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Artificial Intelligence in Entrepreneurship Education: A Nine-Year Bibliometric Analysis and Future Research Directions Toward the Sustainable Development Goals

Choiru Umatin[1*], Vina Budiarti Mustika Sari[2], Nailariza Umami[3], Komm Pechinthorn[4], Eni Susilowati[5]
[1*]Universitas Islam Negeri Syekh Wasil, Kediri, Indonesia
[2]IKIP Widya Darma, Surabaya, Indonesia
[3]Universitas Bhinneka PGRI, Tulungagung, Indonesia
[4]Thai Global Business Administration Technological College, Thailand
[5]Universitas Islam Negeri Sayyid Ali Rahmatullah, Tulungagung, Indonesia

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ABSTRACT

Objective: *This research aims to map research trends in Artificial Intelligence in Entrepreneurship Education which are linked to achieving the SDGs.* ***Method:*** *This research uses a bibliometric approach from the Scopus database which focuses on related themes in the 2017-2025 period. Biblioshiny as a tool and data analyzed descriptively.* ***Results:*** *Research trends on Artificial Intelligence in Entrepreneurship Education show a very significant increase and are appropriate for achieving SDGs, especially points four and eight. The most contributing countries are China and Indonesia. An interesting theme to research is the integration of AI in adversarial machine learning, federated learning, contrastive learning, educational computing in entrepreneurship. Future research direction refers to the design of advanced AI-based entrepreneurship education as well as innovations in various robust AI models for business. Policy recommendations should be in line with increasing the capacity of AI pedagogy teachers and assisting AI training for entrepreneurship.* ***Novelty:*** *This research offers AI research trends in entrepreneurship education according to the framework of achieving the SDGs with the latest data.*

INTRODUCTION

Entrepreneurship is a practical science that is needed by every level of society as a support for prosperity in an era of extreme economic dynamics (Akilah et al., 2025). Entrepreneurship is instilled from a young age at the formal level through entrepreneurship education, although there are also informal ones from family economic education. The urgency of entrepreneurship education is the basis for building several goals in the Sustainable Development Goals (SDGs), especially the points of quality of education and decent work and economic growth (point eight) (Ashari et al., 2022; Valencia-Arias et al., 2025). Based on the 2024 Sustainable Development Goals Index (SDG Index) report, quality education achievements are at major challenges and stagnant, while decent work and economic growth are at the same level.

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Figure 1. The 2024 Sustainable Development Goals Index (SDG Index) Report

The SDGs Index illustrates the level of progress, stagnation, and challenges faced by each SDG, providing a comprehensive picture of the gap between targets and actual achievements across countries. Within this context, SDG 4 reveals that improvements in the quality of education, equitable access to learning, and the development of skills relevant to digital transformation remain at the level of major challenges and show limited progress, indicating a stagnating trend. Similarly, SDG 8 demonstrates that the creation of decent work and improvements in labour productivity are also stagnating, suggesting that current efforts have not yet translated into sustained economic growth.

Entrepreneurship education is the motor of the two SDGS points that have been explained. Entrepreneurship education becomes a means of experiential learning and a form of action learning to create education that is relevant to economic conditions in the real world when they graduate, especially at the tertiary level (Bhatia & Bhatia, 2019; Eisenstein et al., 2021). Through several business projects, proposals, business simulations and MSMEs, students will have new skills according to economic and social needs, both as support and priority. On the other hand, the follow-up is support for the creation of decent jobs and sustainable economic growth. In the midst of limited formal employment, entrepreneurship education instills a new mindset as an innovative and productive entrepreneur (Wang et al., 2022).

In this context, entrepreneurship education is conceptually understood as a learning process that emphasizes practice-based learning, rather than merely the transfer of theoretical knowledge. This approach aligns with Experiential Learning Theory, which views learning as a continuous cycle comprising concrete experience, reflection, active experimentation (Kolb et al., 2014). Through business projects and enterprise simulations, students not only form entrepreneurial intentions based on the Theory of Planned Behaviour (TPB) but also develop competencies, adaptive skills, and decision-making abilities in line with economic dynamics. Thus, the experiential learning framework provides a more comprehensive theoretical basis for understanding how entrepreneurship education shapes the learning process and outcomes, focused on achieving educational quality and employability readiness (Blankesteijn et al., 2024).

As an effort to accelerate, entrepreneurship education in recent years has been integrated with Artificial Intelligence (AI). This shows the transformation of students' learning through mastery of AI-based tools and algorithms. Various types of AI are

relevant in this case, such as generative AI, machine learning, and natural language processing (NLP) which facilitate various entrepreneurial activities, such as identifying business opportunities, market analysis, and designing business models for young people (Li et al., 2025). Within the framework of Artificial Intelligence in Entrepreneurship Education, key outcomes include technology startups, student-led business projects, and AI-supported entrepreneurial mentoring. Artificial Intelligence in Entrepreneurship Education has been proven to be able to improve students' analytical and problem solving abilities (Ji et al., 2025).

Even though it seems to be running smoothly, Artificial Intelligence in Entrepreneurship Education is not without several challenges. The biggest challenge is faced by developing countries where not all people have the knowledge and access to AI to support their businesses (Jha & Singh, 2024). This creates a skills gap. The next challenge is fundamental to the mindset of students who are receiving entrepreneurship education with AI. AI is a double-edged sword, one side can improve analytical skills and entrepreneurial problem solving, the other side is that they rely on and do not carry out empirical reviews and only theoretically come from AI sources. This is a manifestation of the need to adjust curriculum and pedagogy. Regulatory and ethical aspects are also a special discussion in the development of Artificial Intelligence in Entrepreneurship Education.

With the fact that AI in entrepreneurship is developing very quickly, entrepreneurial research and practice at various levels of education risks being out of sync with technological developments and empirical conditions in each country. Therefore, the AI research trend in entrepreneurship education is needed today. A trending topic in research reflects the real needs of the business world and the job market. This is important for curriculum adjustments, innovation, and the integration of AI as best practice in the field of adaptive entrepreneurship. From a policy perspective, mapping trends regarding AI in entrepreneurship education could be one of the Evidence-Based Policy steps regarding the design of innovation and entrepreneurship policies, as well as the development of entrepreneurial incubator and startup programs.

Based on the study of research concepts and methods, the most accurate type of approach is bibliometric. This is related to the advantages of bibliometrics that the literature review method does not have, namely complete quantitative trends and broad relevance. Bibliometrics can also be modeled to add simple qualitative analysis. This approach is very relevant and popular in various globally indexed articles. The bibliometric approach is seen as being able to present patterns comprehensively, which cannot be achieved optimally through traditional literature review methods which tend to be narrative and subjective. More than that, it can present the volume of publications, research growth over time, collaborative networks of authors and institutions, citation patterns, and so on (Ball, 2020; Ginanjar et al., 2025), which are important for knowing the development of Artificial Intelligence in Entrepreneurship Education.

Based on previous research, there is several bibliometric research that discusses Artificial Intelligence in Entrepreneurship. As a representative of the latest and most relevant research is research from Siddiqui et al., (2024) with the finding that AI functions to automate business processes, technology-based innovation, business models, and

facilitate startup activities. Meanwhile, bibliometric research that focuses on Artificial Intelligence in Entrepreneurship Education is limited. Research from Chen et al., (2024) found that big data and machine learning algorithms are types of AI that are relevant for entrepreneurship education. This research uses the Google Scholar database. Meanwhile research from Thottoli et al., (2024) in the 1993-2023 period shows that integrating AI into university incubation centers using cutting-edge tools like chatbots is important.

Based on this description, a research gap was found in the form of the absence of bibliometric research that analyzes in depth the trend of Artificial Intelligence in Entrepreneurship Education with a sharper focus on context. This is important to fill in so that future themes related to focused topics are more specific and have sharper implications. Therefore, this research aims to map research trends in Artificial Intelligence in Entrepreneurship Education in the conceptual, intellectual and social structures associated with achieving comprehensive SDGs. The novelty in this research is the emergence of the SDGs context as a benchmark for developing the Artificial Intelligence in Entrepreneurship Education research theme and the use of the year range from 2017-2025 which presents the latest context and has never been researched before.

