

## Artificial intelligence and entrepreneurship education: A paradigm in Qatari higher education institutions after covid-19 pandemic

Menahi Mosallam Alqahtani<sup>a\*</sup>

<sup>a</sup>Management Department, Management Science, Community College of Qatar, Qatar

CHRONICLE

ABSTRACT

### Article history:

Received: December 2, 2022  
Received in revised format: January 29, 2023  
Accepted: March 4, 2023  
Available online: March 4, 2023

### Keywords:

Artificial Intelligence  
Entrepreneurship Education  
Higher Education Institutions  
Covid-19  
Qatar

The spread of the Covid-19 pandemic and the interruption of personal communication between the teacher and students in higher education led to the need for finding solutions that enable the continuation of the educational process and ensure access to accurate information that improves the level of human capital in dealing with dynamic environments. Therefore, this research sought to analyse the impact of the application of artificial intelligence in entrepreneurship education in Qatari higher education institutions after the Corona pandemic. The measurement of artificial intelligence was based on dimensions (machine learning, natural language processing, expert systems, and machine vision), while entrepreneurship education was measured by dimensions of (entrepreneurial cognition, entrepreneurial competence, and innovation spirit). The research followed an experimental quantitative approach based on collecting data from Qatari university students using a questionnaire developed for the research purpose. Hence, the convenience sample used in the research was composed of 402 students from various Qatari universities, which represents a response rate of 67% from the distributed questionnaires. The statistical analysis of the research data was based on the covariance-based structural equation modeling technique (CB-SEM). The results of the research indicated that all dimensions of artificial intelligence had a positive impact on entrepreneurial education, with the highest impact being machine vision and the lowest impact being natural language processing. Accordingly, the results of the research revealed the need to invest in technological capabilities for supporting the educational system aimed at generating innovative human resources capable of coping with the uncertainty of the work environment.

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## 1. Introduction

In the contemporary economic reality characterized by volatility and instability, entrepreneurship is one of the pivotal aspects for improving sustainable development and supporting the local economy (Neumann, 2022). Numerous empirical studies have proven the critical role of entrepreneurship in creating job opportunities (Al-Alawi et al., 2022), increasing economic efficiency based on innovative models (Zhao et al., 2020), and improving social welfare (Tyagi, 2023). In this regard, governments have devoted significant efforts and resources to developing the entrepreneurial skills of higher education graduates to engage them in continuous development. Entrepreneurship education using cutting-edge curricula stimulates students' creative attitudes and behaviours to enhance their ability to interact with the dynamic business environment (Dana et al., 2021). Moreover, Iwu et al. (2021) stated that entrepreneurial education represents the first step towards increasing the chances of success and competitiveness of projects, along with producing future leaders who can advance sustainable economic development.

\* Corresponding author.

E-mail address: [dr.menahi.alqahtani@gmail.com](mailto:dr.menahi.alqahtani@gmail.com) (M. M. Alqahtani)

ISSN 2561-8156 (Online) - ISSN 2561-8148 (Print)

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doi: 10.5267/j.ijds.2023.3.002

Since the advent of the concepts of the Fourth Industrial Revolution and the repercussions of the Covid-19 pandemic, academics' interest in defining the role of technological progress on the results of the work of institutions has increased (Valencia, 2023). Indeed, the Covid-19 pandemic changed the methods of dealing and human interaction, especially in Middle Eastern societies where the culture of physical expressions prevails, so interest in social distancing culture has increased to limit the negative effects of the pandemic (Ashraf & Goodell, 2022). Accordingly, many institutions, on top of their higher education institutions, have made substantial changes to their teaching protocols. Artificial intelligence played a pivotal role in this change by converting many education procedures from the traditional system that requires physical interaction between the student and the lecturer to an electronic one that relies entirely on artificial intelligence technologies (Islam et al., 2022). The application of artificial intelligence techniques in the educational field represented a clear challenge for many countries as a result of limited resources, on the one hand, and the prevailing culture on the other hand (Owoc et al., 2021). However, these technologies resulted in many advantages that should be taken into account to ensure the continuity of the educational system and reduce routine procedures that require the draining of human resources (Seo et al., 2021).

This manuscript focuses on studying the effects of applying artificial intelligence techniques in supporting entrepreneurship education in Qatari higher education institutions from the perspective of students after the Covid-19 pandemic. Therefore, the current research contributes to supporting the proposed scenarios about strengthening the educational system in Qatar to achieve world-class standards. Moreover, it provides a framework supported by empirical evidence on student interaction with teaching methods based on artificial intelligence technologies. Furthermore, it provides insight into the level of adopting an entrepreneurship education strategy in Qatari higher education institutions to produce human capital at an advanced level of awareness of the conditions of the business environment and the skills of identifying and seizing innovative opportunities from the business environment. This manuscript is organized to provide an integrated theoretical framework on artificial intelligence and entrepreneurial education and the hypothesized relationship between them. Followed by an explanation of the methodology used and the results related to data analysis. The final section of the manuscript was a conclusion and a set of theoretical and applied implications, together with directions for future studies.

