Artificial intelligence in entrepreneurship education: a scoping review

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Abstract

Purpose – The study aims to identify the status quo of artificial intelligence in entrepreneurship education with a view to identifying potential research gaps, especially in the adoption of certain intelligent technologies and pedagogical designs applied in this domain.

Design/methodology/approach – A scoping review was conducted using six inclusive and exclusive criteria agreed upon by the author team. The collected studies, which focused on the adoption of AI in entrepreneurship education, were analysed by the team with regards to various aspects including the definition of intelligent technology, research question, educational purpose, research method, sample size, research quality and publication. The results of this analysis were presented in tables and figures.

Findings – Educators introduced big data and algorithms of machine learning in entrepreneurship education. Big data analytics use multimodal data to improve the effectiveness of entrepreneurship education and spot entrepreneurial opportunities. Entrepreneurial analytics analysis entrepreneurial projects with low costs and high effectiveness. Machine learning releases educators' burdens and improves the accuracy of the assessment. However, AI in entrepreneurship education needs more sophisticated pedagogical designs in diagnosis, prediction, intervention, prevention and recommendation, combined with specific entrepreneurial learning content and entrepreneurial procedure, obeying entrepreneurial pedagogy.

Originality/value – This study holds significant implications as it can shift the focus of entrepreneurs and educators towards the educational potential of artificial intelligence, prompting them to consider the ways in which it can be used effectively. By providing valuable insights, the study can stimulate further research and exploration, potentially opening up new avenues for the application of artificial intelligence in entrepreneurship education.

Keywords Entrepreneurship education, Big data, Machine learning, Scoping review, Artificial intelligence

Paper type Research paper

1. Introduction

The terminology of Artificial Intelligence (AI), a buzzword, nowadays exceeds the computer science field, combining all trades and professions. The definition of AI by Pedro *et al.* (2019) refers to human performance and rationality of computers, systems or software. AI as a trend of educational technologies, which mainly applies to the realm of higher education, releases the burden of educators via automation and therefore saves time and human resources.

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Entrepreneurs, via undertaking entrepreneurship education and starting their own businesses, have the potential to decrease the ratio of unemployment and increase the amount of economic growth using innovative ideas/products/services/technologies and the foundation of ventures, generated as a result of entrepreneurship. AI has been adopted in science, technology, engineering and mathematics teaching and learning at all levels of education institutes whereas social science struggles with this intelligent technology because of ill-structured content (Roll and Wylie, 2016). Meanwhile, despite the recent surge in the utilization of generative AI and its applications, the progression of AI technology, from weak to strong, has yet to research a point where it can effectively replace the tasks performed by experienced educators (Obschonka and Audretsch, 2020). Especially, educators from the domain of entrepreneurship education rarely introduce educational technologies in their daily teaching and administration (Chen *et al.*, 2021). As the widespread integration of AI into entrepreneurship is apparent, there is a notable lag in the development of comprehensive theoretical summaries to guide future entrepreneurship and entrepreneurship education practices. However, scholars and practitioners are eager to know its possibility and opportunities. High-impact entrepreneurial journals have published research on AI in entrepreneurship, with exploration and reviews conducted in the early stages (i.e. Chalmers *et al.*, 2021; Shepherd and Majchrzak, 2022) whereas there is a notable absence of reviews addressing AI application in entrepreneurship education. In comparison to AI in other educational domains (except for entrepreneurship education) (AIED), the articles included in this review underscore the insufficient exploration of AI's potential in entrepreneurship education. Additionally, empirical studies are mainstream in the extant research of entrepreneurship education (i.e. Maritz, 2017; Otache *et al.*, 2021). The review method includes both theoretical studies and empirical research, enhancing the scope of scholarly investigation.

As technology maturity progresses (esp. AI, a destructive innovative technology, provides new paths to solve practical and theoretical problems existing in entrepreneurial learning and teaching) and hybrid learning becomes increasingly prevalent in the field of education (Ratten, 2023), educators responsible for instructing on venture creation should earnestly consider gleaning valuable insights from experts in the realm of AIED. These experts bring a unique blend of both practical acumen and scholarly expertise in the application of AI. In this context, the study aims to provide a scoping review of the research status and explore the possibilities of applying AI in entrepreneurship education on the basis of AIED. A scoping review can summarize outcomes from heterogeneous realms that have not been widely reviewed, in order to identify gaps in a broad topic (Pham *et al.*, 2014; Tricco *et al.*, 2018).

The remainder of this study is shown. The literature pertaining AIED is meticulously examined in section 2, with the primary objective of discerning the current state-of-the-art studies in the domain of AIED. In section 3, we present our scoping review methodology on AI in entrepreneurship education and synthesized published English articles. The results are shown in two tables, presented in section 4, followed by the discussion section that discusses two main findings, in section 5. Finally, the last section consists of the conclusion, limitations of the research and future work.