The theoretical contribution of this research is that it can provide understanding and expansion of literature studies regarding the development of Artificial Intelligence in Entrepreneurship Education which is in line with comprehensive SDGs. Apart from that, it encourages factual understanding regarding the implementation of theory with the latest data. Practically, this research can provide references, context and policy direction regarding aspects that need to be maximized in Artificial Intelligence in Entrepreneurship Education in order to achieve the SDGs for both researchers and policy makers.

Some of the research questions presented in this research include: (1) What is the main information from the development of scientific literature related to Artificial Intelligence in Entrepreneurship Education? (2) What are the conceptual, intellectual and social structures related to the literature on Artificial Intelligence in Entrepreneurship Education? (3) How can the potential and strategy for developing research and policies related to Artificial Intelligence in Entrepreneurship Education be directed to support the achievement of the SDGs?

RESEARCH METHOD

Study Design

This research uses a bibliometric approach to identify patterns of distribution and growth in research that discusses in depth "Artificial Intelligence in Entrepreneurship Education". Through its application, researchers can trace the main thematic directions and gain an understanding of the substance of previous studies. Access to bibliographic databases is essential for finding scientific publications, including articles, authors, abstracts and references. This research uses Scopus, a highly reputable and quality bibliographic database, which provides access to various scientific publications that meet international standards. Scopus is widely known for its focus on curating and indexing research to high academic standards (Boyle & Sherman, 2005; Schotten et al., 2017). Figure 2. Illustrating the bibliometric procedure as follows:

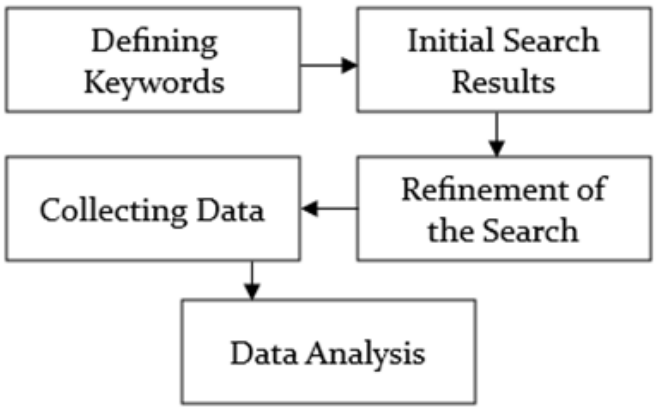

Figure 2. Workflow of The Bibliometrics

Bibliometric Data and Filtering Process

The data search process was carried out in December 2025. The identification stage was done by selecting the columns Article title, abstract, and keywords and entering the keywords "Artificial Intelligence" Or "AI" and "entrepreneurship education". From this initial stage, 230 documents were obtained. Next, a screening was carried out based on the publication year range 2017–2025, resulting in 222 documents. The next screening was done by limiting the document type to articles and the language to English, which produced 101 documents. The reduction is justified by restricting the dataset to peer-reviewed English journal articles to ensure quality and consistency in the bibliometric analysis.

At the eligibility stage, a manual content-based screening was conducted by examining titles, abstracts, and keywords to ensure alignment with the research scope of Artificial Intelligence in Entrepreneurship Education, leading to the exclusion of one article that did not meet the thematic relevance criteria. The total number of documents ready for analysis was 100 articles. Although data were collected up to 2025, the analysis of main trends in this study focused on the period 2017–2024, while the 2025 data are presented separately as an early trend.

Researchers recognize that although the use of the term "AI" is now contemporary, there is potential for ambiguity. Therefore, the screening process was conducted in stages and rigorously, with comprehensive manual screening at the eligibility stage to ensure the research context's suitability. Through this process, documents that did not substantively discuss the application of artificial intelligence in entrepreneurial education were eliminated. Thus, the advantage of a broad initial query, combined with systematic screening and manual evaluation, ensures that the final 100 articles analyzed have strong thematic relevance and align with the research objectives.

The manual content-based screening process was conducted by applying clear inclusion and exclusion criteria. At the inclusion stage, articles were selected if they explicitly discussed Artificial Intelligence in Entrepreneurship Education as the focus of the research, whether in the form of empirical or conceptual studies based on scientific principles. At the exclusion stage, articles were removed if they only discussed artificial intelligence or entrepreneurship indirectly, did not have an educational context, focused

on AI technical development without pedagogical implications, or discussed entrepreneurship education without a clear integration with artificial intelligence. All selection results are then reviewed by two independent evaluators who have expertise in the topic and bibliometric methodology. The research search terms are obtained in the following format: TITLE-ABS-KEY (Artificial Intelligence OR AI AND entrepreneurship education) AND PUBYEAR > 2017 AND PUBYEAR < 2025 AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))

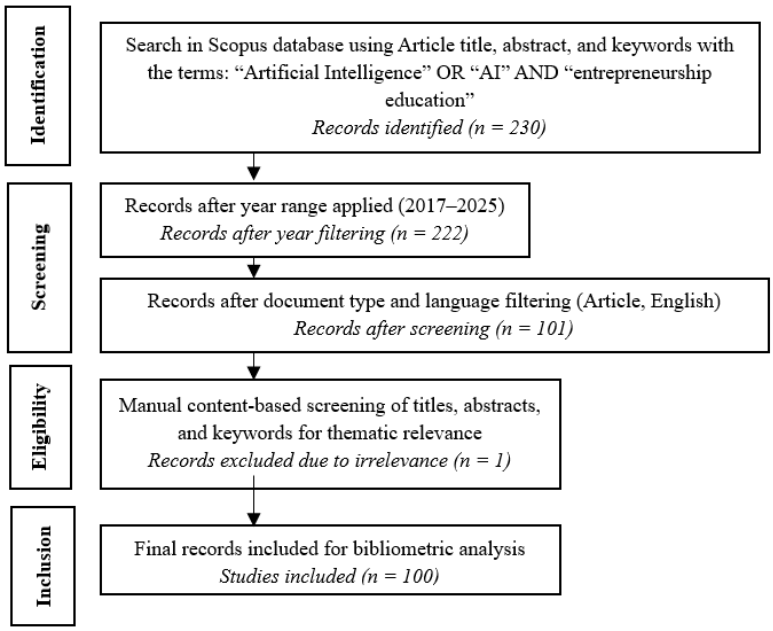

Figure 3. Flow Diagram of Bibliometric Article Selection

Data Analysis

All research results were analyzed descriptively according to the research questions using Biblioshiny (RStudio) as the main tool for bibliometric analysis. This software was used to generate basic bibliometric indicators such as the number of publications per year, the number of citations, and the distribution of authors, institutions, and countries. Co-authorship analysis was conducted through a collaboration network to identify patterns of collaboration between authors and countries, while co-citation analysis was performed using a reference co-citation network to reveal the intellectual structure and works frequently cited together.

In addition, keyword co-occurrence analysis was applied through a keyword co-occurrence network based on author keywords and keywords plus to map research trends and theme relationships. The thematic map was generated using the thematic map function with centrality and density metrics to classify themes into motor themes, basic themes, niche themes, as well as emerging or declining themes, providing a comprehensive overview of the development and structure of Artificial Intelligence research in Entrepreneurship Education.