## 2. Theory and Hypotheses

### 2.1. Artificial intelligence

The concept of artificial intelligence has been widely debated since it was first introduced in the academic field in the mid-1990s. The reason for this controversy is the connection of the concept with the technological elements, which are characterised by rapid development that made it difficult to find a comprehensive formula for artificial intelligence (Muda et al., 2022; Knox, 2020). Moreover, some researchers attribute the reason behind the artificial intelligence controversy to the expansion of the specialized and cognitive fields associated with this concept, such as neuroscience, linguistics, and software engineering, which are considered to have accelerated evolutionary behaviour (Chen et al., 2020; Akour et al., 2023; Hinojo-Lucena et al., 2019; Al-Rwaidan et al., 2023). However, many definitions of artificial intelligence emerged, as Enholm et al. (2022) stated that artificial intelligence revolves around the ability of machines to comprehend, sense, and act in a manner close to human behaviour. Chen et al. (2020) referred to this concept as the ability of a particular system to analyze and interpret the huge amount of data entered accurately and benefit from them in finding formulas for self-learning and decision-making on behalf of humans. Mikalef and Gupta (2021) mentioned that artificial intelligence represents the ability of computerized systems to carry out human tasks, whether they are based on specific rules or not.

Since the emergence of the Covid-19 pandemic, the core significance of applying artificial intelligence to support the educational process has emerged. Generally, the traditional education framework based on face-to-face communication between the lecturer and students changed to a more advanced framework based on blending human and robotic capabilities through artificial intelligence systems (Harahap et al., 2022; Gao et al., 2021). Artificial intelligence contributes to helping lecturers automate routine tasks, along with evaluating learning patterns to improve the curricula used (Zahran et al., 2023; Goksel and Bozkurt, 2019). Moreover, technologies based on artificial intelligence provide the necessary support for students to develop their skills and abilities outside the classroom and also bridge the gap resulting from the lack of qualified lecturers in some novel disciplines (Knox, 2020). During and after the Covid-19 pandemic, Ahmad et al. (2022) expressed that artificial intelligence played a fundamental role in distance education systems by creating smart platforms to automatically respond to student educational inquiries and provide extensive knowledge about study materials through simulation systems and virtual reality technologies.

The main goal of artificial intelligence is centered on defining patterns of computational learning and finding prediction models that simulate human capabilities using big data that humans cannot understand (Vaishya et al., 2020; Attiany et al., 2023). Artificial intelligence has undergone waves of development that contributed to defining two main sub-fields: (i) the technical field of artificial intelligence, for example, machine learning using complementary software, and (ii) the logical field of artificial intelligence such as neural networks to simulate human behaviour (Rahamneh et al., 2023; Mohammad et al., 2022; Chen et al., 2020). The dimensions of artificial intelligence, i.e., machine learning, natural language processing, expert systems, and machine vision, were identified in this research based on studies (Al-Alwan et al., 2022; Enholm et al., 2022; Al-Zyadat et al., 2022; Gray et al., 2022). Machine learning has been defined as algorithms designed to deal with big data to extract self-development information for prediction software without explicit software intervention from humans (Tariq et al., 2022; Al-Shormanana et al., 2021; Chen et al., 2020; Al-Nawafah et al., 2022). Natural language processing is the ability of machines to understand verbally and behaviorally input human instructions and reactions (Mikalef & Gupta, 2021). Expert

systems refer to enabling a machine to make decisions on behalf of humans through a cognitive framework developed using machine learning (Islam et al., 2022). Machine vision revolves around the automated ability to analyze and output data in the form of images and graphics by understanding the nature of color and shape overlap and their implications (Enholm et al., 2022).

## 2.2. Entrepreneurship education

Entrepreneurship learning is a critical component of an effective learning journey to match the requirements of the work environment, as it results in enhancing students' causal and linear understanding of strategic thinking and their involvement in the dynamic business environment (AlTaweel & Al-Hawary, 2021; Wardana et al., 2020 Al-Hawary & Al-Syasneh, 2020). Many universities and educational institutions have included the principles of entrepreneurship within the educational plans of their students to enable them to start their own projects, understand the changing dynamics within turbulent environments, and then seize successful opportunities (Iwu et al., 2021). The theoretical basis for entrepreneurship education is based on the two theories of motivational planned behaviour and knowledge-sharing (Nazari & Abd Rani, 2022). The first theory allows monitoring the entrepreneurial intention of students and predicting associated behaviours and the degree of control over self-efficacy. Whereas the knowledge-sharing theory of entrepreneurship is concerned with studying the mechanisms of active education based on the cognitive and mental skills gained as a result of empirical experience to create a generation that can lead the path of entrepreneurship towards prosperity (Ratten & Usmanij, 2021).