2. AIED

To understand the research status quo of AIED and guide for entrepreneurship education, we synthesized AI technologies applied in education and its developed theoretical framework from ten reviews collected from Google Scholar and ERIC (Education Resources Information Center), shown in Table 1. Zhai *et al.* (2021), Chen *et al.* (2022), Bozkurt *et al.* (2021), Chassignol *et al.* (2018) and Feng and Law (2021) systematically reviewed specific AI technologies

Author	Theoretical framework
Bozkurt *et al.* (2021)	AI, pedagogy, technological issues
Chen *et al.* (2022)	Combine AI technologies with education, learning and teaching
Zhai *et al.* (2021)	AI technology, pedagogical design, domain knowledge and human factor
Feng and Law (2021)	Three-step multi-scale (macro, meso, micro) framework
Chassignol *et al.* (2018)	Educational process (content, teaching methods, assessment, communication) combine with specific AI technology
Baker and Smith (2019)	Learner-facing, teacher-facing and system-facing
Cox (2021)	Learning, administration and research
Talan (2021)	Without particular framework, focusing on AI in higher education
Pua *et al.* (2021)	Students' learning, the relationship between teacher and machine, risk
Salas-Pilco and Yang (2022)	Pedagogy design: learning, teaching and management/administration AI application: predictive modeling in education, AI computer-assisted content analysis, assistive technology, intelligent analytics, image analytics AI techniques, software tools and algorithms used

Source(s): Authors' own creation

Table 1.
The reviews of artificial intelligence in education

applied in education. Baker and Smith's report (2019) primarily centered its attention on pedagogical design, with minimal reference to specific technological aspects. Cox (2021) narratively reviewed eight design fictions, discussing the impact of AI on higher education. Talan (2021) and Pua *et al.* (2021) used a bibliometric review to map AI keywords. The pedagogical design of AIED described in ten pieces of literature is shown in Table 1.

Pedagogical design in certain contexts for learning and teaching needs to be rebuilt in the intelligent age due to the new situation of application of AIED (Popenici and Kerr, 2017). Chen *et al.* (2022) focused on teaching and learning. Cox (2021) emphasized learning, research and administration. Two studies separated the pedagogical design into learning, teaching and system/research/management (Salas-Pilco and Yang, 2022; Baker and Smith, 2019). Pua *et al.* (2021) identified learning, computer–teacher relationship, and risk. Bozkurt *et al.* (2021) mentioned adaptive learning, online learning, human–AI interaction, educational data and higher education. Chassignol *et al.* (2018) emphasized the educational process. Feng and Law (2021) and Zhai *et al.* (2021) did not point out pedagogical design directly. Talan (2021) and Feng and Law (2021) merely mentioned pedagogical design in their studies. In general, according to the thematical analysis of the pedagogical design of AIED, learning, teaching and management/research are pedagogical frameworks when analyzing each intelligent technology in entrepreneurship education. Learning is student performance and development in entrepreneurship education activities whereas teaching is the performance and assessment of teaching activities (Salas-Pilco and Yang, 2022). Higher education institutes' administration or management, such as dropout/retention or university performance, is the third dimension of theoretical analysis.

The ten studies involve specific AI technologies ranging from big data, adaptive/personal learning systems, neural networks, natural language processing and chatbots (see Figure 1 left bar). Specifically, big data in education facilitates learning success, predicting through learning analytics that applies statistics, pedagogy and AI algorithms/models (Alkhalil *et al.*, 2021). McAfee and Brynjolfsson (2012) summarized "volume" (large volume), "variety" (various sourcing) and "velocity" (high speed) as the characteristics of big data. As mentioned in machine learning that examines algorithms on the basis of classified documents and adopts the algorithms in unclassified data (Jordan and Mitchell, 2015; Korkmaz and Correia, 2019). The adaptive/personalized learning system goes further by means of intelligent assessment (Tang *et al.*, 2021). Artificial neural networks are used as a kind of deep learning method (Yakubu *et al.*, 2020). Natural language processing, namely human language has been

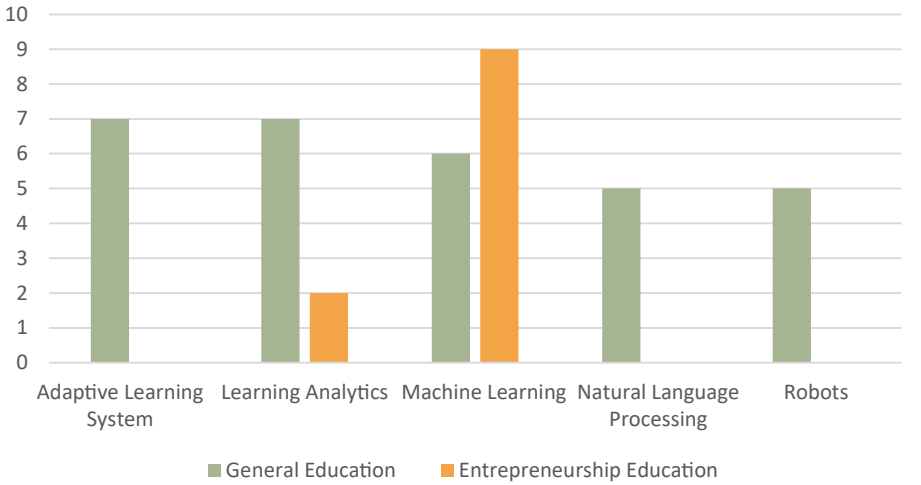

Figure 1.
Comparison of specific artificial intelligence techniques in education and entrepreneurship education

Source(s): Figure created by authors

employed in the field of education, to analyze learning content, writing and reading through feeding model answers (Burstein, 2009; Davidovitch and Eckhaus, 2020). The brief procedure of utilization of chatbot: the end-user inputs text or speech data and chatbots reply to users by getting stored data of relevance in their databases (Adamopoulou and Moussiades, 2020; Clarizia *et al.*, 2018).

