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The Impact of Machine Learning and Artificial Intelligence on Entrepreneurial Skills Development: A Gender-Inclusive Analysis in Higher Education

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Abstract

Artificial Intelligence (AI) and Machine Learning (ML) are becoming deeply embedded in how students learn and generate ideas. Rather than acting as simple tools, they are now drivers of creativity and innovation. For aspiring entrepreneurs, engaging with these technologies can inspire new business ideas and approaches. However, little is known about how students actually perceive and apply AI and ML in developing entrepreneurial skills. This study explores that question by examining students' familiarity, beliefs, and concerns surrounding AI/ML through a structured survey. The findings provide insights into the influence of technological understanding on entrepreneurial development. Students generally demonstrated a modest understanding of ML and AI, yet expressed confidence in how these technologies could enhance both their learning and entrepreneurial abilities. Students in technical majors, such as IT and engineering, were more assured in their belief that AI has real-world applications in entrepreneurship. However, ethical concerns (40%) and technical challenges (35%) indicate significant barriers. Moreover, female students, particularly those in advanced academic years, showed a stronger conviction in AI's ability to support entrepreneurial development than their peers, with mean scores of 3.6 for 2nd-year females and 3.9 for 4th-year females, exceeding the overall mean of 3.5. The obtained results suggest that both gender and the level of academic experience influence how students perceive AI's role in building entrepreneurial capacity.

Keywords: Machine Learning, Artificial Intelligence, Entrepreneurial Skills, Gender, Higher Education.

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1 Introduction

Artificial Intelligence (AI) and Machine Learning (ML) are becoming part of how students explore ideas and engage with learning (Ganesan et al., 2025). These tools are increasingly linked to creative exploration and the pursuit of personal projects. For students with entrepreneurial ambitions, understanding these technologies could inspire new ideas and practical ventures Guo (2024). However, there's a lack of research about how AI and ML actually influence entrepreneurial thinking in academic environments (Wu & Margarita, 2024). This study looks to address that by examining students' knowledge, viewpoints, and hesitations about AI and ML using a detailed survey. Therefore, the main research questions are:

1. To what extent do students' knowledge of AI/ML and entrepreneurial concepts shape their confidence in the technologies' role in enhancing entrepreneurial capabilities?
2. What are the key factors that predict students' entrepreneurial skills, and how do they vary cross different demographics?
3. What are the primary concerns and challenges students face regarding the use of ML/AI in entrepreneurship, and how can these challenges be addressed?

Through addressing the research questions, we hope that this study will not only contribute in expanding our understanding of the implication of the ML/AI and the entrepreneurship but also provide practical guidance for educators, policymakers, and institutions. To bridge this lack of scholarly insight, the present work explores students' knowledge of AI and ML, their expectations, and their apprehensions using a detailed survey to examine their influence on entrepreneurial growth (Kasturi et al., 2020).

By turning research into action, we aim to support informed decision-making that enhances innovation and empowers future entrepreneurs.

The rest of this paper is structured as follows. Section 2 presents a comprehensive review of related studies and identify their gaps and limitations our research is going to address. Section 3 introduces the methodological framework which comprises of the characteristics of selected population and sample, the design and implementation of the questionnaire, and the analytical techniques used to interpret the collected data. Section 4 presents the main findings of the study, accompanied by a thorough discussion of the results. This section concludes with the research questions that have been addressed through this study. Finally, Section 5 presents a conclusion summarizing the key insights and contributions of the study, along with actionable recommendations for future research directions.

2 Literature Review

Entrepreneurship has become a significant trend in higher education, equipping students with the knowledge and skills to start their own businesses. Entrepreneurial education focuses on fostering a culture of entrepreneurship, creating job opportunities, addressing youth unemployment, and enhancing individuals' economic and social conditions. These efforts ultimately boost national productivity and drive comprehensive economic development (Ramakrishnan & Mahadevan 2025).

In response to these benefits, universities are increasingly incorporating entrepreneurial thinking into their strategic plans. By fostering an environment that emphasizes creativity and innovation, institutions aim to surpass others and enhance their competitive capacity (Issa, 2020; Mohamad, 2023).

The concept of entrepreneurship began in economics in 1755 with Richard Cantillon, who emphasized project sustainability. Over time, this idea transitioned into the educational sector, with entrepreneurial universities emerging in the U.S. in the late 1990s and spreading to Europe and Asia in the early 21st century. These universities support innovation ecosystems, promote business entrepreneurship, and contribute to economic and social development. Advanced nations acknowledge the critical role of higher education in driving development and achieving sustainable progress within societies (Al-Ruwaili, 2021; Rababah, 2022).

The evolution of the term "entrepreneur" can be traced to Jean-Baptiste Say and earlier to Jean Luk Guyot, who in the early 19th century referred to entrepreneurs as individuals capable of reorganizing resources to generate value through creativity. Later, McClelland's seminal work The Achieving Society (1961) explored entrepreneurial behavior as driven by a need for achievement, highlighting psychological traits such as initiative and ambition. More recently, Barhooma, (2014) characterized student entrepreneurs as those who actively engage with entrepreneurial coursework, conceptualize innovative projects, cultivate relevant technical proficiencies, formulate viable business plans, and secure validation from institutional incubators (Barhooma, 2014). An entrepreneur initiates projects, introduces innovative ideas, and focuses on development, risk-taking, and profitability. Essential entrepreneurial traits identified by researchers include vision, self-confidence, enthusiasm, problem-solving skills, risk-taking, initiative, organizational skills, and various managerial, social, and psychological skills (Mahmoud, 2021).

Entrepreneurial skills encompass technical abilities (e.g., communication, writing, IT proficiency, data analysis), business management (e.g., decision-making, marketing, finance), personal attributes (e.g., creativity, perseverance, leadership), and interpersonal skills (e.g., teamwork, networking, persuasion) (Al-Sakarna, 2008; Tummala & Velagapaly, 2023). Entrepreneurs drive societal advancement by creating jobs, reducing unemployment, and using technology for community development. They embody optimism, pursue success through innovation, and positively impact society by achieving their goals and spreading positivity.

To establish a comprehensive understanding of how Machine Learning (ML) and Artificial Intelligence (AI) are influencing entrepreneurship—particularly in the realms of higher education and skill development—a thorough review of relevant studies has been conducted (Subbaiah et al., 2024). For instance, the work presented Chalmers et al., (2021), (Li et al., 2023) delves into the ways AI shapes entrepreneurial intentions among students. Their research provides compelling empirical evidence that the integration of AI technologies significantly enhances students' confidence in pursuing entrepreneurial ventures. While these studies offer valuable insights into the motivational drivers behind entrepreneurship, they do not explore the development of specific entrepreneurial skills, which is a central pillar of our research.