RESULTS AND DISCUSSION

Results

Main Information

Table 1. Main Information from (2017-2024), Early Trend (2025), and Final (2017-2025)

Description	Results		
Main Information About Data			
Timespan	2017-2024	2025	2017-2025
Sources (Journals, Books, Etc)	40	49	82
Documents	43	57	100
Annual Growth Rate %	55.52*	0	65.76*
Document Average Age	3.02	1	1.87
Average Citations Per Doc	21.02	2.8	10.65
References	385	522	891
Document Contents			
Keywords Plus (Id)	158	158	286
Author's Keywords (De)	182	228	388
Authors	125	179	304
Authors Of Single-Authored Docs	5	9	14
Authors Collaboration			
Single-Authored Docs	5	9	14
Co-Authors Per Doc	3	3.37	3.21
International Co-Authorships %	25.58	19.3	22
Document Types			
Article	43	57	100

Source: Processed Data (2025)

**The annual growth rate of 55.52% and 65.76% arose because in the early years the number of publications was still very limited, followed by a sharp increase in the number of articles in subsequent years. This condition causes the annual growth percentage to appear very large, even though in absolute terms the number of publications in the early phase was still low. This figure reflects the initial development process and acceleration of research interest in this topic, rather than constant growth in a linear sense.*

Table 1 presents the main bibliometric information distinguishing the core period 2017–2024, the early 2025 trend, and the final aggregate 2017–2025. In the 2017–2024 period, the annual growth rate of 55.52% indicates consistent growth in a still-developing research field, while the document average age of 3.02 years suggests a relatively stable literature structure beginning to form. In contrast, 2025 is marked by a very low document average age (1 year) and a zero annual growth rate, reflecting the dominance of very recent publications and confirming its position as an early expansion phase. When the entire period is combined (2017–2025), the annual growth rate rises to 65.76% and the document average age decreases to 1.87 years, indicating that the overall growth dynamics are heavily influenced by the surge in recent publications. These results indicate that the development of the related topic can be regarded as positive, marked by a transition from the initial phase to rapid growth, although long-term consolidation in this field is still ongoing.

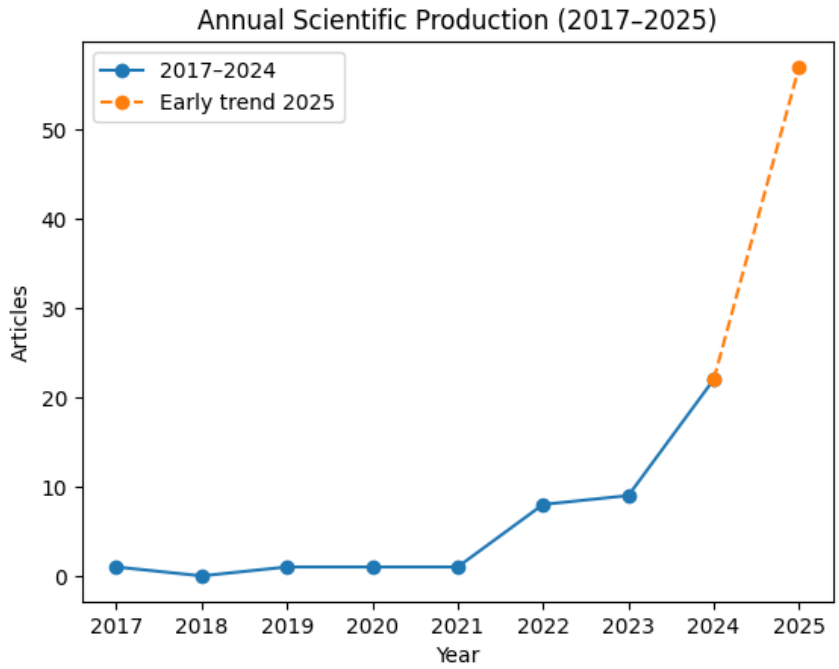

Figure 4. Annual Scientific Production

Figure 4 shows the development trend of research on Artificial Intelligence in entrepreneurship education. During the main observation period 2017–2024, the number of publications was relatively low and stable in the early years, with the lowest number occurring in 2017 (n = 1). Since 2022, an increase in the number of publications has been observed, marking growing academic interest in this topic. In 2024, the number of publications reached 22 articles, reflecting significant growth compared to previous years. The surge in the number of publications in 2025 (n = 57) is presented separately as an early trend, given that the data for that year does not cover a full year. Therefore, this sharp increase should be interpreted cautiously and understood as an early indication of growing research activity. Nevertheless, the research trend on Artificial Intelligence in entrepreneurship education appears very promising in the coming years.

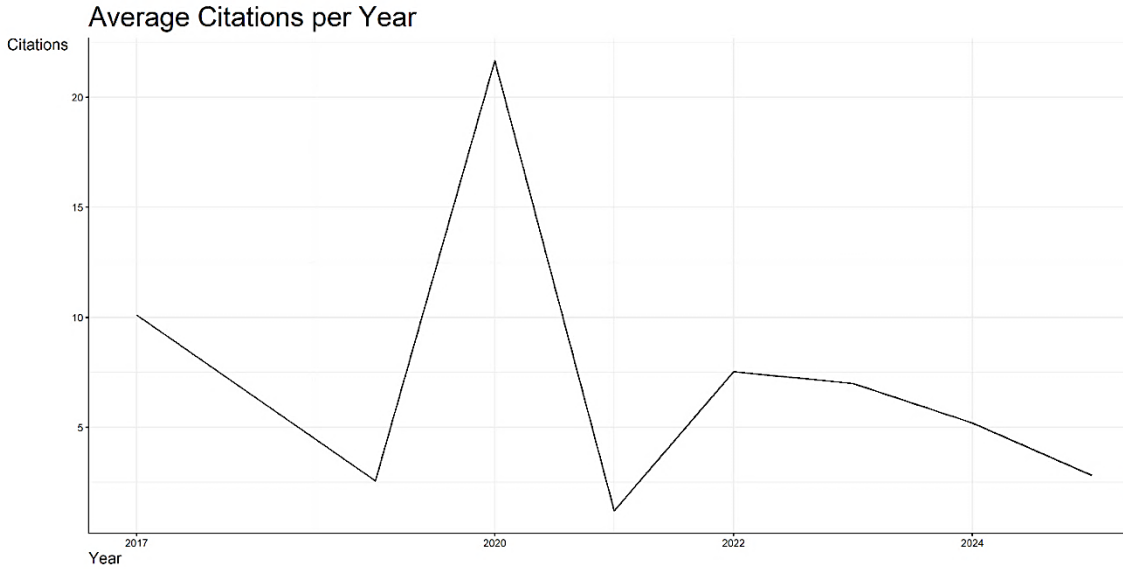

Figure 5. Average Citations per Year

Figure 5 shows the average number of citations per year for articles related to Artificial Intelligence in Entrepreneurship Education. The peak in average citations occurred in 2020 with a value of 21.7, while in the following years a declining trend is observed, reaching 2.8 in 2025. The sharp decrease in the most recent period is a common phenomenon in bibliometric analysis and can be explained by the limitations of the citation window, where newly published articles have not had enough time to acquire high citations. Therefore, this trend does not indicate a decline in the quality or relevance of the research, but rather reflects a shift in research focus towards the development and empirical application of Artificial Intelligence in Entrepreneurship Education, which is still relatively new and evolving.