Motivated by the influence of AI in various educational domains, this investigation identifies two research queries within the scope of entrepreneurship education:

RQ1. What specific AI technologies have been utilized in entrepreneurship education?

RQ2. What specific pedagogical designs have been utilized in the analysis of AI in entrepreneurship education?

3. Methodology

3.1 Identifying relevant studies

Any synonyms surrounding AI and entrepreneurship education in the search terms are collected to broaden the search strings. Machine learning and deep learning are the further development of AI. Both of them relies on big data, including data mining and data analysis. When typing in "artificial intelligence" during a pilot search, the results in Google Scholar showed keywords: machine learning, deep learning and other variants of intelligence technologies. This research adopted "artificial intelligence", "machine learning", "big data" and "deep learning" as search strings. Meanwhile, the synonyms of entrepreneurship were taken into consideration. Thus, education went further with "learning", "teaching" and "administration". The results of title screening in our pilot review adopted combined search terms, "intelligen*" and "start a business", being irrelevant to research questions. Additionally, "administration" combined with AI and entrepreneurship was hard to be found. Therefore, we iterated and defined the final search strings in Table 2.

The examination involved the perusal of electronic databases, namely, Web of Science and Google Scholar (two prominent and comprehensive databases), along with ERIC (a substantial educational database). Within the category of entrepreneurship and

instructional literature on entrepreneurial learning/teaching, this study systematically gathered peer-reviewed papers published in *Entrepreneurship Theory and Practice, Journal of Business Venturing, Education and Training, Entrepreneurship Education and Pedagogy and the Journal of Entrepreneurship Education.* The academic journals refer to technology and education: *International Journal of Artificial Intelligence in Education, Computers in Human Behavior, Computers and Education, International Journal of Emerging Technologies in Learning, Computer Application in Engineering Education, Computer Application in Engineering Education* and *Educational Technology Society* from a bibliometric study conducted by Talan (2021). This scoping review was conducted between October 2021 and April 2022 with an update in August 2023.

3.2 Selection of relevant studies

In order to collect studies of optimal relevance and high quality pertaining to AI in entrepreneurship education, the research team deliberated upon and established inclusion and exclusion criteria through three online meetings, each lasting approximately 30 min. Subsequently, the criteria were presented and discussed in a seminar attended by 16 Ph.D. students and one professor. The criteria underwent refinement and consensus-building, culminating in the specification of six criteria, as delineated below.

(1) Included paper titles must pertain to entrepreneurship/entrepreneurs, excluding those focused on finance/business/management;

(2) AI used as a learning or teaching tool is considered, while AI as learning content or curriculum is disregarded;

(3) Articles omitting mention of entrepreneurship without education are excluded;

(4) Research with low quality (in terms of reliability and viability) is excluded to mitigate potential bias;

(5) The chosen literature encompasses works published from January 2010 to August 2023. The selection criteria include full-text accessibility online and publication in the English language. This time frame was selected due to notable achievements in AI surpassing human game players and rapid advancements in autonomous driving technology since the beginning of the 2010s;

(6) Articles mentioning AI in the title and/or abstract but lacking practical guidance on its use in the main content are excluded, as scholars primarily introduced AI as background information.

The scoping review methodology is comprehensively delineated in Figure 2. A total of 172 articles underwent the identification and screening phase through a title-based screening approach. In the assessment of eligibility, 18 papers were culled following the screening title and abstract. The final selection for inclusion comprised peer reviewed journal articles ($N = 6$) and conference proceedings ($N = 1$), contingent upon a rigorous full-text review

AI		Entrepreneurship		Education
"Artificial intelligen*" OR "machine learning" OR "deep learning" OR "big data"	AND	"Entrepreneur*" OR "startup" OR "business plan"	AND	"Learning" OR "teaching" OR "education" OR "administration"