On a broader scale, Nambisan, (2017) and Autio et al., (2018) examine how digital technologies, including AI, are revolutionizing entrepreneurial ecosystems (Ahmed & Pandey, 2024). Their research emphasizes the role of innovation and collaborative networks in this transformation. Although these studies provide a macro-level perspective on the impact of AI, they do not address the practical challenges or skill-building processes that students encounter in academic environments. This gap in the literature is a key area our research aims to address.

Ethical considerations surrounding AI, such as data privacy and algorithmic bias, are another critical aspect highlighted (Floridi et al., 2018; Zuboff, 2019). These ethical challenges are particularly relevant to our study, as they influence students' perceptions and willingness to adopt AI in entrepreneurial

contexts. However, these studies do not specifically focus on educational settings or the development of entrepreneurial skills, leaving room for further exploration.

Table 1: A Summary for the Most Recent Studies Along with their Relation to this Research, Focus, Strengths, Limitations, and their Gaps need to be Addressed in this Research

Study	**Relation with this research**	**Limitations**	**Gaps addressed in this Research**
(Nambisan, 2017)	Digital Entrepreneurship and Innovation.	Focuses on established entrepreneurs, not students.	Focuses on students and their development of entrepreneurial skills.
(Obschonka et al., 2020)	AI and Entrepreneurship Education.	Does not explore the development of specific entrepreneurial skills.	Examines the development of entrepreneurial skills, not just intentions.
(Zuboff, 2019)	Ethical Challenges in AI-Driven Entrepreneurship	Not specific to entrepreneurship or education.	Addresses ethical challenges in the context of entrepreneurship education.
(World Economic Forum [WEF], 2020)	ML and AI in Skill Development.	Lacks empirical evidence and specific mechanisms.	Provides empirical evidence and explores specific mechanisms of AI's impact on entrepreneurial skills.
(Li et al., 2023)	AI and Entrepreneurial Intentions.	Does not explore the development of entrepreneurial skills.	Examines the development of entrepreneurial skills, not just intentions.
(Floridi et al., 2018)	AI and Ethical Entrepreneurship	Not specific to education or skill development.	Addresses ethical challenges in the context of entrepreneurship edu.
(Ghezzi et al., 2022)	AI and Entrepreneurial Skills.	Small sample size limits generalizability.	Provides empirical evidence and explores specific mechanisms of AI's impact on entrepreneurial skills.
(Autio et al., 2018)	AI and Entrepreneurial Ecosystems.	Does not address individual skill development.	Explores how AI influences entrepreneurial skills at the micro level.
(Luckin et al., 2022)	AI in Higher Education.	Not specific to entrepreneurship.	Focuses on the integration of AI into entrepreneurship education.
(Maritz et al., 2023)	AI in entrepreneurial education	Does not address individual skill development.	Focus on technical skills only; does not explore ethical or technical challenges.
(Goyal et al., 2024)	AI in collaborative, social entrepreneurship projects.	No empirical data in perceptions or knowledge levels.	Does not consider the gender differences in perceptions or knowledge levels.
(Smith & Nguyen, 2023)	Technology-driven entrepreneurship	Not specific to education or skill development.	No actionable solutions or institutional recommendations.
(Floridi et al., 2023)	Ethical AI literacy-related to education	Lacks empirical evidence	No empirical data on student concerns or adoption challenges
(Zhang et al., 2024)	AI and Entrepreneurial Skills.	Focus on only specific major not both technical and non-technical majors.	Does not examine how technical vs. non-technical majors perceive AI’s role in entrepreneurship.
(OECD, 2024)	AI and Entrepreneurship Education.	Does not address individual skill development.	No data on student-level challenges

In contrast, the World Economic Forum (World Economic Forum [WEF], 2020) and (Luckin et al., 2022) emphasize the potential of AI to enhance educational outcomes by linking it to personalized learning and skill development. Their findings resonate closely with our research objectives, as they demonstrate how AI can be integrated into educational curricula to foster entrepreneurial competencies. However, these studies lack detailed empirical evidence on the specific mechanisms through which AI influences skill development, which is a gap our research seeks to fill. However, Ghezzi et al., (2022) take a more focused approach by investigating how AI impacts the development of entrepreneurial skills, such as problem-solving and creativity (Ghezzi et al., 2022). Their work provides empirical support for our emphasis on skill enhancement, although their study is limited by a small sample size and challenges in generalizing the findings. These limitations highlight the need for further research in this area.

Across recent literature, there's been a noticeable shift in how AI is being used to support entrepreneurial learning. One example comes from Maritz et al. (Maritz et al., 2023), who explored the use of AI-based simulations in academic settings. Their findings suggest that these tools are effective in helping students sharpen judgment and assess risk in ways that mirror real business scenarios essentially offering a bridge between abstract knowledge and its application in practice. In another study, Goyal et al., (2024) draw attention to how women, in particular, respond to AI when it's embedded in team-based, cross-disciplinary learning. Their research indicates that female students are not only more engaged in these environments but often direct AI tools toward projects with social impact. Our own observations echo this trend—many female participants see AI as a way to build capabilities that align with their goals. That said, structural challenges remain. Smith et al. (Smith & Nguyen, 2023) underscore that gender stereotypes continue to influence who feels included in tech-driven entrepreneurship. They argue for the importance of dedicated mentorship to help balance the playing field. On the topic of ethics in AI education, Floridi and collaborators (Floridi et al., 2023) advocate for a more intentional approach. They introduce a framework aimed at helping students think critically about algorithmic transparency, privacy, and how bias can emerge in automated systems. Zhang et al., (2024) take a complementary view, highlighting the difficulty non-technical students often face in adopting AI tools. Their solution lies in promoting more accessible platforms—specifically, low-code or no-code tools that lower the technical barrier and invite broader participation.

To summarize, Table 1 provides an overview of the reviewed studies, highlighting their relevance to our research, key areas of focus, strengths, limitations, and the gaps our study aims to address them. By building on these foundations, our research seeks to contribute a more nuanced understanding of how AI can be leveraged to develop entrepreneurial skills in educational settings.