Entrepreneurship education has been defined as an educational approach that focuses on enhancing the financial independence of students and motivating them to engage in businesses that lead to the creation of new job opportunities (Bell & Bell, 2020). Moreover, Cui et al. (2021) considered that entrepreneurship education is based on training students to invest their innovative capabilities in projects that produce additional profits and improve their sense of self-respect and discipline. In fact, the strategic goal of entrepreneurship education is to prepare graduates who could contribute effectively to the development of their local economy and achieve sustainability (Nazari & Abd Rani, 2022). According to Dana et al. (2021), entrepreneurship education is related to three aspects of students' personality: (i) behavioural, (ii) mental, and (iii) situational. The behavioural aspect of entrepreneurship education involves identifying and empowering students to determine the appropriate identity to launch their project, the decision-making process, and communication with stakeholders (Jena, 2020).

The mental aspect of entrepreneurship education contributes to refining students' cognitive abilities and developing innovative skills (Rădulescu et al., 2020). As for the situational aspect of entrepreneurship education, it highlights the mechanism of dealing with business environment risks and unfavourable conditions to identify possible opportunities and seize them before others (Cui et al., 2021). In this study, the three-dimensional model of entrepreneurship education consisting of entrepreneurial cognition, entrepreneurial competence, and innovation spirit was relied upon. Entrepreneurial cognition emphasizes the need to provide students with the mental skills necessary to receive information from the business environment and process it to make objective decisions related to a specific investment opportunity (Grosholz et al., 2020). Entrepreneurial competence is a set of capabilities acquired from the educational system and related to coordinating, managing, and directing organizational resources to exploit a favourable opportunity (Wang et al., 2019). The innovation spirit focuses on supporting the personal innovative features and new ideas presented by students and encouraging them to constantly develop and exploit technological capabilities to find novelty solutions to current problems (Bian et al., 2021).

## 2.3. Artificial intelligence and entrepreneurship education

Our patterns of thinking, behaviour and the way we interact have changed dramatically since the use of digital technology enhanced by artificial intelligence. In fact, this concept has developed radically in recent years, as the actual use of robots is linked to artificial neural networks and deep learning (Chen et al., 2020). The educational system could benefit from this progress through an adaptive learning approach based on meeting individual educational needs using interactive platforms with robots and other artificial intelligence tools (Enholm et al., 2022). In the context of special education, Garg and Sharma (2020) conducted a study to determine the impact of artificial intelligence applications on supporting the educational system for people with audiovisual and motor special needs. The results of the study showed that the applications of artificial intelligence have a fundamental role in enhancing the learning of people with special needs. More comprehensively, Owoc et al. (2021) identified the strategic benefits and challenges of applying artificial intelligence systems to all stakeholders in the educational sector. The results confirmed that students benefit from these systems in planning their educational careers and scheduling their lectures, along with the benefits obtained by attendees from reducing the burden of routine activities. These findings and conclusions were supported by (Limna et al., 2022).

The impact of artificial intelligence in the context of e-learning on social anxiety and computer anxiety in universities in the Gulf region was examined (Almaiah et al., 2022). The results of the study were contrary to what was expected, as it showed that most students still resist the use of digital technologies enhanced by artificial intelligence in receiving information due to factors related to motivation, satisfaction, and self-efficacy from these technologies. Moreover, Seo et al. (2021) revealed the crucial role of artificial intelligence in supporting students' individual abilities and directing them to innovative activities. The results of the study showed that modern technologies based on artificial intelligence systems enable predicting the entrepreneurial behaviour of students and their ability to generate creative ideas that establish pioneering projects. A systematic review was implemented by Zawacki-Richter et al. (2019) to demonstrate the role of artificial intelligence in supporting higher education efforts using a qualitative review of 2656 published research. The results of this review confirmed the enhanced role

of artificial intelligence in providing the business environment with graduates with a high level of entrepreneurship and the ability to model and evaluate innovation prediction models through the experiences gained from smart education systems. Accordingly, the following research hypotheses were proposed to identify the impact of the dimensions of artificial intelligence on entrepreneurship education in Qatari higher education institutions:

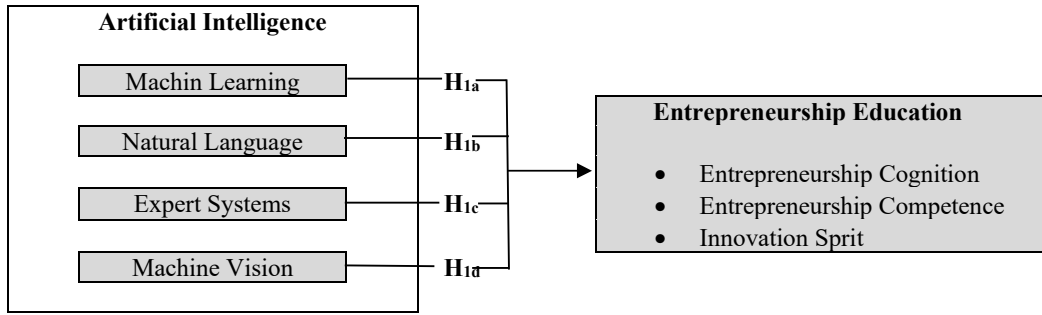
**H<sub>1a</sub>:** *Machine learning has a positive impact on entrepreneurship education.*

**H<sub>1b</sub>:** *Natural language processing has a positive impact on entrepreneurship education.*

**H<sub>1c</sub>:** *Expert systems has a positive impact on entrepreneurship education.*

**H<sub>1d</sub>:** *Machine vision has a positive impact on entrepreneurship education.*

Through the research hypotheses, it is possible to depict the conceptual framework shown in Fig. 1 to demonstrate the effect of the artificial intelligence dimensions on entrepreneurship education in Qatari higher education institutions.



**Fig. 1.** Conceptual framework

**3. Methods**

*3.1. Population and sampling*

The target population in this research revolved around students of higher education in Qatari universities. In accordance with the state's vision for 2030, Qatar seeks to provide the best educational opportunities for students at the regional and international levels by focusing on intensive technological application and cooperation with prestigious international academic institutions. Based on Mohamed et al. (2022), the higher educational qualification represents the first step for young people to engage in practical and professional life, along with providing professional human capital that could contribute to building the local community and achieving sustainable development by investing the acquired knowledge. To accomplish this comprehensive goal, Qatar has established an educational system consisting of 10 government educational institutions, 6 military institutions, 9 community institutions, and 9 private institutions. These institutions contribute by submitting 366 academic programs in various disciplines for about 39 thousand students.

**Table 1**  
Demographic profile of respondents (N= 402)

Variables	Categories	n	%
Gender	Male	233	57.9
	Female	169	42.1
Educational stage	Diploma	74	18.4
	Bachelor	266	66.2
	Master	40	9.9
	PhD	22	5.5
Age group	18-24	224	55.7
	25-29	123	30.6
	30-34	37	9.2
	35 and older	18	4.5
Major	Engineering and Technology	118	29.4
	Medicine and Pharmacy	98	24.4
	Education and Social Sciences	38	9.6
	Business and Economics	82	20.3
	Mathematics and Sciences	22	5.5
	Sharia and Islamic Studies	32	7.9
	Other	12	2.9

The conduction of the comprehensive survey approach in such cases is considered inefficient as a result of the researcher's inability to reach the population members, along with the time and financial constraints associated with the research (Mahmud et al., 2020). Therefore, the sampling approach was relied upon to collect primary data related to the impact of artificial intelligence on entrepreneurship education in Qatari higher education institutions. Convenience samples were used by distributing the research tool to 600 students in Qatari universities. Bougie and Sekaran (2019) stated that the sufficiency of sampling could be achieved in unlimited populations when collecting 384 valid responses. The responses received were 431 responses

that included 29 incomplete ones and were excluded from the final sample of the current research. Therefore, the final sample was composed of 402 responses which constitute a 67% participation rate of the total distributed. Table 1 lists the results of the demographic analyzes of the respondents.

### 3.2. Variables and Measurements

Primary data related to the impact of artificial intelligence on entrepreneurship education in Qatari higher education institutions was collected through a self-administered questionnaire. This questionnaire was designed electronically and disseminated on social networking for students at Qatar universities in order to provide the time flexibility to accurately respond to it. The data collection process was extended within the period December 28, 2022, and February 5, 2023, after obtaining the approval of the official authorities of the universities. The research questionnaire included a cover letter and three main sections. The cover letter explained the aim of the research and emphasized the confidentiality of the data and the mechanisms of storing and using it. The first section was for the categorical variables used to determine the demographic characteristics of the sample, i.e., gender, educational stage, age group and major. The second and third sections were for the research variables in which students were asked to evaluate their items according to a five-point Likert scale with a minimum (1) strongly disagree and a maximum (5) strongly agree.

**Artificial intelligence:** it was defined procedurally as the ability of Qatari universities to invest in contemporary technology related to the Internet and smart analytical capabilities to develop educational curricula and facilitate the flexible education process. Artificial intelligence was the independent variable of research whose items were developed in proportion to Gray et al. (2022). This variable consisted of four first-order variables. Machine learning was measured by four items “the university provides interactive websites that could be auto-customized according to students' requirements”. Natural language processing was measured using four items “the university website enables student voice recognition and speech analysis to identify and schedule desired services”. Expert systems were measured through four items “the university's website could solve problems and suggest possible solutions based on knowledge dialogue with the student”. Machine vision was measured through four items “the university website could analyse the graphics and images that the student enters to extract the required information”.