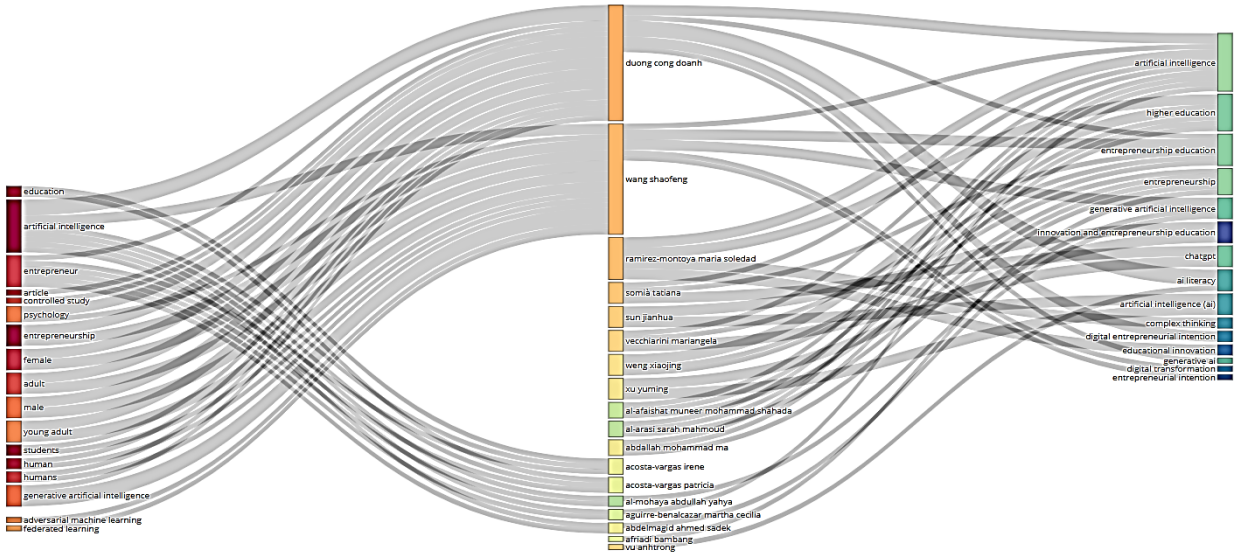

Figure 6. Sankey Diagram

Figure 6 is a Sankey diagram, which maps the development of the context or science of Artificial Intelligence in Entrepreneurship Education. Based on this diagram, it is known that initially the terminology was still separate between artificial intelligence, entrepreneurship and education. Most authors develop it in several terminologies and contexts both in the same and different forms. Duong Cong Doanh, Wang Shaofeng and so on

Table 2. Top Authors

Authors	Articles	Articles Fractionalized	H-index	Total Citation
Duong Cong Doanh	9	6.06	2	13
Wang Shaofeng	3	1.33	2	18
Ramirez-Montoya Maria Soledad	2	0.45	1	5
Somià Tatiana	2	1.00	2	88
Sun Jianhua	2	0.83	1	8

Source: Processed Data (2025)

Table 2 shows the five best authors in terms of quantity and quality of research on related topics. The first is Duong Cong Doanh, a researcher from the National Economics

University, Vietnam, who published nine articles and has an H-index (n=2) and a total of 13 citations. The second author is Wang Shaofeng from China. The writer with the most total citations is Somià Tatiana from the Free University of Bozen-Bolzano, Italy.

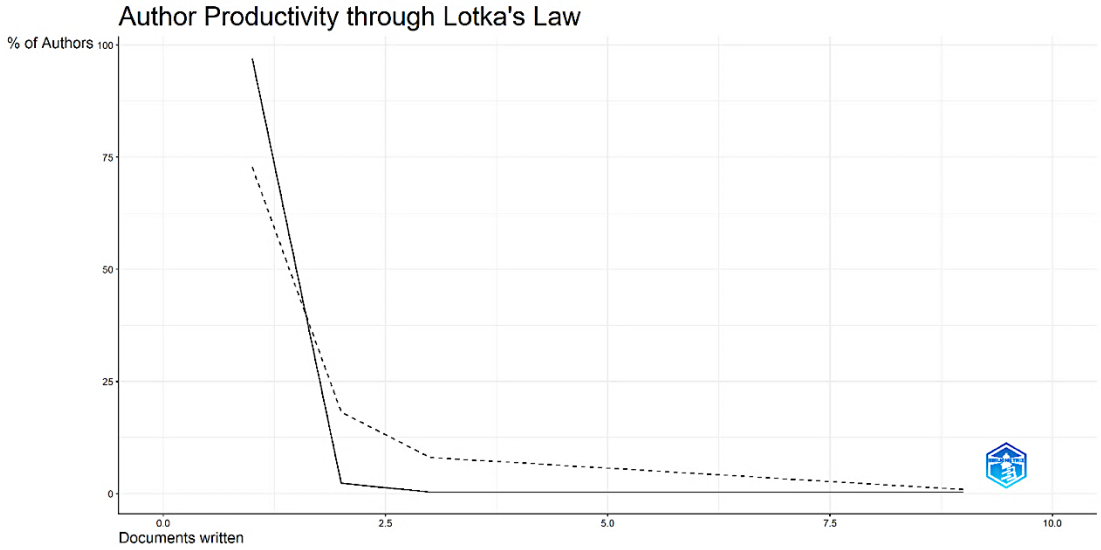

Figure 7. Lotka's Law

Figure 7 is Lotka Law which shows the distribution of author productivity in scientific publications related to Artificial Intelligence in Entrepreneurship Education. Based on the existing results, it indicates that most authors on the topic Artificial Intelligence in Entrepreneurship Education are only involved in a small portion of the documents. The topic in question is dominated by authors with single contributions, so that the research community is still scattered and not concentrated in a handful of authors (1 article = 97% authors). Meanwhile the maximum number is nine articles with 0.3% authors.

Table 3. Top Sources

Source Name	N	Cite Score	H_Index	G_Index	M_Index	TC	Py_Start
Frontiers In Psychology	4	6.3	4	4	0.800	53	2021
Scientific Reports	4	6.7	2	2	1.000	9	2024
Sustainability (Switzerland)	4	7.7	2	3	1.000	15	2024
Education And Information Technologies	3	11.8	3	3	1.500	33	2024
International Journal of Management Education	3	13.7	2	3	0.667	79	2023

Source: Processed Data (2025)

Table 3 shows a list of the best journal sources to gain a comprehensive understanding of the topic Artificial Intelligence in Entrepreneurship Education. First place is Frontiers In Psychology which has successfully published four documents.

Similar numbers were published by Scientific Reports, and Sustainability (Switzerland). This list of journals can be used as a reference for studying related topics.

Table 4. Most Influential Article

Paper	DOI	Total Citations	TC per Year	Normalized TC	Sources
Shepherd & Majchrzak/2022	10.1016/j.jbusvent.2022.106227	144	36.00	4.78	Journal of Business Venturing
Cantú-Ortiz et al./2020	10.1007/s12008-020-00702-8	130	21.67	1.00	International Journal on Interactive Design and Manufacturing
Vecchiarini & Somià/2023	10.1016/j.ijme.2023.100879	68	22.67	3.24	International Journal of Management Education
Dabbous & Boustani/2023	10.3390/jrfm16010027	55	18.33	2.62	Journal of Risk and Financial Management
Zhou et al./2024	10.53761/xzjprb23	49	24.50	4.71	Journal of University Teaching and Learning Practice
Gofman & Jin/2024	10.1111/jofi.13302	43	21.50	4.13	Journal of Finance
Khan et al./2022	10.1016/j.techfore.2022.122047	39	9.75	1.29	Technological Forecasting and Social Change
Demaidi/2025	10.1007/s00146-023-01779-x	38	38.00	13.45	AI and Society
Chen et al./2024	10.1108/ET-05-2023-0169	32	16.00	3.07	Education and Training

Source: Processed Data (2025)

Table 4 shows a list of research on Artificial Intelligence in Entrepreneurship Education that has had a significant influence on the development of the topic. The first is research entitled "Machines augmenting entrepreneurs: Opportunities (and threats) at the Nexus of artificial intelligence and entrepreneurship". This research discusses the nexus between AI and entrepreneurship and how the two can be combined (Shepherd & Majchrzak, 2022).

Table 5. Top Countries

Country	Frequency
China	63
Indonesia	39
Usa	35
Mexico	20
Germany	12
Ecuador	11
Jordan	9
Malaysia	9
Thailand	9

Source: Processed Data (2025)

Table 5 shows a list of countries that have contributed the most to research on the topic Artificial Intelligence in Entrepreneurship Education. The dominance of developing countries is the main thing because of the higher urgency in overcoming macroeconomic problems there. China leads development with a total of 63 frequencies, followed by Indonesia (n=39) and the USA (n=35). The country's dominance is also on the Asian continent. The dominance of China and Indonesia can be explained by strong national policies in the development of artificial intelligence, increased investment in higher education and digital entrepreneurship, as well as the strategic role of entrepreneurship education.