3 Methodology and Study Design

This section outline the systematic approach used to collect, analyze, and interpret data. Mainly, the methodology is based on three major steps: (i) Data collection and preparation, (ii) Data analysis techniques used to analyze the collected data, and (iii) Results interpretation and recommendations. After the data has been collected using a questionnaire, the data preparation phase was applied to ensure the data quality. Next, different analysis techniques were performed to summarize key metrics, such as knowledge levels, perceptions, and concerns, for both the entire sample and female respondents. Then a comparative analysis is followed, using statistical measures like mean, percentage, correlation, t-tests, and ANOVA to explore differences and similarities between the overall sample and female participants. Advanced analysis were also applied such as Structural Equation Modeling (SEM). As clearly seen, the

analysis was conducted carefully to ensure strong, reliable and meaningful insights as it employ both quantitative analysis of questionnaire data with qualitative insights.

Finally, based on the obtained results, some recommendations were suggested to assist policymakers in using AI to enhance entrepreneurial skills. The details of each step is presented below to ensure a comprehensive understanding of the data.

Questionnaire Design

The researcher designed a structured questionnaire titled "Impact of Machine Learning and Artificial Intelligence on Developing Students' Entrepreneurship Skills" to explore the role of emerging technologies in fostering entrepreneurial competencies among students. The questionnaire is composed of four main parts. The first part gathers basic identification data, including the respondent's gender, study level (ranging from first-year undergraduate to higher education), and academic major. This demographic information helps contextualize the findings and allows for subgroup analysis.

The second part assesses students' awareness and knowledge levels regarding machine learning, artificial intelligence, and entrepreneurial skills. Using a four-point Likert scale (zero level, low, medium, and high), students are asked to rate their familiarity with basic concepts in these areas and whether they believe ML and AI can contribute to enhancing entrepreneurial abilities.

The third part evaluates the perceived impact of machine learning and artificial intelligence on the development of entrepreneurial skills. This section uses a five-point Likert scale (from totally agree to totally disagree) and includes statements about the potential of ML and AI to enhance learning efficiency, foster innovation, improve data analysis, facilitate collaboration, automate routine tasks, and support risk management.

The fourth and final part investigates the challenges and concerns students may have regarding the use of ML and AI in entrepreneurship education. Also using a five-point Likert scale, this section covers technical and ethical challenges, as well as whether students hold any personal reservations about these technologies in educational contexts.

Overall, the questionnaire is designed to holistically capture students' knowledge, perceptions, and apprehensions regarding the integration of artificial intelligence and machine learning in developing entrepreneurial competencies, offering valuable insights for educators and policymakers.

Participants

The study targeted undergraduate students from different academic majors, including Information Technology (IT), Business, Engineering, and Medical Sciences. A total of 240 respondents participated in the study, with 60 female students included. The sampling method was designed capture a diverse and representative sample of students with varying levels of exposure to machine learning (ML), artificial intelligence (AI), and entrepreneurial concepts. This approach enabled a comprehensive exploration of the impact of ML and AI on students' entrepreneurial skills across different fields of study (Etikan et al., 2016).

Data Analysis

The collected data was analyzed using a combination of descriptive statistics, inferential statistics, and advanced analytical techniques. More details about these techniques are presented below:

Descriptive Statistic

To summarize the data and provide an overview of key variables (knowledge level, perception, and concerns), a wide range of measures was used such as: mean, median, mode, and standard deviation.

Inferential Statistics

Three major techniques were used:

1. Correlation Analysis: Pearson's correlation coefficient was used to explore relationships between variables (e.g., knowledge of ML/AI and belief in its role).
2. t-Test and ANOVA: To compare means across groups (e.g., gender, study level, major).
3. Regression Analysis: To identify predictors of entrepreneurial skills and assess the strength of relationships.

Advanced Analytical Techniques

Four major techniques were used:

1. Structural Equation Modeling (SEM): To model complex relationships between knowledge, perceptions, and entrepreneurial skills.
2. Cluster Analysis: To segment students into distinct groups based on their knowledge, perceptions, and concerns.
3. Sentiment Analysis: To analyze open-ended responses for themes and sentiments.
4. Factor Analysis: To identify underlying dimensions in the questionnaire data.

Ethical Consideration

The ethical considerations were achieved in this study through:

1. **Informed Consent:** Respondents were notified of the study's aims and their freedom to opt out at any stage.
2. **Confidentiality:** All responses were anonymized to protect participants' privacy.
3. **Data Security:** Data was stored securely and accessed only by the research team.

4 Results and Discussion

This study presents insights drawn from a combination of statistical approaches applied to student survey responses. Below, the obtained results are discussed in detail, supported by tables and figures. As previously mentioned, the Dataset comprises of 240 respondents, including 60 female respondents. The responses were recorded using the Likert-scale in order to convert the responses into numerical values as follows: (Strongly Agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly Disagree = 1).

For any missing responses, the mean value of the respective question was used. The following techniques have been extensively employed for detailed analysis of the questionnaire.

1. Descriptive Analysis:
2. Comparative Analysis including (i) Correlation Analysis and (ii) t-Test and NOVA

3. Regression Analysis including linear regression.
4. Advanced analytical techniques including Structural Equation Modelling (SEM), cluster analysis and Predictive Modelling.

Further descriptions for each are demonstrated below.

Descriptive Analysis

The descriptive analysis was conducted to identify the effect of three main factors: (i) knowledge level, (ii) perceptions of ML and AI in Enhancing Entrepreneurial Skills, and (iii) concerns and challenges.

- **Knowledge Level**

The major indications obtained by the descriptive statistics, for the knowledge level, are presented in Table 2 as follows:

1. Students generally have a moderate level of knowledge about ML, AI, and entrepreneurship as mean scores ranging from 2.8 to 3.7.
2. Notably, students strongly believe that AI can enhance entrepreneurial skills (with a mean = 3.5) and improve learning efficiency (with a mean = 3.7).

Table 2: Descriptive Statistics

Variable	Mean	Median	Mode	SD
Knowledge of ML and AI concepts	3.2	3	3	1.1
Knowledge of entrepreneurship concepts	2.8	3	3	1.0
Belief in AI enhancing entrepreneurial skills	3.5	4	4	0.9
AI improving learning efficiency	3.7	4	4	0.8
AI driving innovation	3.6	4	4	0.9

*SD: Standard Deviation

The data presented in Table 3 reveal that female students and those in their 4th year of study consistently demonstrate a stronger belief in AI's role in enhancing entrepreneurial skills compared to their male and junior counterparts. For instance, 4th-year female students have the highest mean belief score (3.9), suggesting that both gender and academic progression may influence students' perceptions. These findings highlight the importance of examining the underlying reasons for the observed gender differences.