**Entrepreneurship education:** it was defined procedurally as providing Qatari universities with educational curricula and complementary training courses that improve the creative ability of students and increase their entrepreneurial knowledge. Entrepreneurship education was the dependent variable of current research whose items were developed according to Bian et al. (2021). This variable consisted of three first-order variables. Entrepreneurial cognition was measured by four items “the university curricula include real-world examples that enhance the awareness of the local and regional business context”. Entrepreneurial competence was measured using four items “the university's curricula provide core competencies for entrepreneurship along with specialized courses in organizing and managing innovative projects”. Innovation spirit was measured through four items “the university supports the foundations of scientific research that produces creative ideas that contribute to community development”.

### 3.3. Analytical processes

This research used an analytical method through covariance-based structural equation modeling (CB-SEM) to examine the impact of artificial intelligence on entrepreneurship education in Qatari higher education institutions. This method is widely conducted in similar research, as it enables an accurate determination of the causal relationship between the independent variable and the dependent variable according to the maximum likelihood approach (Mohammad et al., 2020; Usakli & Rasoolimanesh, 2023; Boudlaie et al., 2022; Mia et al., 2019). The application of the CB-SEM method requires an initial test of the validity and reliability of the primary data collection instrument. Moreover, extracting the effect coefficients to evaluate the hypothetical relationship. The results of the research were also supported by extracting results of the demographic analysis of the respondents along with the results of the descriptive analysis to clarify the adoption of artificial intelligence technologies and entrepreneurship education in Qatari universities.

## 4. Findings

### 4.1. Measurement model evaluation

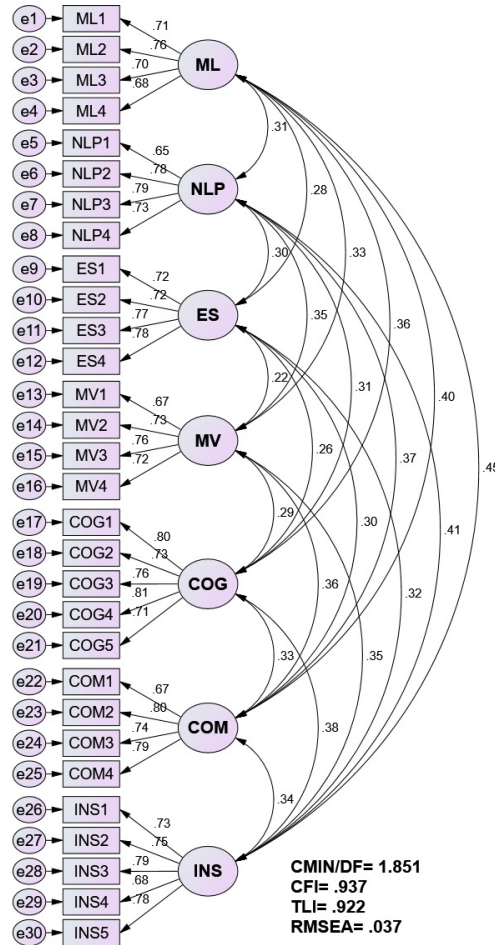
Several techniques were used to determine the validity and reliability of the measurement model for the impact of artificial intelligence on entrepreneurial education before proceeding with the application of structural equation modeling. Table 1 presents the results achieved from this test in addition to the results of descriptive statistics. The validity of the model was measured by convergent validity and discriminant validity. Determining the convergent validity was based on factor loads on the latent constructs (FLR) and the average variance extracted (AVE). While the maximum shared variance (MSV) and the square root of the average variance extracted were used to evaluate the discriminant validity. Besides, reliability was measured using the McDonald's Omega coefficient which specifies the composite reliability (CR) of the measurement model.

**Table 2**  
Reliability, validity, and descriptive statistics

Variables	M	SD	FLR	AVE	MSV	CR	ML	NLP	ES	MV	COG	COM	INS
ML	3.57	0.858	0.684-0.765	0.514	0.374	0.809	<b>0.717</b>						
NLP	3.49	0.795	0.652-0.792	0.551	0.402	0.830	0.414	<b>0.742</b>					
ES	3.62	0.881	0.717-0.781	0.561	0.387	0.836	0.502	0.466	<b>0.749</b>				
MV	3.71	0.905	0.675-0.758	0.522	0.381	0.814	0.486	0.425	0.443	<b>0.723</b>			
COG	3.75	0.911	0.707-0.813	0.585	0.432	0.876	0.662	0.682	0.603	0.611	<b>0.765</b>		
COM	3.65	0.935	0.667-0.798	0.564	0.419	0.837	0.635	0.624	0.618	0.675	0.524	<b>0.751</b>	
INS	3.73	0.906	0.681-0.790	0.559	0.378	0.864	0.598	0.605	0.641	0.630	0.587	0.552	<b>0.748</b>

Note: ML: machine learning, NLP: natural language processing, ES: expert systems, MV: machine vision, COG: entrepreneurial cognition, COM: entrepreneurial competence, INS: innovation spirit, FLR: factor loadings range, bold fonts in the table are the square root of AVE.