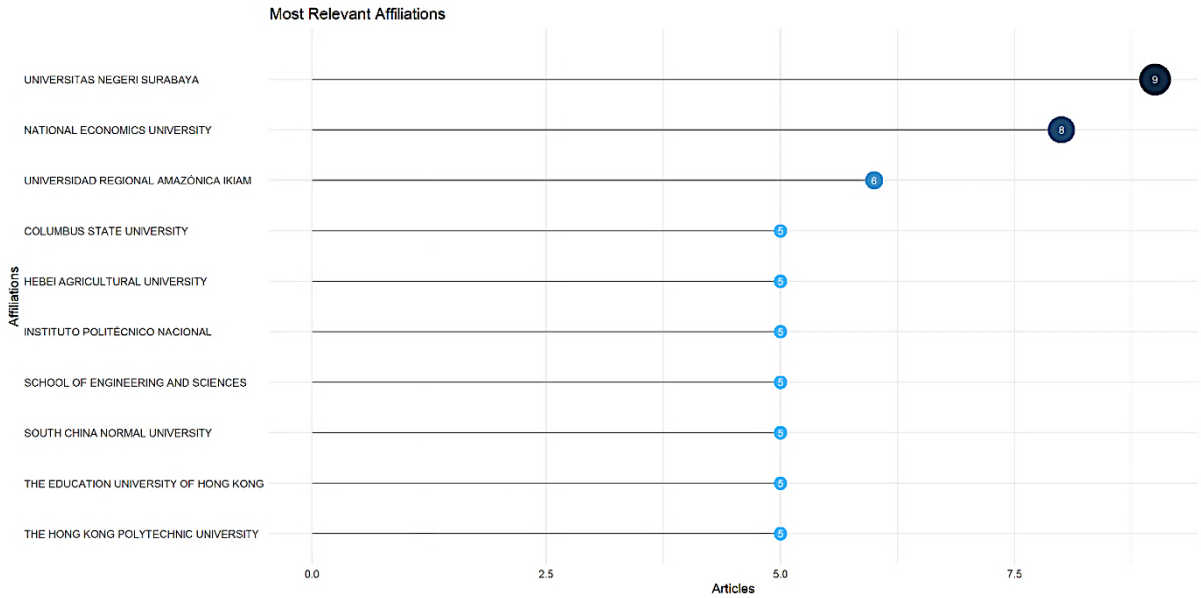

Figure 8. Most Relevant Affiliations

Figure 8 displays the ranks of agencies that have contributed massively to research on Artificial Intelligence in Entrepreneurship Education. The most influential institution is Surabaya State University, which comes from Indonesia with a total of nine articles. The second institution is the National Economics University from Vietnam (n=8). In third place is Universidad Regional Amazonica Ikiam from Ecuador (n=6).

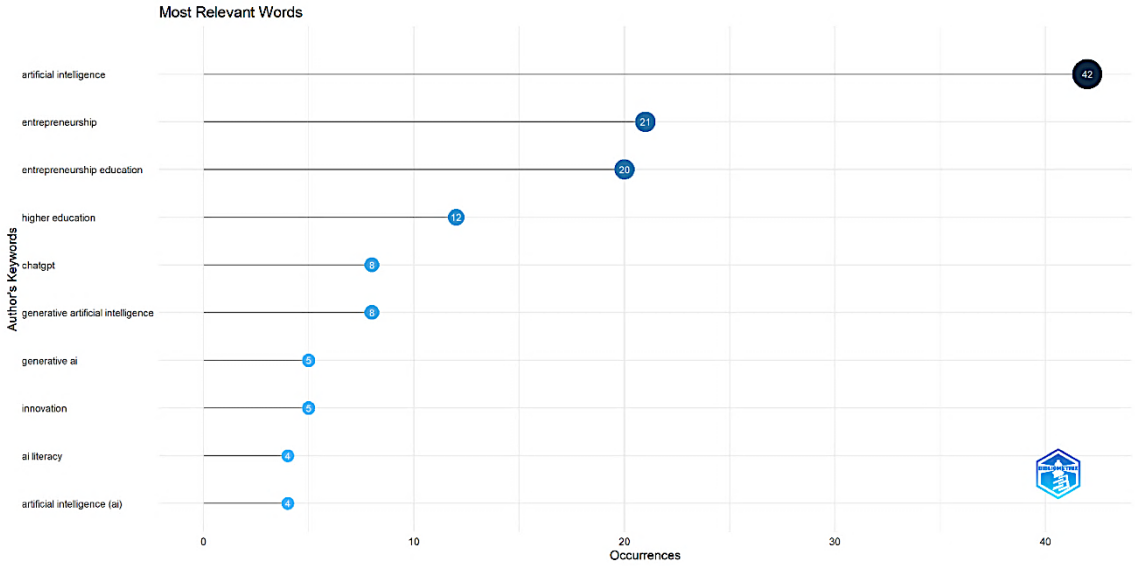

Figure 9. Most Relevant Words

Figure 9 reflects the words or terminology that appear most frequently to describe the focus of Artificial Intelligence in Entrepreneurship Education. Apart from reflecting existing contexts such as artificial intelligence and entrepreneurship education, several important words to highlight are higher education (n=12), Chatgpt (n=8), to Innovation (n=5)

Conceptual Structure

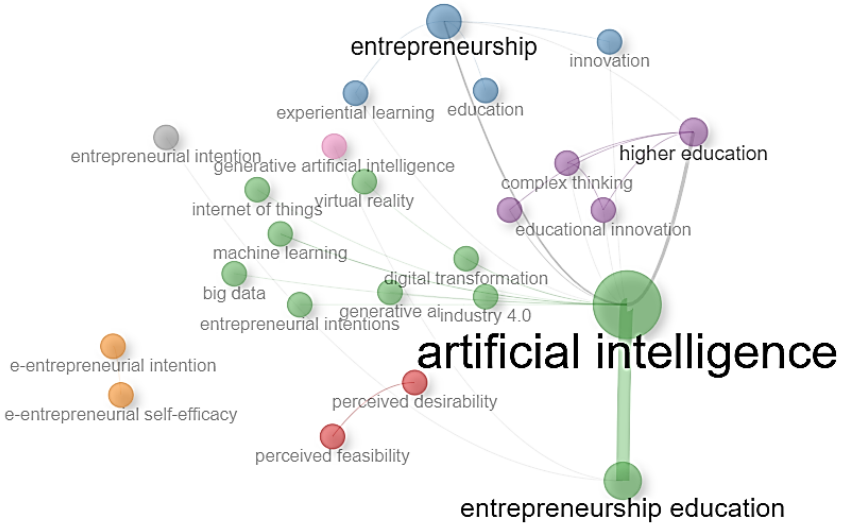

Figure 10. Co-occurrence Network

Figure 10 shows the mapping of keywords or terms that often appear together. The main cluster in green focuses on artificial intelligence which is connected to entrepreneurial education. This cluster is strongly connected to the blue cluster with a focus on entrepreneurship, experiential learning, education and innovation. Both are related to the purple cluster which focuses on higher education, complex thinking and educational innovation. The strong interconnection between these clusters indicates that

research on Artificial Intelligence in Entrepreneurship Education is developing in a multidisciplinary manner, integrating technological approaches, pedagogy, and the development of entrepreneurial competencies.