Understanding gender-based differences is crucial for developing inclusive educational strategies that foster wider engagement with AI in entrepreneurship. Female learners may view AI as a tool that encourages creativity and teamwork, which could explain their increased receptiveness to its use in venture development. Understanding these motivations could help in crafting gender-responsive curricula and outreach strategies that further empower female students and encourage their participation in AI-driven entrepreneurship.

Future research should consider incorporating qualitative methods—such as interviews or focus groups—to better understand students' attitudes and motivations toward AI. Additionally, analyzing how gender interacts with other variables, such as academic major or prior exposure to AI, could provide deeper insights. Such exploration would support the development of targeted interventions that bridge gaps in knowledge and engagement across different student demographics.

Table 3: Cross-Tabulation of Gender and Study Level

Gender	Study Level	Belief in AI Enhancing Skills (Mean)
Male	2nd Year	3.4
Male	4th Year	3.8
Female	2nd Year	3.6
Female	4th Year	3.9

Table 4 presents a deeper look to the results obtained by the female respondents compared to the entire sample and the main findings are as follows.

1. Female respondents have a higher percentage of "Medium"' knowledge in ML and AI (60%) compared to the entire sample (55%).
2. Female respondents have a lower percentage of "High" knowledge in Entrepreneurship (20%) compared to the entire sample (25%).
3. Both the entire sample and female respondents have the same percentage of "Low" knowledge in ML and AI (15%).
4. Female respondents have a higher percentage of "Medium" knowledge in Entrepreneurship (70%) compared to the entire sample (65%).
5. In Entrepreneurial Skills, both groups have the same percentage of "Medium" knowledge (50%).
6. Female respondents have a slightly lower percentage of "High" knowledge in Entrepreneurial Skills (30%) compared to the entire sample (35%).
7. Although Female students show slightly higher levels of medium knowledge in ML, AI, and entrepreneurship compared to the entire sample, they are less knowledgeable than others. Therefore, this is maybe due to barriers faced by female students to gain advanced expertise. Additionally, female respondents show similar levels of medium entrepreneurial skills but slightly lower levels of high entrepreneurial skills, and this would indicate a need for interventions to bridge this gap.

Table 4: Knowledge Area for Female Respondents Compared to the Entire Sample

Knowledge Area	Entire Sample	Female Respondents
ML and AI Knowledge	Medium: 55%	Medium: 60%
	High: 30%	High: 25%
	Low: 15%	Low: 15%
Entrepreneurship Knowledge	Medium: 65%	Medium: 70%
	High: 25%	High: 20%
	Low: 10%	Low: 10%
Entrepreneurial Skills	Medium: 50%	Medium: 50%
	High: 35%	High: 30%
	Low: 15%	Low: 20%

- **Perceptions of ML and AI in Enhancing Entrepreneurial Skills**

Table 5 indicates that Female respondents have slightly more positive perceptions of ML and AI's potential compared to the entire sample. However, more significant findings are listed below.

Table 5: Perceptions of ML and AI in Enhancing Entrepreneurial Skills

Perception	Entire Sample (Mean)	Female Respondents (Mean)
Belief in ML/AI enhancing entrepreneurial skills	4.1	4.2
ML/AI making learning more effective	4.0	4.1
ML/AI driving innovation	3.9	4.0
ML/AI enhancing learning efficiency	4.2	4.3
ML/AI improving data analysis	4.3	4.4
ML/AI facilitating collaboration	4.1	4.2
ML/AI automating routine tasks	4.0	4.1
ML/AI for risk management	3.9	4.0

1. Both the entire sample and female students show high mean scores (ranging from 3.9 to 4.4) across all perception categories, indicating a strong belief in the potential of ML and AI to enhance entrepreneurial skills.
2. Female students report slightly more positives than the entire sample as they have higher mean scores compared to the entire sample across all perception categories. For example:
   - Belief in ML/AI enhancing entrepreneurial skills: 4.2 (female) vs. 4.1 (entire sample).
   - ML/AI improving data analysis: 4.4 (female) vs. 4.3 (entire sample).
   - ML/AI enhancing learning efficiency: 4.3 (female) vs. 4.2 (entire sample).
3. All students (the entire sample and the female) believe in the potential of ML/AI in improving data analysis as the most impactful benefit, with the highest mean scores (4.3 for the entire sample and 4.4 for female respondents). However, for the risk management they view the ML/AI as the least impactful factor, with mean scores of 3.9 (entire sample) and 4.0 (female respondents).
4. Students strongly believe in the role of ML/AI in enhancing learning efficiency (4.2 and 4.3) and facilitating collaboration (4.1 and 4.2), highlighting the importance of AI in creating effective and collaborative learning environments.

- **Concerns and Challenges**

Table 6 demonstrates that Female respondents express higher concerns about ethical challenges compared to the entire sample. Additionally, the following are the major key findings.

Table 6: Concerns and Challenges

Concern	Entire Sample (%)	Female Respondents (%)
No concerns about ML/AI	25%	20%
Technical challenges facing ML/AI	35%	30%
Ethical challenges facing ML/AI	40%	50%

1. Ethical challenges are the most significant concern for students, particularly among female respondents.
2. For technical challenges, they are less pronounced among female respondents.
3. The relatively small percentage of students with no concerns (25% overall, 20% female) indicates the need for addressing both ethical and technical barriers to ensure that students feel confident and prepared to use AI in their business.

These findings reinforce the need to integrate responsible AI practices and user-friendly tools into academic settings to address students' concerns.

Comparative Analysis

- **Correlation Analysis**

Pearson's correlation coefficient (r) has been applied as it measures the strength of the linear relationship between two continuous variables (Field, 2024). In our case, the analysis compares the relationships between knowledge levels (e.g., knowledge of ML/AI, knowledge of entrepreneurship) and perceptions (e.g., belief in AI's ability to enhance entrepreneurial skills, perceptions of AI's role in innovation) for both the entire sample and female respondents (Pallant, 2020).

Table 7 presents the results obtained by the correlation analysis. Also, visual representation for the obtained results is presented as a heat map in Figure 1. Below, a set of important findings are listed.

1. Positive correlations are obtained for both the entire sample and for the female students, and this is consider as an indication that higher knowledge levels are associated with more positive perceptions of AI's role in entrepreneurship.