The results of Table 1 indicated that the values of factor loadings on the latent constructs of the research were within the range (0.652-0.813). Shrestha (2021) confirmed that values of factor loadings above the lower threshold of 0.50 are indicative of factor retention without deletion. Accordingly, all factors contributing to the formation of the measurement model of the impact of artificial intelligence in entrepreneurship education were retained. Moreover, the average variance extracted (AVE) for all latent constructs in the measurement model was greater than the lower limit of 0.50 (Rubia, 2019). Therefore, the measurement model used in the research was considered to have convergent validity (Dos Santos & Cirillo, 2021; Mukhlis et al., 2022). On the other hand, the results of Table 1 indicated that MSV is smaller than AVE for all constructs, along with the square root of AVE which exceeds all correlation coefficients between other constructs. Rönkkö and Cho (2022) stated that these conclusions are evidence of the discriminant validity. Concerning reliability, the results reported that the McDonald's Omega coefficients were within the range (0.809-0.876), thus exceeding the minimum composite reliability (CR) of 0.70 (Bell et al., 2023). Hence, the measurement model for this research has obtained an appropriate level of composite reliability. In addition to the reliability and validity tests of the measurement model, in this research, constructional validity was evaluated based on the goodness of fit indicators shown in Fig. 2.



**Fig. 2.** Confirmatory factor analysis results

The results of Fig. 2 show that the modified chi-square index (CMIN/DF) was 1.851 which is lower than the upper threshold of the ratio of chi-squared to degrees of freedom of 3 (Goual & Yousof, 2020; Mohammad, 2020). The comparative fit index (CFI) and Tucker–Lewis index (TLI) were respectively 0.937 and 0.922, which means that they were above the lower bound

of those indices of 0.90 (Xia & Yang, 2019). As for the root mean square error of approximation (RMSEA), whose value was 0.037, it obtained acceptable levels, being less than 0.08 (Shi & Maydeu-Olivares, 2020; Mohammad, 2019). Based on these results, the research model was judged to be constructional valid.

4.2. Descriptive statistics

The results of the descriptive analysis are reported in Table 1. The results confirm that the application of artificial intelligence in Qatari universities was moderate. Moreover, all variables of artificial intelligence were at a moderate level except for machine vision (M= 3.71, SD= 0.905), which was at a high level and ranked first. The second rank was for expert systems (M= 3.62, SD= 0.881), followed by the third rank for machine learning (M= 3.57, SD= 0.858), and then natural language processing (M= 3.49, SD= 0.795) in the fourth and last rank. In contrast, entrepreneurship education in Qatari universities was at a high level. Entrepreneurial cognition (M= 3.75, SD= 0.911) ranked first with a high level, followed by innovation spirit (M= 3.73, SD= 0.906) in second rank with the same level of relative importance. However, entrepreneurial competence (M= 3.65, SD= 0.935) was ranked third but at a moderate level. The results of multicollinearity using correlation coefficients demonstrated that the level of correlation between the variables of artificial intelligence was moderate and ranged within the domain (0.414-0.502). Gokmen et al. (2022) indicated that the correlation coefficients between the independent variables that do not exceed 0.80 are evidence that the data do not include multicollinearity and each of them expresses an autonomic parameter. Therefore, it could be noted that the data of the current research did not include multicollinearity between the variables of artificial intelligence.

4.3. Hypotheses test

The relationship between the research variables, i.e., artificial intelligence and entrepreneurship education, was estimated by structural equation modeling (SEM) applied using version 22 of the AMOS program. SEM enables us to determine whether the model used represents the research data optimally as well as if the latent constructs are linked together correctly (Hair et al., 2019). Figure 3 illustrates the parameters used to validate the model along with the weights of the extracted paths to test the impact of artificial intelligence dimensions on entrepreneurial education.