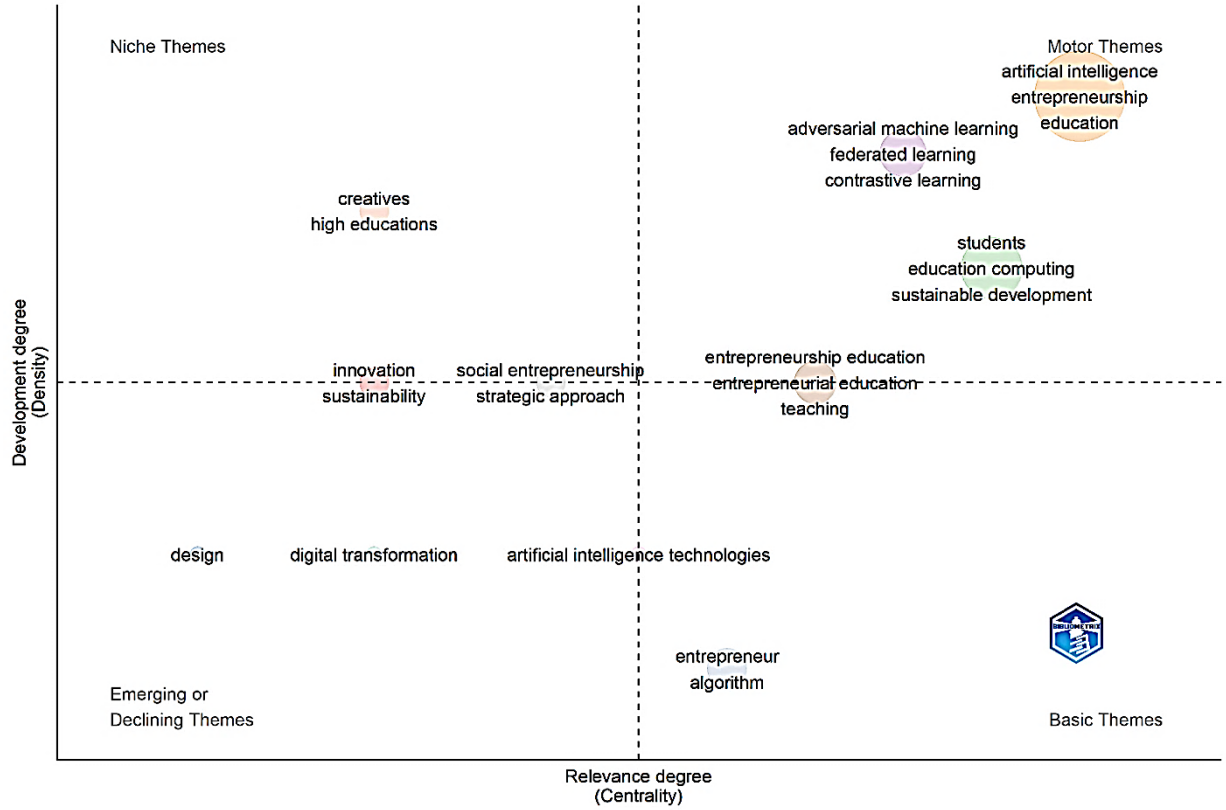

Figure 11. Thematic Map

Figure 11 presents a thematic map of research on Artificial Intelligence in Entrepreneurship Education based on Callon's framework, with the horizontal axis representing the relevance of the theme within the overall research field, and the vertical axis indicating the level of internal development of a theme. The Basic Themes quadrant (high centrality, low density) includes themes that play a strong fundamental role within the research field but are still relatively underdeveloped conceptually. Themes such as entrepreneur and algorithm fall into this quadrant, both being core concepts in the study of Artificial Intelligence in Entrepreneurship Education, yet still requiring further theoretical and empirical exploration.

The Motor Themes quadrant (high centrality, high density) includes conceptually mature themes that act as key drivers of the field, such as artificial intelligence, entrepreneurship education, adversarial machine learning, federated learning, contrastive learning, educational computing, and sustainable development, which are both well-developed internally and highly relevant to the direction of research in Artificial Intelligence in Entrepreneurship Education. The Niche Themes quadrant (low centrality, high density) comprises specialized topics such as creatives and higher education, which are well developed in specific contexts but remain weakly connected to the broader research discourse. Meanwhile, the Emerging or Declining Themes quadrant contains topics like digital transformation, innovation, sustainability, social entrepreneurship, and strategic approach, which currently show limited

interconnectedness but hold potential for future development with increased research attention.

Intellectual Structure

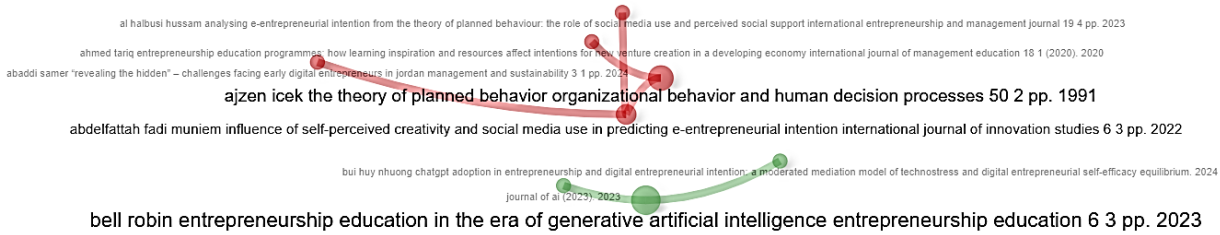

Figure 12. Co-citation Network

Figure 12 shows a co-citation network representing articles frequently cited together in research on Artificial Intelligence in Entrepreneurship Education. The largest cluster (in red) is centred on Ajzen's article, The Theory of Planned Behavior (Ajzen, 1991), which is one of the most frequently co-cited works in the related literature. This theory is widely used to explain entrepreneurial intention through three main constructs: attitude towards the behaviour, subjective norms, and perceived behavioural control. Several studies within the same cluster explicitly adopt or adapt TPB to analyze entrepreneurial intention and the adoption of digital technologies, including the context of e-entrepreneurship and the use of AI-based technologies (Abdelfattah et al., 2022; Ahmed et al., 2020; Al Halbusi et al., 2023)

TPB serves as one of the theoretical references frequently used, particularly in studies focusing on individual intentions and behaviours, and not as the sole theoretical foundation across the entire field of Artificial Intelligence in Entrepreneurship Education. The green cluster, which includes Bell & Bell, (2023), represents a more contemporary literature stream with a focus on the implications of generative artificial intelligence for entrepreneurship education, particularly in curriculum design, learning practices, and pedagogical transformation. Articles in this cluster do not explicitly derive from the TPB framework, but rather emphasize educational and technological perspectives.

Social Structure

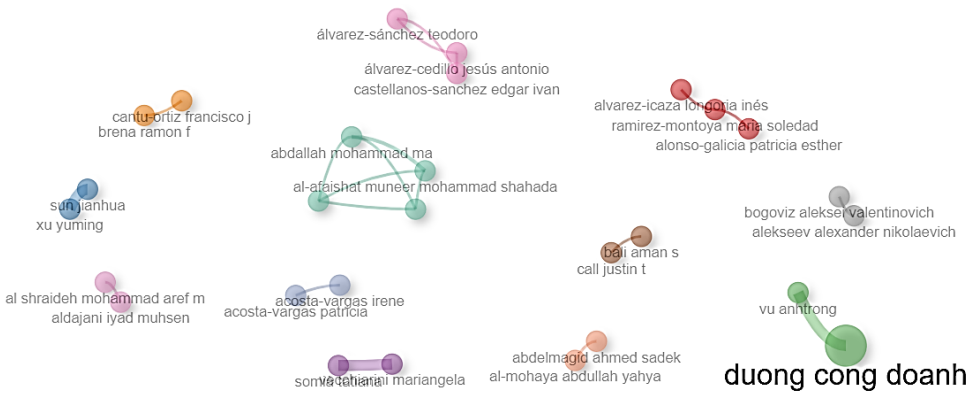

Figure 13. Collaboration Network

Figure 13 shows the collaboration network among authors in research on Artificial Intelligence in Entrepreneurship Education, divided into 12 collaboration clusters. The network structure, still fragmented and dominated by a single main cluster led by Duong Cong Doanh, indicates that this research field is not yet fully mature and is still developing through relatively isolated research groups. This is reflected in collaborative articles such as *"Nurturing e-entrepreneurs with artificial intelligence: Curvilinear effects of perceived desirability and perceived feasibility based on the entrepreneurial event model"* (Ngo et al., 2025), which focus on empirical testing and strengthening theoretical frameworks of behaviour in the AI context.

The research focus, still centered on conceptual validation and behavioural models, indicates that existing collaborations play a greater role in establishing the initial foundation of the field, while cross-cluster integration and the exploration of more diverse themes remain limited. Thus, this collaborative network confirms that research on Artificial Intelligence in Entrepreneurship Education is in an early consolidation phase, with significant opportunities for maturity improvement through collaboration across researchers, institutions, and countries.