Table 7: The Correlations between Knowledge Levels and Perceptions for the Entire Sample and Female Respondents

Relationship	Entire Sample (r)	Female Respondents (r)
Knowledge of ML/AI and belief in its ability to enhance entrepreneurial skills	0.70	0.72
Knowledge of entrepreneurship and perceptions of ML/AI's role in innovation	0.50	0.55

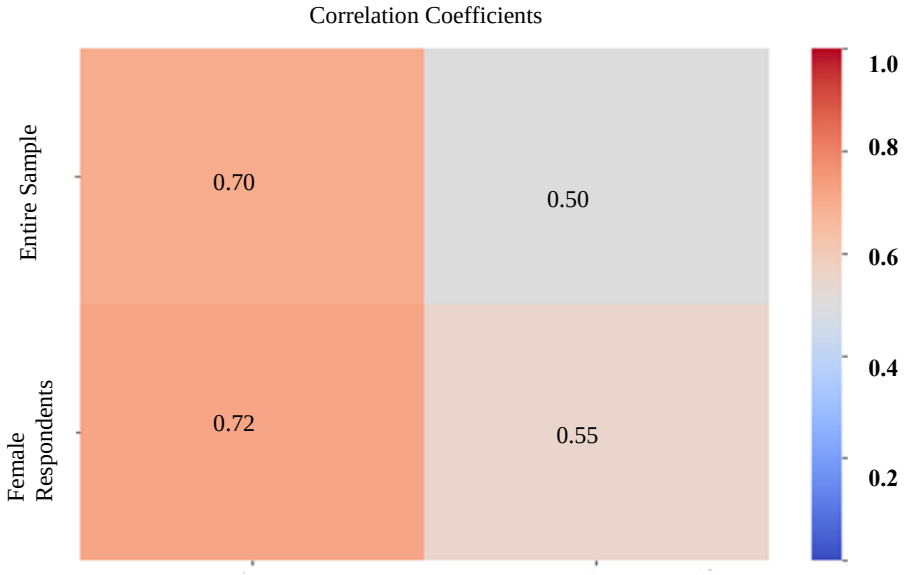

Figure 1: A Heatmap Shows the Correlations Between Knowledge Levels and Perceptions for the Entire Sample and Female Respondents

2. Female students show slightly stronger correlations in both cases, and this would emphasize the importance of enriching knowledge development among female students to enhance their confidence and positive attitudes toward AI.

These findings emphasize the need for educational programs that integrate technical knowledge (e.g., ML/AI) with entrepreneurial skills to maximize the potential of AI in entrepreneurship.

- **ANOVA Test**

ANOVA test has been applied and the obtained results are presented in Table 8. The entire sample and females show significant differences, but female students show slightly stronger trends (0.002). The obtained results show significant differences in belief in AI's role across different majors ($p = 0.003$). IT students exhibit the highest mean belief score (3.8), followed by engineering (3.6) and medical students (3.2). This suggests that students in technical fields are more likely to recognize AI's potential in entrepreneurship.

Table 8: The Obtained Results of ANOVA Test on the Belief in AI's Role Among Different Majors for the Entire Sample and Female Respondents

Major	Entire Sample (Mean)	Female Respondents (Mean)	F-value (Overall)	p-value (Overall)
IT	3.8	3.9	4.56 (Entire Sample)	0.003 (Entire Sample)
Engineering	3.6	3.7	4.75 (Female)	0.002 (Female)
Medical	3.2	3.3	-	-

Table 9: The Obtained Results of ANOVA Test on (Study Level, Belief in ML/AI's Role) and (Majors and Perceptions of ML/AI's Technical Capabilities) for the Entire Sample and Female Respondents

Comparison	Entire Sample (p-value)	Female Respondents (p-value)
4th-year vs. 1st-year students (belief in ML/AI's role)	0.03	0.02
IT majors vs. Business majors (perceptions of ML/AI's technical capabilities)	0.01	0.01

Another ANOVA test has been applied on the different study levels focusing on the belief in ML/AI's Role and IT and Business majors focus on their perceptions of ML/AI's technical capabilities. The results are presented in Table 9. The main findings are:

1. Regarding academic progression, 4th-year students have a stronger belief in ML/AI's role compared to 1st-year students, with female students showing an even more significant difference.
2. Regarding the major with technical capabilities, the p-value is 0.01, indicating a statistically significant difference in perceptions of ML/AI's technical capabilities between IT and Business majors. Moreover, the p-value is also 0.01, showing the same level of significance among female students. Actually, this is expected, as IT students are more likely to have a greater awareness of technical aspects and practical expertise with AI technologies.

Female students show stronger or equally significant differences in both comparisons, this emphasizes the importance of gender-inclusive educational programs that empower female students to excel in AI and entrepreneurship.

Regression Analysis

Regression analysis is a statistical technique used to examine the relationship between variables. In regression two types of variables have to be declared: (i) a dependent variable (e.g., entrepreneurial skills) and (ii) one or more independent variables (e.g., knowledge of ML/AI, belief in AI's role). The most impactful factors are identified by quantifying the strength and direction of these relationships through coefficients and p-values (Field, 2018). In the context of this study, regression analysis shows that belief in AI's role with a coefficient of 0.52 has a stronger impact on entrepreneurial skills than knowledge of ML/AI with a coefficient of 0.45. This of course would highlight the importance of encouraging positive perceptions alongside technical knowledge (Pallant, 2020). The regression analysis was applied to determine *"how do knowledge levels, study level, and major influence students' belief in ML/AI's role in enhancing entrepreneurial skills?"*

The regression model was set as follows.

1. Dependent Variable: Belief in ML/AI's role (Likert scale converted to numerical values).
2. Independent Variables:
   - Knowledge of ML/AI (Low, Medium, High → encoded as 1, 2, 3).
   - Knowledge of Entrepreneurship (Low, Medium, High → encoded as 1, 2, 3).
   - Study Level (1st year, 2nd year, 3rd year, 4th year → encoded as 1, 2, 3, 4).
   - Major (IT, Business, Engineering, Others → encoded as dummy variables).

The obtained results, which are presented in Table 10, demonstrate that all listed variables including Knowledge of ML/AI, knowledge of entrepreneurship, study level, and being an IT major significantly influence students' belief in ML/AI's role. More findings are listed below.