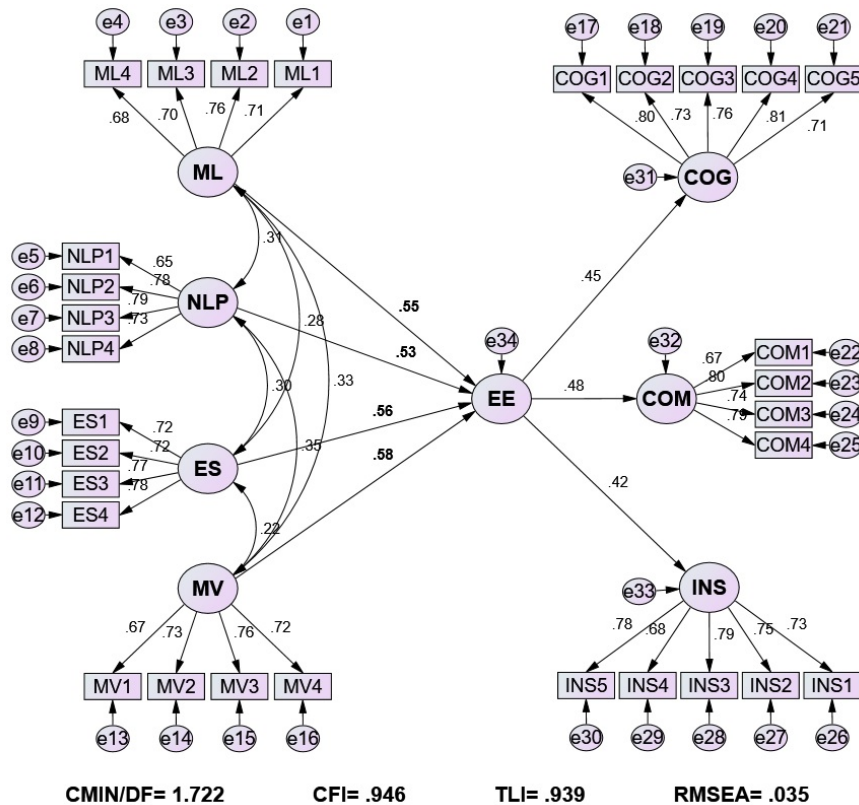


Fig. 3. SEM for the impact of artificial intelligence on entrepreneurship education

The results of Fig. 3 show that the modified chi-square index (CMIN/DF) was 1.722 which is lower than the upper threshold of the ratio of chi-squared to degrees of freedom of 3 (Goual & Yousof, 2020). The comparative fit index (CFA) and Tucker–Lewis index (TLI) were respectively 0.946 and 0.939, which means that they were above the lower limits of those indices of 0.90 (Xia & Yang, 2019). As for the root mean square error of approximation (RMSEA), whose value was 0.035, it obtained

acceptable levels, being less than 0.08 (Shi & Maydeu-Olivares, 2020). Based on these results, the structural model was considered to be valid. Table 2 lists the path parameters used to assess the impact of artificial intelligence dimensions on entrepreneurship education.

**Table 3**  
Results of path coefficients

Hypotheses	Paths	B	S.E.	$\beta$	t	p
H1a	ML $\rightarrow$ EE	0.566	0.073	0.550	7.753	0.000
H1b	NLP $\rightarrow$ EE	0.541	0.076	0.534	7.118	0.000
H1c	ES $\rightarrow$ EE	0.584	0.075	0.565	7.786	0.000
H1d	MV $\rightarrow$ EE	0.624	0.071	0.582	8.789	0.000

Note: ML: machine learning, NLP: natural language processing, ES: expert systems, MV: machine vision, EE: entrepreneurship education.

Table 2 reports the results of testing the research hypotheses using the SEM technique. The first hypothesis (H1a) argued that machine learning has a positive impact on entrepreneurship education. This hypothesis was supported based on the statistical values ( $\beta = 0.550$ ,  $t = 7.753$ ,  $p = 0.000$ ) and the probability value which was less than 0.05. This means that entrepreneurship education in Qatari higher education institutions could be enhanced by 0.550 when increasing one unit of machine learning usage. The second hypothesis (H1b) expressed that natural language processing has a positive impact on entrepreneurship education. This hypothesis was supported based on the statistical values ( $\beta = 0.534$ ,  $t = 7.118$ ,  $p = 0.000$ ) and the probability value which was less than 0.05. This refers that entrepreneurship education in Qatari higher education institutions could be developed by 0.534 when increasing one unit of natural language processing applied.

The third hypothesis (H1c) delicate that expert systems have a positive impact on entrepreneurship education. This hypothesis was supported based on the statistical values ( $\beta = 0.565$ ,  $t = 7.786$ ,  $p = 0.000$ ) and the probability value which was less than 0.05. This means that entrepreneurship education in Qatari higher education institutions could be enhanced by 0.565 when increasing one unit of expert systems usage. The fourth hypothesis (H1d) indicated that machine vision has a positive impact on entrepreneurship education. This hypothesis was supported based on the statistical values ( $\beta = 0.582$ ,  $t = 8.789$ ,  $p = 0.000$ ) and the probability value which was less than 0.05. In another word, entrepreneurship education in Qatari higher education institutions could be improved by 0.582 if increasing one unit of machine vision was applied.