Source(s): Authors' own creation

Table 2. Search strings of the scoping review

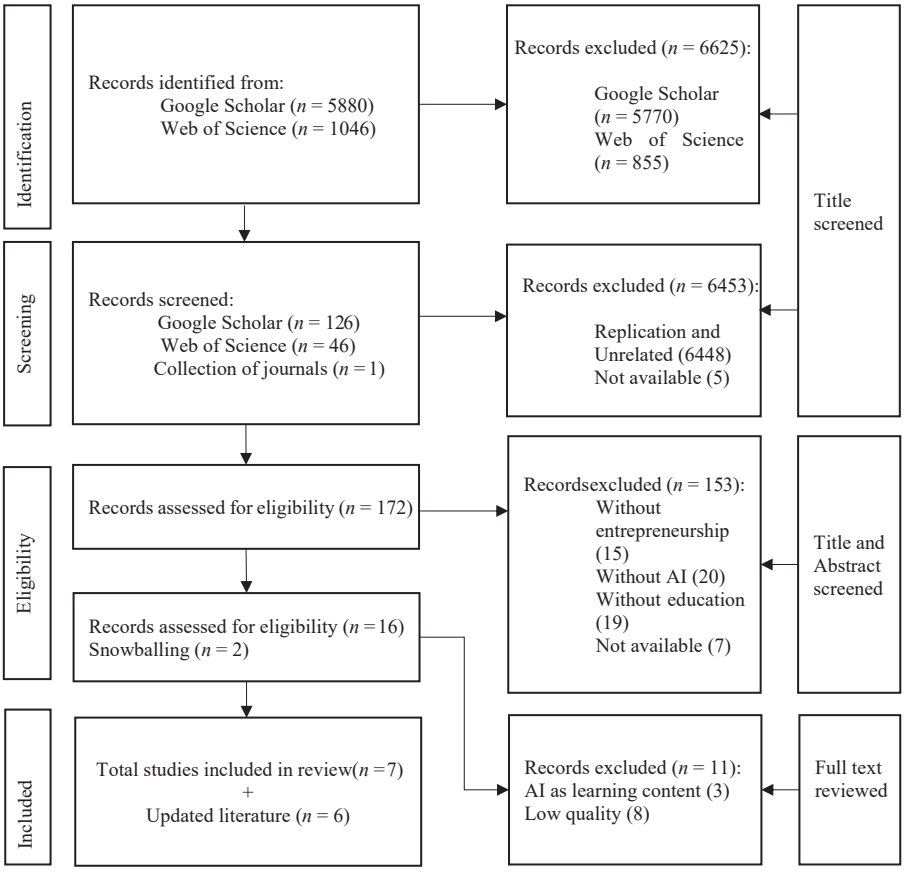

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Figure 2.
PRISMA flow diagram adapted from Turner and Stough (2020)

process. Additionally, six peer reviewed papers were added with the same procedures when updating the literature in August 2023.

4. Results

The detailed results of 13 included studies were shown in Table 3 coded and agreed by two authors, adoption of AI technology, the definition of intelligent technology, research purpose, education purpose (learning, teaching and administration/research), research method, sample size, research quality (low, moderate and high) and publication. The comparison between AIED (left bar) and AI applied in entrepreneurship education (right bar) in the specific AI technique was drawn in Figure 1.

4.1 Artificial intelligence technologies in entrepreneurship education (RQ1)

4.1.1 Big data analytics. Two studies discussed data mining and analytics (Toledo *et al.*, 2020; Sedkaoui, 2018). Findings showed that (1) despite the pervasive integration of big data analytics in the broader educational landscape, the utilization of this sophisticated analytical technique

Table 3. Artificial intelligence technologies in entrepreneurship education

Authors	Adoption of AI technology	Definition of applied AI technology	Research method	Sample size	Education purpose T	L	M/R	Research aim	Research Quality	Publication
Tkachenko *et al.* (2019)	Machine learning (fuzzy model and neural network)	Standpoint of cognitive understanding of information development of the entrepreneurial training	Qualitative research	n/a	+			M-machine concept for development of the artificial intelligence technology in provision of the entrepreneurial education	Middle	Journal of Entrepreneurship Education
Liang *et al.* (2021)	Machine learning (Neural network)	Not given directly, explaining and integrating two algorithms	Experiment study	30 (20 training, 10 test data)	+			Sustainability evaluation of innovation and entrepreneurship education for clean energy majors	High	Sustainability
Botha *et al.* (2021)	Machine learning (neural networks)	A technique to identify patterns and trends in a string of behaviors	Experiment study	150 samples (125 valid)			+	Test non-linear relationships and compare with linear regression model	Middle	Development Southern Africa
Sedkaoui (2018)	Big data (data analytics)	A natural crop of the advanced digital artifacts and their applications (volume, variety, velocity)	Qualitative research	n/a		+		The potential of introducing big data analytics in learning process and making entrepreneurial decisions	Middle	International Journal of Innovation Science
Xu and Zhang (2021)	Machine learning (Wavelet neural network)	A mathematical model, similar to the human nervous system	Experiment study	20 graduates		+		Analysis and prediction model of college students' entrepreneurial psychology	High	Frontiers in psychology

(*continued*)

Table 3.