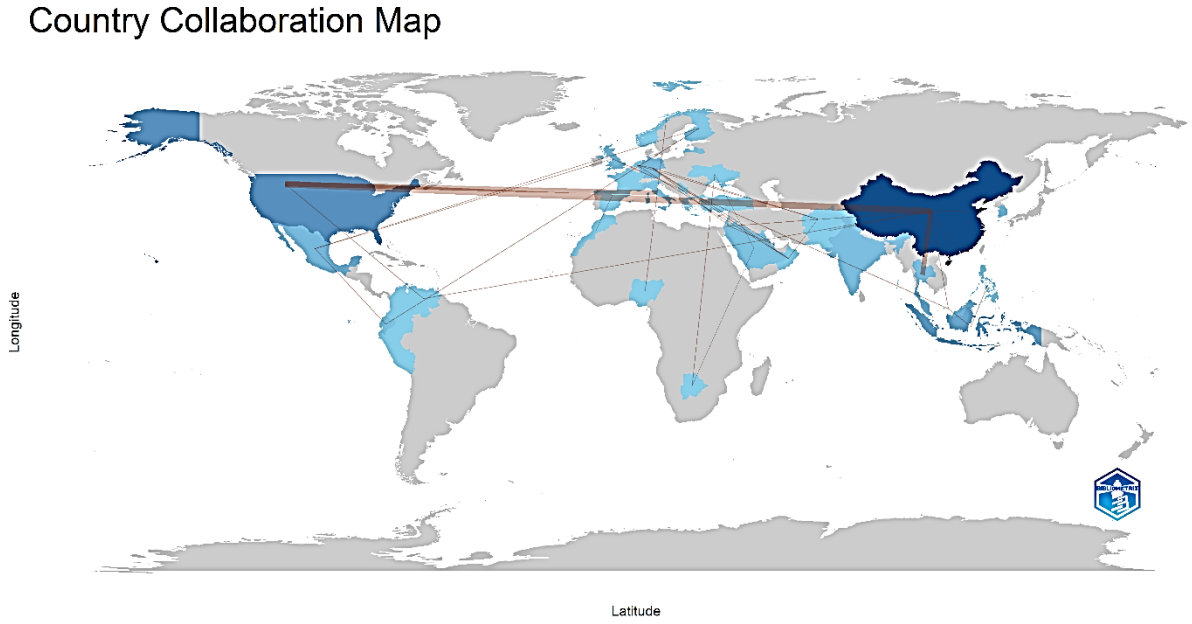

Figure 14. Country Collaboration Map

Figure 14 illustrates the pattern of international collaboration between countries in research on Artificial Intelligence in Entrepreneurship Education. The thickness of the collaboration lines represents the intensity of scientific cooperation, while the colour intensity indicates the level of a country's involvement in the global research network. International collaboration is concentrated in several specific countries, with China and the United States occupying central positions in the collaboration network. The strong collaborative relationships between China–United States and China–Thailand indicate that countries with high research capacity or strong national policies in the field of artificial intelligence tend to become main hubs in the development of this research.

From a social structure perspective, this map also shows the imbalance in collaboration between developed and developing countries. Cross-country collaboration is still largely dominated by countries in East Asia, North America, and Western Europe,

while the involvement of countries in Africa, Eastern Europe, and Australia is relatively limited or not yet significant. This indicates that the flow of global collaboration is not yet fully balanced, and research on Artificial Intelligence in Entrepreneurship Education remains concentrated in certain regions.

Synthesis of the 5 Best Articles

Table 6. Systhesis of The Best Article

Title	Findings	Implication
Machines augmenting entrepreneurs: Opportunities (and threats) at the Nexus of artificial intelligence and entrepreneurship	AI is more than an enabling technology, but rather a strategic tool when combined with entrepreneurship. AI has great potential in creating business opportunities in the customer service, finance, health and integration sectors in higher education.	The integration of AI in entrepreneurial education expands the theoretical framework of entrepreneurship by including AI as a strategic resource in the development of entrepreneurial competencies and intentions. This encourages more applied learning through the use of AI for solving real business problems. There is a demand for curriculum adjustments and learning guidelines to ensure that AI integration is carried out in a sustainable manner.
An artificial intelligence educational strategy for the digital transformation	AI is a relevant strategy in supporting digital transformation. AI is a core skill that higher education graduates must have to face digital transformation and the demands of the 21st century world of work. The AI program developed is not only oriented towards mastering technology, but also encourages students to develop innovation	The use of AI for product innovation, and decision-making strengthens the theory of digital entrepreneurship and technology adoption in the educational context. AI enhances students' readiness to face 21st-century economic challenges. This requires institutional support for the development of a technology-based entrepreneurial learning ecosystem.
Redefining entrepreneurship education in the age of artificial intelligence: An explorative analysis	One type of AI-based chatbot, namely ChatGPT, has great potential to support entrepreneurial learning in higher education, especially in conceptual and analytical activities, for example idea generation, crafting a	The use of generative AI such as ChatGPT supports experiential and constructivist learning theories, where students actively explore business models. AI serves as a learning assistant that helps

Title	Findings	Implication
	business model, writing a business plan, or conducting customer interviews.	novice students in the process of exploring and analysing business. Therefore, guidelines for the ethical of generative AI in the academic environment are required.
Digital Explosion and Entrepreneurship Education: Impact on Promoting Entrepreneurial Intention for Business Students	Entrepreneurship education and performance expectancy from solutions, especially from AI, do not directly influence entrepreneurial intentions, but influence through perceived behavioral control (PBC).	Perceived behavioural control strengthens the theory of entrepreneurial behaviour in the context of technology. In educational practice, this approach helps students develop sustainable entrepreneurial competencies oriented. Therefore, it is necessary to have a learning and evaluation design that emphasises the development of competencies.
Unveiling students' experiences and perceptions of Artificial Intelligence usage in higher education	This research found that higher education students have utilized various AI tools in learning entrepreneurship, starting from academic writing, analyzing business ideas and others. AI successfully increases productivity and personalizes learning	The deployment of AI marks a theoretical shift from traditional learning towards technology-based adaptive learning. This encourages innovation in teaching methods of entrepreneurship learning quality. Higher education institutions need to be adaptive by supporting AI integration so that entrepreneurial competencies align with the digital era.

Source: Processed Data (2025)

Based on the synthesis of key articles in Table 6, the findings indicate that Artificial Intelligence has evolved into a strategic tool in entrepreneurship education, rather than merely a supporting technology. The analyzed studies affirm that AI contributes significantly to the development of opportunity recognition, product innovation, market analysis, and decision-making, as well as enhancing the personalization and efficiency of entrepreneurship learning at universities. However, other findings also indicate that these benefits are not automatic, as the effectiveness of AI heavily depends on the pedagogical design and the learning context applied.

From a pedagogical perspective, AI integration tends to encourage a shift in learning from a teacher-centered model to a student-centered, experience-based approach, where students actively explore and validate business ideas with AI support. In this context, the lecturer's role shifts from delivering content to designing AI-based

entrepreneurial learning experiences that require reflection, critical discussion, and independent decision-making, thereby reducing the risk of students becoming overly reliant on technology.

From a curriculum perspective, the synthesis of articles indicates that AI is most effective in enhancing analytical and opportunity-driven entrepreneurial competencies, such as recognizing opportunities and data-driven innovation. Conversely, competencies such as resilience, independence, and ethical reasoning may be neglected if AI is used without a reflective approach. Findings regarding the mediating role of perceived behavioural control (PBC) suggest that AI-based entrepreneurship curricula should be explicitly designed to build students' confidence and control over business processes, rather than merely technical skills in using AI.

In the context of assessment and ethics, the synthesized literature also suggests a shift in evaluating learning outcomes from mere originality of ideas towards students' ability to critically evaluate, validate, and make decisions regarding AI outputs. Furthermore, findings indicating a neutral or limited impact of AI on entrepreneurial intent highlight tensions within the literature, underscoring the importance of reinforcing an entrepreneurial mindset such as curiosity, autonomy, and ethical responsibility so that the use of AI does not undermine the essence of entrepreneurial learning.