## 5. Conclusions

The manuscript aimed to test the impact of artificial intelligence on entrepreneurship education from the perspective of students in Qatari higher education institutions. The study data included 402 student responses from various academic disciplines to represent the study population objectively and accurately. The results confirmed that the level of application of artificial intelligence in Qatari higher education institutions was moderate in proportion with (Garg & Sharma, 2020; Limna et al., 2022). Hence, higher education institutions seek to gradually implement the digital transformation plan to enable students to engage positively with the fundamental changes that this transformation produces. Moreover, the moderate level of adoption resulted from the requirements of some scientific disciplines to conduct face-to-face meetings with lecturers to make the most of their expertise and experience. On the other hand, it is noted that there is a high percentage of respondents belonging to medicine and pharmacy disciplines that affected the general level of artificial intelligence, as changes in teaching protocols did not include these disciplines due to their primary role in supporting the Qatari health system and the requirements of discipline by conducting experimental trainings.

In contrast, the level of entrepreneurship education was high in Qatari higher education institutions, as this level corresponds with (Wardana et al., 2020; Rădulescu et al., 2020). Accordingly, it is possible to deduce the orientations of the decision-makers in these institutions to produce local human capital that possesses a set of cognitive and applied capabilities and skills in the business environment. Furthermore, these institutions seek, through the development of educational curricula that include the foundations of entrepreneurship, to strengthen their regional position and reach advanced levels globally, based on stimulating the principles of active education linked to knowledge sharing. On the other hand, it could be noted that Qatari educational institutions adopt a vision that is in line with the state's 2030 vision, which includes promoting sustainable development by training graduates to create business models that reduce negative social, economic, and environmental impacts.

The results also demonstrated that the dimensions of artificial intelligence had a positive impact on entrepreneurship education, according to the student's perspectives in Qatari higher education institutions. The greatest impact was for machine vision, while the lowest one was for natural language processing. Hence, Qatari higher education institutions focus on providing software that could handle graphics and shapes to support students' imaginative ability and stimulate their mental creativity. Higher education institutions were investing in the potential of expert systems to reduce human bias in the decision-making process and encourage students to develop their own skills in the local business environment. Moreover, machine learning, one of the dimensions of artificial intelligence, allows increasing the flexibility of e-learning platforms and their ability to access similar platforms to enhance the experiential experience of students on topics related to entrepreneurship and enterprise startup. However, there was a limitation in the use of natural language processing within the virtual reality of Qatari higher education institutions due to the novelty of these systems and their compatibility with the beliefs and values of the local community believes, which led to their lack of use to obtain information related to entrepreneurship.



## 6. Implications and Limitations

A set of theoretical and applied implications derived from the results of the current research were provided. In theory, this research contributed to strengthening the technology acceptance theory in the education field, which represents the cornerstone of the knowledge economy by providing the labour market with technologically qualified human resources capable of dealing with the dynamic business environment. Moreover, it presents a proposed framework supported by empirical results on the ability of educational institutions to apply contemporary technology to enhance the entrepreneurial business environment through curricula and courses that increase the ability and competence of students to innovate.

From an applied point of view, this research provides decision-makers in Qatari educational institutions with objective foundations about the application of artificial intelligence, especially after the covid-19 pandemic and the lessons learned from that experience, to improve cooperation and knowledge sharing at local and international levels. Moreover, the research motivates officials in the Qatari Ministry of Education to adopt a contemporary approach to promote the principles of entrepreneurship and develop educational curricula that help engage students in a volatile work environment that requires high levels of innovation. However, the research focuses on the necessity of adopting review and evaluation standards based on international criteria in order to determine the risks of exaggerating the application of artificial intelligence techniques in the educational field, as it limits the visual and applied communication between the teacher and the student, which is required by some disciplines.

Although the theoretical and practical implications provided by this research, it is not devoid of some research limitations that should be noted. Firstly, the research was conducted on Qatari higher education students who are aware of some artificial intelligence technologies. Therefore, future research could be conducted at lower educational levels to emphasize the results achieved and exclude the role of prior knowledge of artificial intelligence technologies. Secondly, the research data was collected based on a cross-sectional approach consisting of a limited size of respondents. Accordingly, we suggest implementing future studies using a longitudinal approach and with a larger sample size to determine the change in the level of effect over time and the different circumstances of the respondents. Thirdly, the study was applied to one of the important sectors contributing to the generation of qualified human resources who can engage in the Qatari labour market. Therefore, future research might take advantage of the opportunity to apply the research in other sectors, for example, the training and consulting sector. Last but not least, the current research examined the impact of artificial intelligence on entrepreneurship education in Qatari higher education institutions. Subsequent studies could examine the impact of artificial intelligence on other variables that contribute to enriching the outcomes of the education system, such as dynamic capabilities and core competencies.

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