Authors	Adoption of AI technology	Definition of applied AI technology	Research method	Sample size	Education purpose T	L	M/R	Research aim	Research Quality	Publication
Chen (2021)	Machine learning (fuzzy neural network)	Improving the real-time scheduling and collocation ability of the innovation and entrepreneurship education model of college students FNN control the innovation and entrepreneurship education model of college students	Experiment study (survey)	219	+			Improve the automatic scheduling and control method, innovation and entrepreneurship education model for college students based on fuzzy neural network	Middle	Security and Communication Networks
Toledo *et al.* (2020)	Big data (learning analytics)	n/a	Survey and log data on learning system	23 participants with both survey and platform data			+	Using learning analytics to explore the case of dropout during a female-oriented online entrepreneurship education program	Middle	Psychology
Zhu and Zhang (2022)	Machine learning (deep learning)	n/a	Qualitative research	n/a			+	Learning resource recommendation on problem-based learning management system	Middle	Frontiers in Psychology
Zhao *et al.* (2022)	Machine learning (BP neural networks)	a multilayer feedforward neural network in artificial neural network	Experiment study	9 neurons			+	Evaluation results of women's entrepreneurship education	Middle	Scientific Programming

(*continued*)

Table 3.

Authors	Adoption of AI technology	Definition of applied AI technology	Research method	Sample size	Education purpose T	L	M/R	Research aim	Research Quality	Publication
Alqahtani (2023)	AI (machine learning, natural language, expert systems, machine vision)	AI includes machine learning, natural language, expert systems, machine vision	Experiment study	402 respondents	+	+		Identifying the impact of the dimensions of artificial intelligence on entrepreneurship education at higher education level	High	International Journal of Data and Network Science
Shepherd and Majchrzak (2022)	Machine learning	Machines that are trained to perform tasks associated with human intelligence	Qualitative research	n/a	+	+	+	AI in territory education from entrepreneurial context	High	Journal of Business Venturing
Giuggioli and Pellegrini (2022)	Intelligence demonstrated by machines changing with circumstances	n/a	Review	12	+	+	+	The influence of AI (as enabler) for entrepreneurship	High	International Journal of Entrepreneurial Behavior&Research
Bell and Bell (2023)	AI undertake tasks previously performed by intelligent beings a type of artificial intelligence which can generate new content, including text, images and sound and music, based on directed input	Generative AI	Qualitative research	n/a	+	+	+	The implications of generative artificial intelligence for entrepreneurship education	High	Entrepreneurship Education

Note(s): L = learning, T = teaching, M = management, R = research, n/a = not available
Source(s): Authors' own work

within the domain of entrepreneurship education is conspicuously constrained concerning teaching, learning and administrative applications. Specifically, in contrast to the contextualization of students' requirements and preferences within the ambit of big data, coupled with the provision of personalized learning guidance facilitated by algorithmic models, the learning analytics method within entrepreneurship education identified, through the employment of both surveys and log data, eight potential factors influencing the heightened attrition rates observed among female entrepreneurs in the online entrepreneurship education environment (Toledo *et al.*, 2020); (2) big data analytics operates entrepreneurship analytics to predict the success of an entrepreneurial project for learners. Using statistics analytics, entrepreneurial analytics applies data insights to social sustainable development, extracting entrepreneurial opportunities/ideas and enhancing learners' entrepreneurial competencies (Sedkaoui, 2018); (3) data storage, multiple modal data and the amount of data are considered. Following data privacy regulations, entrepreneurial data is stored in learning management platforms/systems, the Academic Affairs Office and Career Guidance Center. Additionally, certain data is intentionally recorded, while some is captured through automated processes on social media platforms. A survey with 23 participants and platform log data were captured (Toledo *et al.*, 2020). The research, on the other hand, gathered a limited amount of data that did not possess the attributes typically associated with big data, such as volume, variety and velocity. No data were collected but rather a qualitative explanation was given for the reason for the application of big data (Sedkaoui, 2018). Hence, the volume of data is limited in the collected researches. Strictly speaking, survey data cannot be considered as big data (Schwab and Zhang, 2019). The research is deficient in collecting and analyzing diverse modal data or datasets with a high level of variety.

4.1.2 Machine learning. Nine of 13 studies mentioned machine learning (Alqahtani, 2023; Shepherd and Majchrzak, 2022; Xu and Zhang, 2021; Liang *et al.*, 2021; Tkachenko *et al.*, 2019; Botha *et al.*, 2021; Chen *et al.*, 2021; Zhao *et al.*, 2022; Zhu and Zhang, 2022). Except for educational purposes, the findings were coded from data sourcing, sample size, machine learning algorithm and validation of algorithm, summarized from Luan and Tsai's (2021) methodology of machine learning analysis.

Four studies pointed out the collected number of samples and data sourcing. Three of the research employed split validation (train and test data). Xu and Zhang (2021) adopted 20 samples ($N = 10$ trained and $N = 10$ tested) from a survey. Liang *et al.* (2021) used 30 samples (20 universities to train and tested 10 institutes) by field research. Botha *et al.* (2021) trained 89 and tested 36 entrepreneurship graduates. Alqahtani (2023) collected 408 respondents attending the experiment. Chen *et al.* (2021) used physical information by means of information-sensing recognition to build nodes and surveyed 219 participants to test nodes and models. Zhao *et al.* (2022) verified evaluation results through nine neurons. Tkachenko *et al.* (2019), Zhu and Zhang (2022) and Shepherd and Majchrzak (2022) mentioned neither the sample size nor data source.