Discussion

RQ1. Main Information on the Development of Scientific Literature on Artificial Intelligence in Entrepreneurship Education

Overall, the scientific literature on Artificial Intelligence in Entrepreneurship Education shows a positive and significant growth trend, indicating increasing academic attention to this still developing field. The surge in publications observed in 2025, although still an early trend, indicates a strong acceleration of research interest as well as the growing relevance of AI applications in entrepreneurship education. From a writing perspective, Duong Cong Doanh (Vietnam) emerged as the most prolific contributor, with research focusing on entrepreneurship, artificial intelligence, and higher education students. This reflects the important role of individual researchers in shaping the early development of this field of study.

In terms of publication media, Frontiers in Psychology was noted as the most prominent journal in disseminating the latest findings, highlighting the interdisciplinary nature of this topic, particularly at the intersection of education, psychology, and technology. From a geographical perspective, China and Indonesia are major contributing countries, indicating strong involvement of developing nations in advancing research on Artificial Intelligence in Entrepreneurship Education. At the institutional level, the State University of Surabaya stands out as the most productive affiliation, underscoring the important role of universities in Southeast Asia in the development of this research domain.

The development of artificial intelligence literature in entrepreneurship education not only reflects an increase in the quantity of publications but also indicates a shift in focus towards stronger interdisciplinary integration. The dominance of psychology and education journals, as well as the active contribution of researchers from developing countries, suggests that this field is largely influenced by behavioural and pedagogical approaches, consistent with previous literature emphasizing the role of intention,

attitude, and individual readiness in the adoption of entrepreneurial technology. Theoretically, these findings reinforce the argument that AI-based entrepreneurship education is evolving to bridge entrepreneurship theory, and technology adoption, while also opening space for the development of adaptive conceptual frameworks in the future.

RQ2. Conceptual, Intellectual, and Social Structures of Literature

From a conceptual perspective, the thematic map reveals several research themes with potential relevance for advancing the Sustainable Development Goals (SDGs). Key and driving themes highlight the integration of artificial intelligence technologies such as adversarial machine learning, federated learning, contrastive learning, and educational computing within entrepreneurship education. Furthermore, themes related to digital transformation, innovation, and strategic approaches suggest promising directions for future research connecting AI-driven entrepreneurship education to wider economic and societal outcomes.

In terms of intellectual structure, the co-citation analysis indicates that literature on entrepreneurial intention particularly the TPB is the most frequently cited theoretical reference, reflecting its continued relevance in explaining entrepreneurial intention and technology adoption. However, TPB does not operate as a single dominant framework, as it is increasingly complemented by pedagogical and learning-oriented models that address AI-driven teaching, learning processes, and competency development. From a social structure perspective, the collaboration analysis reveals that research networks remain concentrated in Southeast Asia, China, and the United States, highlighting an imbalance in global participation and underscoring the need for broader cross-country collaboration to enhance the generalizability and global relevance of research on Artificial Intelligence in Entrepreneurship Education.

RQ3. Potential and Strategy for Developing Artificial Intelligence Research and Policy in Entrepreneurship Education to Support the Achievement of SDGs

Table 7. Future Research Directions and Policy Recommendations

SDGs Category	Suggested Future Research Context	Policy Recommendation
Quality education (SDG 4)	1. A strategic approach to machine learning with the adoption of AI as a tool for entrepreneurial learning according to the challenges of digital transformation and the 21st century. 2. Design AI-based entrepreneurship education (contrastive learning and federated learning) that systematically increases perceived behavioral control (PBC)	1. The government and higher education institutions should introduce compulsory AI-integrated entrepreneurship courses such as AI for entrepreneurial problem solving, that require students to use AI tools for opportunity, and business model testing, while critically validating AI outputs using real-world business data. 2. Higher education institutions need to mandate certified AI pedagogy training for entrepreneurship lecturers to ensure effective and

SDGs Category	Suggested Future Research Context	Policy Recommendation
		standardized teaching competence in the digital era. 3. Research funding agencies should provide special grant schemes for cross-country empirical studies focusing on evaluating the impact of AI in entrepreneurship education.
Decent work and economic growth (SDG 8)	1. Innovation Research on adversarial machine learning to test the robustness of business AI models at various scales. 2. Research based on PBC to understand AI development, job readiness, and entrepreneurial decision-making abilities, especially for small businesses.	1. Policymakers should mandate triple helix collaboration (universities–industry–government) within entrepreneurship incubation programmed to develop locally sourced business datasets (e.g., MSMEs, startups,) that can adapt AI models for entrepreneurial learning. 2. Universities and training institutions should implement hands-on training programmed that require students and entrepreneurs to use locally trained or fine-tuned AI models for business idea validation. 3. The government needs to establish an international consortium for AI-based entrepreneurship education research to identify and replicate empirically proven best practices.

CONCLUSION

Fundamental Finding: The research trend on Artificial Intelligence in Entrepreneurship Education in the last nine years shows a very significant increase. This is a new opportunity that related topics can be used to achieve SDGs. The most contributing writer is Duong Cong Doanh from Vietnam. The most contributing countries are China and Indonesia. Meanwhile, Surabaya State University is the best affiliate. The best knowledge on related topics comes primarily from the Frontiers in Psychology journal. **Implication:** The development of Artificial Intelligence research in Entrepreneurship Education needs to be directed towards the integration of AI that is pedagogically and contextually relevant, such as adversarial machine learning, federated learning, contrastive learning, and educational computing, which support experiential entrepreneurship learning and digital transformation. Studies in this field cannot rely solely on TPB but need to be combined with pedagogical design and the development of AI-based entrepreneurial competencies. Within the SDG framework, these implications require the development of AI-integrated entrepreneurship courses, as well as helic collaboration to enhance graduate capacity. Research collaboration across countries is necessary. **Limitation:** Limitations in this research are the use of the Scopus database which is the sole source.

In addition, the latest trends and findings are focused on and linked to the SDGs. future research is recommended to integrate various databases such as Web of Science, Dimensions, Google Scholar. **Future Research:** For SDG 4, further research needs to empirically evaluate the effectiveness of mandatory AI-based entrepreneurship courses, including how the use of machine learning, contrastive learning, and federated learning in project-based tasks affects learning quality, and their perceived behavioural control. Meanwhile, in the context of SDG 8, it is necessary to examine the impact of applying AI models trained using local business datasets through a triple helix collaboration scheme on the quality of entrepreneurial decision-making and business sustainability across.

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*__Choiru Umatin (Corresponding Author)__
Universitas Islam Negeri Syekh Wasil, Kediri, Indonesia
Address: Jl. Sunan Ampel No.7, Ngronggo, Kediri, Indonesia
Email: choiruummatin@uinkediri.ac.id

Vina Budiarti Mustika Sari
IKIP Widya Darma, Surabaya, Indonesia
Address: Jl. Ketintang No.147-151, Surabaya, Indonesia
Email: vinabudiarti1990@gmail.com

Nailariza Umami
Universitas Bhinneka PGRI, Tulungagung, Indonesia
Address: Jl. Mayor Sujadi No.7, Tulungagung, Indonesia
Email: umaminailariza@gmail.com

Komm Pechinthorn
Thai Global Business Administration Technological College, Thailand
Address: 99 553 หมู่ 8 Srinagarindra Rd, Bang Mueang Mai, Mueang Samut Prakan District, Samut Prakan 10270, Thailand
Email: komm.p@tgbc.ac.th

Eni Susilowati
Universitas Islam Negeri Sayyid Ali Rahmatullah, Tulungagung, Indonesia Address: Jl. Mayor Sujadi Timur No. 46. Tulungagung, Indonesia
Email: enisusilowati@uinsatu.ac.id

Artificial intelligence in entrepreneurship education: A nine-year bibliometric analysis and future research directions toward the sustainable development goals