M., Xia, Q. & Chiu, T. K. SWOT analysis of AI empowered entrepreneurship education: insights from digital learners in higher education. *Think. Skills Creativity.* **56**, 101763 (2025).
57. Shore, A., Tiwari, M., Tandon, P. & Foropon, C. Building entrepreneurial resilience during crisis using generative AI: an empirical study on SMEs. *Technovation* **135**, 103063 (2024).
58. Zwolińska-Gładys, K., Lorenc, S., Kowalska, N. & Pomykała, R. Higher education staff development: a need-oriented approach based on survey research. *Sci. Rep.* **14** (1), 31455 (2024).
59. Saeedikiya, M., Salunke, S. & Kowalkiewicz, M. Toward a dynamic capability perspective of digital transformation in smes: A study of the mobility sector. *J. Clean. Prod.* **439**, 140718 (2024).
60. Wang, S., Gao, M. & Zhang, H. Enhancing Creativity and Sustainable Competitive Advantage through Data-Driven Decision-Making and Digital Leadership. *IEEE Trans. Eng. Manag.* **72**, 1361–1375 (2025).

Acknowledgements

Thank all respondents for participating in this survey. Thanks to our colleagues and Digital Tools for their help with the article's language.

Author contributions

Conceptualization, S.W. and Y.X.; methodology, S.W. and Y.X.; software, S.W.; validation, S.W.; formal analysis, S.W. and Y.X.; investigation, S.W.; resources, S.W.; data curation, S.W.; writing —original draft preparation, S.W. and Y.X.; visualization, S.W.; supervision, S.W. and Y.X.; funding acquisition, Y.X. All authors have read and agreed to the published version of the manuscript.

Funding

This work was supported by the Zhejiang Province Philosophy and Social Sciences Planning Departmental Cooperation Special Research Project Grant Number [25BMHZ071YB], Zhejiang Province Human Resources and Social Security Program [2025044], Ministry of Education of People's Republic of China under Grant [19YJC880104], and Fujian Province Undergraduate University Education and Teaching Research Project under Grant [FBJY20240273].

Declarations

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to S.W.

Reprints and permissions information is available at www.nature.com/reprints.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Open Access This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

© The Author(s) 2025