In contrast with other algorithms, neural networks, like the human neural network, are not traditional AI techniques due to their nonlinear processing, self-organization and reasoning capabilities (Xu and Zhang, 2021). The back propagation neural networks are multi-level neural networks (Zhao *et al.*, 2022). Neural networks are normally combined with other algorithms such as pattern recognition (Botha *et al.*, 2021) and wavelet transform (Xu and Zhang, 2021). In an applied example, Liang *et al.* (2021) optimized an evaluation module partly by generalized regression neural network. So neural networks is the main algorithm applied in entrepreneurship education.

4.2 Pedagogical design (RQ2)

The findings of the RQ2 are shown following. (1) Two studies have analyzed AI from entrepreneurial learning aspects (Sedkaoui, 2018; Alqahtani, 2023). In light of the research

framework prompted by Sedkaoui (2018), to identify the gap between market demands and existing learning projects, big data technology was guided by pedagogical design tailored learning modules for entrepreneurial learners. Additionally, the adoption of big data facilitates entrepreneurship education by building an efficient learning process (Sedkaoui, 2018). Alqahtani has identified the impacts of four specific intelligent technologies on entrepreneurship cognition, competence and innovation spirit (Alqahtani, 2023). (2) Six papers attempt to solve teaching-relevant problems (Botha *et al.*, 2021; Chen *et al.*, 2021; Zhao *et al.*, 2022; Tkachenko *et al.*, 2019; Liang *et al.*, 2021; Alqahtani, 2023). The procedures or stages of neural networking have been considered as teaching steps to design entrepreneurial tasks and activities (learning from technological logic) (Tkachenko *et al.*, 2019). The multiply neural network evaluated entrepreneurship education for woman (Zhao *et al.*, 2022). It may also be possible to build a model to predict the effectiveness of entrepreneurship education (Chen *et al.*, 2021). Liang *et al.* (2021) constructed and verified an evaluation index model for the sustainability of entrepreneurship education. Alqahtani (2023) proposed and verified four hypotheses related to the effectiveness of AI applied in entrepreneurship education. (3) Two papers tried to answer administration/research (Botha *et al.*, 2021; Xu and Zhang, 2021). To maintain high retention rate and avoid dropping out, the neural network was used to predict students' entrepreneurial psychology (Xu and Zhang, 2021) and the relationship between prior entrepreneurial exposure, entrepreneurship education and entrepreneurial action (Botha *et al.*, 2021). Additionally, a deficiency in scholarly investigations with high quality pertaining to adaptive learning management systems is discernible.

Three studies (Shepherd and Majchrzak, 2022; Giuggioli and Pellegrini, 2022; Bell and Bell, 2023) introduced AI in entrepreneurship education, not pointing out clear about learning, teaching or administration. These intelligent technologies such as teaching assistants, chatbots, plagiarism and so forth, all these adopted in other disciplines in higher education levels, have possibilities to adopt in entrepreneurship education to support nascent and experienced entrepreneurs (Shepherd and Majchrzak, 2022; Giuggioli and Pellegrini, 2022; Bell and Bell, 2023). On the other side, AI enables entrepreneurship efficiently in such as opportunity identification, pitches, venture creation process, entrepreneurial analysis, training emotional intelligence and so forth (Davidsson and Sufyan, 2023; Short and Short, 2023; Shepherd and Majchrzak, 2022; Giuggioli and Pellegrini, 2022). It improves the success of entrepreneurial projects, being incubated and accumulated by entrepreneurship education activities (Giuggioli and Pellegrini, 2022; Shepherd and Majchrzak, 2022; Bell and Bell, 2023).

5. Discussion

5.1 Artificial intelligence technologies in entrepreneurship education (RQ1)

The exploration of AI applications in entrepreneurship education encompasses various intelligent techniques, as illustrated in Table 4. These techniques are interwoven within the context of AI in entrepreneurship and other educational domains. In this section, we delve into a detailed discussion of the two primary intelligent technologies.

5.1.1 Big data analytics. On grounds of the procedure of mining, analyzing and visualizing big data, scholars analyze participants' and environmental information to improve learning performance and success. Mining a large magnitude of entrepreneurship and entrepreneurship education data is a precondition for computer science engineers and educators to construct models or patterns. Except for cognitive data, huge chunks of social and affective data should be captured (Luan *et al.*, 2020). Educators need to capture and retrieve multimodel data relevant to learners' performance, from mouse clicks to times of attempts (behavioral data) and facial recognition (Sharma *et al.*, 2019; Wang, 2016) to extract features (Ochoa *et al.*, 2022) and teach in a targeted manner (Ma *et al.*, 2020). The current