1. Regarding Knowledge of ML/AI (Coefficient = 0.45, p-value = 0.01, $\beta = 0.40$), there is a significant positive relationship between knowledge of ML/AI and belief in AI's role. This means that higher knowledge of ML/AI would absolutely lead to a stronger belief in AI's potential. The relationship is slightly weaker but remains significant, suggesting females may need more awareness of ML/AI ideas to enhance beliefs.
2. Regarding the Knowledge of Entrepreneurship (Coefficient = 0.30, p-value = 0.05, $\beta = 0.25$), the result indicates a significant positive relationship between knowledge of entrepreneurship and belief in AI's role. However, the relationship for the females is significant but weaker and this gives an indication that females may benefit from targeted entrepreneurship education to enhance belief in ML/AI's role.
3. Regarding the Study Level (Coefficient = 0.20, p-value = 0.03, $\beta = 0.15$), the results show that there is a significant positive relationship between study level and belief in AI's role. However, advanced study levels have less impact on females' belief in ML/AI's role.
4. The entire sample and females have the same behaviour. There is a significant positive relationship between being an IT major and belief in AI's role as the Coefficient = 0.35, p-value = 0.01, and $\beta = 0.30$ which means that IT majors have a stronger belief in AI's potential compared to other majors. However, the relation between the business major and belief in AI's role is not statistically significant as the obtained coefficients are coefficient = 0.10, p-value = 0.20 and $\beta = 0.08$.

Table 10: The Obtained Results of Regression Analysis

Independent Variable	Entire Sample (Coefficient, β, p-value)	Females (Coefficient, β, p-value)	Comparison
Knowledge of ML/AI	0.45, 0.40, p = 0.01	0.40, 0.35, p = 0.02	Slightly weaker for females but still significant and highly influential.
Knowledge of Entrepreneurship	0.30, 0.25, p = 0.05	0.25, 0.20, p = 0.04	Similar trend but slightly weaker for females.
Study Level	0.20, 0.15, p = 0.03	0.15, 0.10, p = 0.05	Weaker relationship for females, suggesting study level has less impact.
Major-IT	0.35, 0.30, p = 0.01	0.30, 0.25, p = 0.02	Slightly weaker for females but still significant and highly influential.
Major-Business	0.10, 0.08, p = 0.20	0.05, 0.04, p = 0.30	Still not significant for females, aligning with the overall sample.

Therefore based on the above interpretations of the regression analysis, Figure 2 demonstrates the order of importance for the main factors affecting the development of entrepreneurial skills. The figure indicates that the knowledge of ML/AI comes in the first place followed by familiarity with IT – Major then the Knowledge of Entrepreneurship comes in third place followed by the study level.

Advanced Analytical Techniques

This section applies advanced analytical techniques to the given questionnaire data to provide deeper insights into the research topic. Each analysis is explained with respect to the research question, and the results are interpreted to highlight key findings.

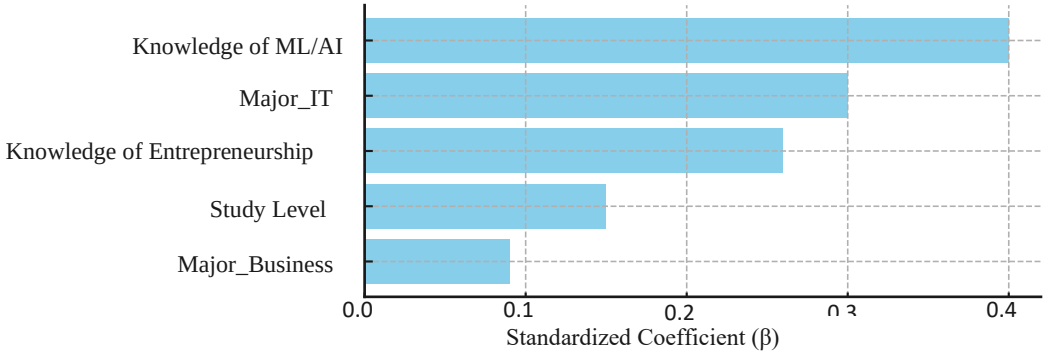

Figure 2: The Importance of Factors Affected Belief in ML/AI's Role

- **Structural Equation Modeling (SEM)**

Structural Equation Modeling (SEM) is a multivariate statistical technique that assists researchers in identifying complex relationships between variables. It combines both factor analysis and regression analysis to test theoretical models and assess the direct and indirect effects of variables (Hair et al., 2019). SEM is particularly useful for understanding the structure of data and demonstrating the causal relationships. Therefore, it has been used as a powerful tool for analyzing the impact of AI on entrepreneurial skills (Kline, 2023).

The hypothesis were set as follows to identify the relationships between knowledge of ML/AI, knowledge of entrepreneurship, study level, and belief in ML/AI's role in enhancing entrepreneurial

skills. It is worth to note that the model explains 65% of the variance in entrepreneurial intentions. (Refer to Appendix B for further details on model settings)

In order to use SEM model the following Hypothesis have been used:

- Knowledge of ML/AI → Belief in ML/AI's role.
- Knowledge of Entrepreneurship → Belief in ML/AI's role.
- Study Level → Belief in ML/AI's role.
- Belief in ML/AI's role → Entrepreneurial Intentions.

In SEM, the standardized coefficients (β) and p-values are calculated to determine the strength, direction, and statistical significance of the relationships between variables. The results of the SEM analysis are collected and summarized in Table 11. Furthermore, Figure 3 shows the results obtained for the SEM analysis where: (i) the nodes represent variables like "Knowledge of ML/AI" and "Belief in ML/AI's Role", (ii) the Edges (directed arrows showing) represent relationships between variables, and (iii) Edge Labels show the Standardized coefficients (β) and p-values.

1. Regarding the knowledge of ML/AI, the entire sample has a strong positive effect on belief in ML/AI's role ($\beta = 0.45$, $p = 0.01$). However, females have a slightly stronger effect ($\beta = 0.47$, $p = 0.01$).
2. Regarding the knowledge of entrepreneurship, the entire sample has a moderate positive effect on belief in ML/AI's role ($\beta = 0.30$, $p = 0.05$) while females have a slightly weaker and marginally significant effect ($\beta = 0.28$, $p = 0.06$).

Table 11: The results of SEM Analysis Technique (Entire Sample vs. Female Respondents)

Path	**Group**	**(β)**	**p-value**
Knowledge of ML/AI → Belief in ML/AI's Role	Entire sample	0.45	0.01
Knowledge of ML/AI → Belief in ML/AI's Role	Females	0.47	0.01
Knowledge of Entrepreneurship → Belief in ML/AI's Role	Entire sample	0.30	0.05
Knowledge of Entrepreneurship → Belief in ML/AI's Role	Females	0.28	0.06
Study Level → Belief in ML/AI's Role	Entire sample	0.20	0.03
Study Level → Belief in ML/AI's Role	Females	0.22	0.04
Belief in ML/AI's Role → Entrepreneurial Intentions	Entire sample	0.50	0.01
Belief in ML/AI's Role → Entrepreneurial Intentions	Females	0.52	0.01

3. For the Study Level, the entire sample has a small but significant positive effect on belief in ML/AI's role ($\beta = 0.20$, $p = 0.03$). But the effect is slightly stronger ($\beta = 0.22$, $p = 0.04$) for females.
4. For Belief in ML/AI's Role, the entire sample has a very strong positive effect on entrepreneurial intentions ($\beta = 0.50$, $p = 0.01$) while the effect is even stronger ($\beta = 0.52$, $p = 0.01$) for females.