AI in EE	Keywords	Research gap	Sourcing
Big data and EE	1. Data collection 2. Data analysis 3. Data visualization 4. Data privacy 5. Entrepreneurship analytics	1.1 Collection of multimodal data (i.e. gaze, electrodermal test, brainwave) 1.2 Collection of social and emotional data 1.3 Disparate data in various platforms 2.1 Learning analytics for learners and stakeholders 2.2 Data science 3.1 Dashboard specialized in EE 3.2 Mescal data visualization produced in lab or classroom 4.1 Data ethics and privacy 5.1 Entrepreneurial ideas analytics	Alam (2021), Daniel (2015), Ochoa *et al.* (2022), Verbert *et al.* (2013)
Machine learning in EE	1. Algorithm	1.1 Optimal algorithms for assessment of EE 1.2 Prediction of EE 1.3 Model training	Korkmaz and Correia (2019), Ciolacu *et al.* (2017)
Personalized learning management system in EE	1. Learner model 2. Knowledge model 3. Pedagogical model	1.1 Learning style 1.2 Demographic background 2.1 Knowledge coding 2.2 Modernizing learning content 3.1 Entrepreneurial learning strategies 3.2 Entrepreneurial instruction design	Kahraman *et al.* (2010), Martin *et al.* (2020)
Natural language processing in EE	1. Utilization	1.1 Learning assessment 1.2 Big language model	Sarker *et al.* (2019)
Chatbot in EE	1. Utilization	1.1 Application of AI-based Chatbot in entrepreneurship education effectively 1.2 When to leverage AI-based Chatbot in entrepreneurship education	Ferrucci *et al.* (2010)

Note(s): EE is entrepreneurship education
Source(s): Authors' own work

Table 4. Opportunities for research of AI in Entrepreneurship Education

entrepreneurship education analyzed data is coarse-grained. Additionally, the data quality and extraction methods need to be considered (Ifenthaler and Yau, 2020) in entrepreneurship education.

Parallel to other educational fields, entrepreneurship education participants use data analytics as an educational tool to diagnose, predict, intervene and recommend entrepreneurial learning (Luan and Tsai, 2021). The presentation of data analytics needs to learn from logs of entrepreneurship education activities, especially in the visualization of the assessment to increase the readability of results and learners' course satisfaction (Verbert *et al.*, 2013). Ferguson pointed out that learning analytics needs "a shift away from a technological focus towards an educational focus" (Ferguson, 2012, p. 305). Entrepreneurship education educators and their stakeholders should focus on pedagogical design, namely how to combine technology with entrepreneurship education appropriately. In addition, when

embarking upon an entrepreneurial venture, it is crucial to take into consideration a number of key factors such as data privacy and ethical considerations (Williamson, 2016). It is worth noting that ethical and privacy considerations are not only important from a moral standpoint but also from a legal perspective (Giuggioli and Pellegrini, 2022). In fact, legal requirements mandate that entrepreneurs take into account the ethical and privacy implications of their business activities (Alam, 2021; Schumacher and Ifenthaler, 2018). Overall, data analytics needs to stand on the shoulders of other disciplines and reach new heights with many visible and invisible possibilities and solutions to problems.

The utilization of big data facilitates entrepreneurial endeavors, as exemplified by its role in shaping media coverage for entrepreneurial activities (von Bloh *et al.*, 2020). The analytical competence of entrepreneurs in data analytics exerts a direct and indirect influence on the formulation and innovation of business models (Ciampi *et al.*, 2021). Within the particular context of entrepreneurship, leveraging nuanced insights into customer behavior allows nascent and experienced entrepreneurs to effectively target customers and deliver personalized services. This strategic approach is evident in the adoption of big data by four ventures within a specific industry prior to the commercialization of their respective products or services (Jiang and Tornikoski, 2019).

5.1.2 Machine learning. In entrepreneurship education courses, machine learning is applied to verify learners' entrepreneurial ideas, analyzing the initial supervised or unsupervised data (Mavlutova *et al.*, 2020). In order to increase validity and avoid performance bias, machine learning usually needs to validate models based on samples with high dimensions or big data (Balki *et al.*, 2019; Vabalas *et al.*, 2019). A small sample size might threaten the effectiveness of the algorithm (Winkler-Schwartz *et al.*, 2019), although the research adopts a split validation. The included literature in this study had a relatively small sample size. Scholars exchange the training and testing data, as well as explore more data from various datasets, from social media to learning management platforms and surveys/interviews to achieve higher performance of models.

Under the employment of data analytics where inputted existing data as fuel trains model through a computer to achieve, machine learning in the study is not a general terminology, but a set of certain algorithms that can be leveraged in the learning prediction (Hodges and Mohan, 2019; Luan and Tsai, 2021) and assessment. Except for neural networks reviewed in this study, other popular algorithms: regression, decision tree, K-means and Bayes employed in the education (Ciolacu *et al.*, 2017; Zhai *et al.*, 2020) can be introduced into the assessment of entrepreneurial learning directly, optimizing algorithms and models based on questions to solve. Additionally, entrepreneurship education educators continue to employ decision trees mostly adopted in other educational fields (Korkmaz and Correia, 2019). Hence, developers train and optimize algorithm models, releasing the educators' burden of assessment and achieving assessment with high accuracy (Saha and Rao, 2022).

According to the topics/purposes of entrepreneurship education research, neural networks identify impact factors of entrepreneurship education and explore the effectiveness of diverse approaches (Blenker *et al.*, 2014; Salas-Rueda, 2021). Assessment and evaluation of entrepreneurial assignments are suitable to apply machine learning. Nevertheless, the unstandardized response is characterized by its personalized, extensive nature, rendering it intricate for computational analysis. The advent of natural language processing, exemplified by the emergence of big language models, has substantially enhanced machine intelligence, enabling efficacious problem-solving capabilities. Except for building corpora, based on entrepreneurship as a process of designation (learning from design thinking) (Berglund *et al.*, 2020), educators and software developers can standardize the procedure of entrepreneurship education. The well-structured design thinking steps: the empathize, define, ideate, prototype are inspired by Herbert Simon who describes the detailed requirement of each step (Camacho, 2016). Furthermore, the Google Design Sprint helps individuals and organizations launch new ideas quickly and efficiently

(Banfield *et al.*, 2015). In the end, educators and developers will easily analyze the structured data by the assistant of machine.

5.2 Pedagogical design (RQ2)

Educators apply AI technologies to their entrepreneurial teaching processes, learning analytics and education administration/research with particular entrepreneurial content and context using optimized pedagogical design in-depth. In the field of entrepreneurship education, scholars learn from the experience of other educational fields in a combination of AI and pedagogy design.

From the learning aspects, the integration of AI technology in entrepreneurship education is general. Software developers and educators should go further to utilize technologies in specific entrepreneurship learning content. We still lack practical and experimental results to examine its application. AI as entrepreneurship learning content has been widely discussed whereas learning with AI or AI as a digital learning tool is less analyzed in entrepreneurship education (i.e. Bogoviz *et al.*, 2019; Cantú-Ortiz *et al.*, 2020). The application of AI is pointed out with possible utilization, which is still broad and lacks empirical proof (Tarabasz *et al.*, 2018). Learning content recommendations have been discussed (Zhu and Zhang, 2022). Research such as the integration of specific learning content and intelligent technologies, visualization and data privacy will be the further step for educators and software developers. From the teaching aspects, except for assessment of teaching methods (Zawacki-Richter *et al.*, 2019), machine learning predicts and assesses business ideas for would-be and nascent entrepreneurs (Mavlutova *et al.*, 2020). AI enables preoccupations on project mentoring (value-add activities), not teaching monitor (repetitive tasks) (Shepherd and Majchrzak, 2022). From administration/research aspects, the machine (computer) provided bespoke feedback partly instead of tasks completed by administrative staff (Popenici and Kerr, 2017). Algorithms are applied to academic topics, improving the accuracy of prediction and evaluation. Intelligent recommender systems recommend personalized learning content and entrepreneurial projects by analyzing data such as learners' age and learning behavioral and cognitive data (Kahraman *et al.*, 2010; Martin *et al.*, 2020).

6. Conclusion

Technology (i.e. AI in this research) affects entrepreneurship (Elia *et al.*, 2020). AI is a digital technology, being resource for or outcome of digital entrepreneurship (Sahut *et al.*, 2021; Steininger, 2019). Thus, AI has direct and indirect impacts on entrepreneurship education. The study shown that big data and algorithms of machine learning have been introduced into entrepreneurship education. Big data analytics use multimodal data to improve the effectiveness of entrepreneurship education and examine entrepreneurial opportunities. In entrepreneurship context, big data analytics analyzes entrepreneurial projects with low costs and high effectiveness to facilitate the success of venture creation. Machine learning releases educators' burdens and improves the accuracy of the assessment. However, AI applied in entrepreneurship education needs more sophisticated pedagogical designs in diagnosis, prediction, intervention, prevention and recommendation, combined with specific entrepreneurial learning content and entrepreneurial procedure, obeying entrepreneurial pedagogy.

The limitations of the research and methodology are clear but difficult to avoid because of objectiveness: the current number and quality of published literature relevant to AI applied in entrepreneurship education is rare, although the research extended nine months after the launching of big language model, leading to the adoption of scoping review that is difficult to make a systematic review or meta-review and operate a highly robust study. Meanwhile, the

pedagogical design seldom offers useful hints for those of education, because the majority of explanation and application of AI is generic and unclear, not detailed. In the context of advancing scholarly inquiry, an augmented volume of publications pertaining to AI in the domain of entrepreneurship education prompts the adoption of a methodical examination process. The authors will undertake a comprehensive review, adhering to the delineated procedures outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Subsequently, the research team will methodically incorporate a specific AI methodology, exemplified by machine learning, into the pedagogical framework of entrepreneurial education. The ensuing analysis will involve a systematic evaluation of outcomes, with a concurrent emphasis on refining the efficacy of the implemented AI techniques.

AI presents novel opportunities for addressing extant challenges in the realm of education. This scholarly endeavor initiates an exhaustive inquiry into the academic landscape delimiting the engagement of AI in the sphere of entrepreneurship education. It serves as a catalyzing force, impelling entrepreneurs, educators, policy-makers and their respective stakeholders to initiate strategic endeavors and propel the advancement of theoretical frameworks pertinent to the application of technology in entrepreneurship education and training.

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