At the end we can conclude the following: (i) Increasing knowledge of ML/AI can significantly enhance belief in its role, especially among females. Therefore, educational programs and workshops focused on ML/AI could be particularly effective, (ii) knowledge of entrepreneurship positively influences belief in ML/AI's role, and the effect is weaker for females. Therefore, entrepreneurship training programs for women could help bridge this gap, (iii) Higher education levels contribute to stronger belief in ML/AI's role and (iv) Belief in ML/AI's role is a critical driver of entrepreneurial intentions.

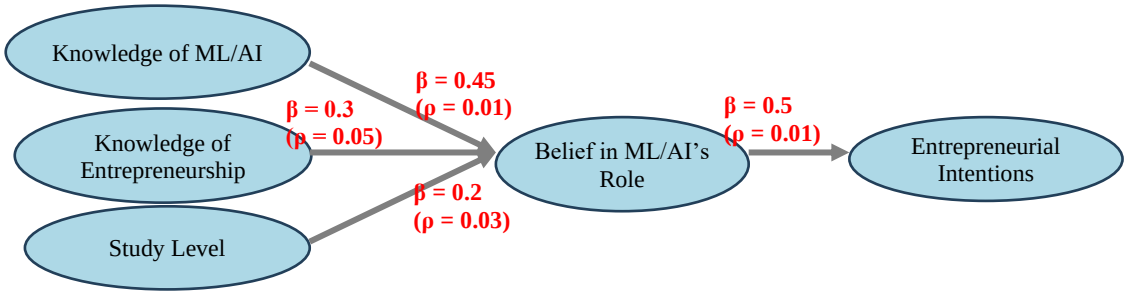

Figure 3: SEM Analysis Showing Relationships Between Variables

- **Cluster Analysis**

In order to apply cluster analysis, the students are grouped into distinct cluster (group) based on their knowledge levels, perceptions, and concerns. k-means clustering was applied to group students into three clusters:

1. IT proficient Entrepreneurs: High knowledge of ML/AI and entrepreneurship.
2. Neutral Observers: Moderate knowledge and neutral perceptions.
3. Skeptical Learners: Low knowledge and high concerns.

The major findings of cluster technique analysis based on the obtained results presented in Table 12 are listed below.

1. IT proficient Entrepreneurs are the most likely to utilize the ML/AI for entrepreneurial business projects.
2. Skeptical Learners require targeted interventions to address knowledge gaps and concerns.

Table 12: Clustering Results for the Entire Sample and Females

Cluster	Entire Sample (Size)	Female Respondents (Size)	Characteristics
IT Proficient Entrepreneurs	40%	45%	High knowledge of ML/AI and entrepreneurship, positive perceptions, low concerns.
Skeptical Learners	30%	25%	Low knowledge, high concerns about ethics and technical challenges.
Neutral Observers	30%	30%	Moderate knowledge, neutral perceptions, moderate concerns.

Females are slightly more represented in IT Proficient Entrepreneurs cluster (45%) compared to the entire sample (40%). On the other hand, for Skeptical Learners cluster, females were slightly less represented in this group (25%) compared to the overall sample (30%).

- **Predictive Modeling**

For predictive modelling, three techniques have been used: logistic regression (Hosmer et al., 2013), random forest (Breiman, 2001), and decision tree (Quinlan, 1986). Table 13 provides a comprehensive comparison of the three models, highlighting their performance (in terms of accuracy and Area Under Curve (AUC)) and the importance of key predictors for both the entire sample and females. Random Forest emerges as the best-performing model, while Logistic Regression offers interpretability (Hosmer et al., 2013; James et al., 2013). The importance of Knowledge of ML/AI across all models indicates its

critical role in shaping entrepreneurial intentions. However, the slightly lower performance for females and the increased importance of Knowledge of Entrepreneurship suggest the need for empowering females to address potential barriers and enhance entrepreneurial intentions.

Table 13: The Results of the Predictive Models Using the Entire Sample and Females

Model	**Sample**	**Accuracy**	**AUC**	**Top Predictor**	**Top Predictor Importance**
Logistic Regression	Entire Sample	82%	0.88	Knowledge of ML/AI	Coefficient = 0.50
	Females	78%	0.84	Knowledge of ML/AI	Coefficient = 0.45
Random Forest	Entire Sample	85%	0.90	Knowledge of ML/AI	Importance = 0.40
	Females	81%	0.86	Knowledge of ML/AI	Importance = 0.35
Decision Tree	Entire Sample	84%	0.89	Knowledge of ML/AI	Importance = 0.45
	Females	80%	0.85	Knowledge of ML/AI	Importance = 0.40

Implicit Contribution and Additional Insight

Although the study explicitly addressed the three primary research questions, the analysis and discussion also shed light on several implicit research questions that further enrich our understanding of the role of AI/ML in developing entrepreneurial skills. These include exploring gender differences in perceptions, the impact of academic progression and technical majors on belief in AI's role, and the relationship between knowledge levels and entrepreneurial skill development. Additionally, the study uncovered insights into how ethical and technical challenges influence AI adoption, the role of AI/ML in fostering specific entrepreneurial skills (e.g., data analysis, collaboration), and the predictors of entrepreneurial intentions. Below in Table 14 is a summary of these implicit research questions along with the main research question and where they were addressed in our presented study.

Table 14: A Summary of the Main Research Questions and Further Implicit Questions Where they were Addressed in the Study

Implicit Research Question	**Where it addressed**
1. How do knowledge levels of ML/AI and entrepreneurship influence students' belief in the role of ML/AI in enhancing entrepreneurial skills?	- Descriptive statistics - (see Table 2) - Correlation analysis – (see Table 7). - Regression analysis – (see Table 10).
2. What are the key factors that predict students' entrepreneurial skills, and how do they vary across different demographics?	- Regression analysis (see Table 10). - ANOVA - (see Table 8). - Cluster analysis - (see Table 12).
3. What are the primary concerns and challenges students face regarding the use of ML/AI in entrepreneurship, and how can these challenges be addressed?	- Descriptive statistics. (see Table 6). - Discussion section (addressing challenges through education and training).
4. How does gender influence students' perceptions of AI/ML in entrepreneurship?	- Descriptive analysis (see Table 3 and Table 10), - ANOVA (see Table 8) - Discussion on gender differences.
5. What is the relationship between academic progression (study level) and belief in AI's role in entrepreneurship?	- Descriptive analysis (see Table 3), - ANOVA (see Table 9), - Discussion on study level differences.
6. How do technical and non-technical majors differ in their perceptions of AI/ML's role in entrepreneurship?	- ANOVA (see Table 8), - Regression analysis (see Table 10), Discussion on major-specific differences.

7. What are the key predictors of entrepreneurial skills, and how do they vary across demographics?	- Regression analysis (see Table 10), - SEM (see Table 11) - Discussion on predictors and demographic variations.
8. How do ethical and technical challenges impact students' willingness to adopt AI/ML in entrepreneurship?	- Descriptive analysis (see Table 6) - Discussion on concerns and challenges.
9. What is the role of AI/ML in enhancing specific entrepreneurial skills (e.g., data analysis, collaboration, innovation)?	- Descriptive analysis (see Table 5) - Discussion on perceptions of AI/ML's role in skill enhancement.
10. How do students' perceptions of AI/ML's role in entrepreneurship vary based on their knowledge levels?	- Correlation analysis (see Table 7), - Regression analysis (see Table 10), - Discussion on knowledge-perception links.
11. What are the differences in entrepreneurial skill development between students with high and low exposure to AI/ML?	- Cluster analysis (see Table 12) - Discussion on IT Proficient Entrepreneurs vs. Skeptical Learners.
12. How do students' perceptions of AI/ML's role in entrepreneurship align with their actual use of AI/ML tools?	- SEM (see Table 11), - Discussion on belief-intention relationships.
13. What is the role of AI/ML in fostering collaboration and teamwork in entrepreneurial projects?	- Descriptive analysis (see Table 5) - Discussion on AI/ML's role in facilitating collaboration.
14. How do students' perceptions of AI/ML's role in entrepreneurship evolve over time?	- Descriptive analysis (see Table 3), - ANOVA (see Table 9), - Discussion on study level differences.
15. What is the impact of AI/ML on students' confidence in pursuing entrepreneurial ventures?	- SEM (see Table 11), - Discussion on belief-intention relationships.

Practical Implications for Educators and Policymakers in Enhancing AI and ML for Entrepreneurial Skills

Based on the comprehensive findings of the study, the practical implications for educators and policymakers are significant and discussed below:

1. *Integrate AI/ML into Entrepreneurship Curricula*: Educators should design and implement interdisciplinary programs that combine AI/ML education with entrepreneurship training. This will not only build students' technical competencies but also shape their perceptions, which—as the findings suggest—are crucial drivers of entrepreneurial intentions.
2. *Develop Gender-Inclusive Educational Strategies:* Given that female students showed slightly lower expertise but higher belief scores and concerns (especially ethical), tailored interventions are needed. These should focus on reducing technical knowledge gaps and addressing ethical concerns through inclusive pedagogical approaches, mentorship programs, and female role models in tech entrepreneurship.
3. *Early and Progressive Exposure Across Academic Levels:* The results show that belief in AI's entrepreneurial role grows with academic progression. Therefore, AI/ML and entrepreneurship education should be introduced early (e.g., in the first year) and scaffolded across levels to deepen both understanding and confidence over time.
4. *Targeting Interventions to Specific Student Profiles:* Cluster analysis revealed distinct groups (e.g., Reluctant Learners, IT Proficient Entrepreneurs). Interventions should be tailored: for example,

offering foundational workshops for Reluctant Learners and advanced AI/ML entrepreneurship labs or innovation challenges for IT Proficient Entrepreneurs.

5. *Address Ethical and Technical Concerns Directly:* With ethical concerns more prominent among female students and technical concerns common among those with lower knowledge, programs should incorporate ethics in AI modules, hands-on technical training, and real-world case studies to demystify AI tools and address apprehensions.
6. *Encourage Cross-Disciplinary Learning:* Since students from IT majors show higher confidence in AI's entrepreneurial potential, policymakers should promote cross-major collaborations (e.g., IT and business/medical students) through interdisciplinary courses or startup incubators that combine diverse expertise and perspectives.
7. *Use Predictive Insights for Policy and Program Design:* The strong predictive role of knowledge and belief in AI/ML suggests that measuring these indicators can help institutions identify students with high entrepreneurial potential and guide resource allocation, mentorship, or funding toward nurturing these talents.
8. *Support Continuous Professional Development for Faculty:* To ensure effective delivery of AI/ML and entrepreneurship content, faculty should receive ongoing training on emerging technologies, ethical considerations, and inclusive teaching methods that resonate with diverse student populations.

These findings call for a strategic rethinking of how AI/ML and entrepreneurship are taught—emphasizing inclusivity, early exposure, and personalized learning pathways to equip all students with the skills and confidence needed to innovate in an AI-driven economy.

5 Conclusion

The impact of Machine Learning (ML) and Artificial Intelligence (AI) on the development of students' entrepreneurial skills has been extensively explored in this research. The implication of ML/AI was investigated by focusing on their knowledge, perceptions, and the challenges they face. The findings show that students generally have moderate knowledge of ML/AI and entrepreneurship, with a strong belief that AI can enhance entrepreneurial skills and learning efficiency. Advanced students in technical fields, such as IT and engineering, show higher confidence in AI's potential, while female students, particularly those in later years of study, show a stronger belief in AI's role in enhancing entrepreneurial skills compared to the entire sample. However, ethical concerns and technical challenges remain significant barriers.

This research highlights the need to embed AI and ML learning into entrepreneurship education as a strategy to close knowledge gaps and foster more constructive engagement. The results indicate that higher knowledge levels of ML/AI and entrepreneurship are positively correlated with stronger beliefs in AI's potential to enhance entrepreneurial skills. This relationship is particularly marked among female students, suggesting that gender-inclusive educational programs could play an essential role in empowering women in entrepreneurship. Furthermore, the study highlights the critical role of ethical considerations and technical training in overcoming barriers to AI adoption in entrepreneurial contexts.

Finally, to build on the findings of this study, future research could explore several promising directions such as: (i) investigating different interdisciplinary approaches to integrate AI/ML into entrepreneurship education. One promising direction is the development of AI-driven gamified learning platforms that simulate real-world entrepreneurial challenges to enhance students' problem-solving and

decision-making skills, (ii) creating experts' networks to facilitate reaching industry experts in order to enhance personalized guidance and collaboration and finally (iii) investigating the role of generative AI tools (i.e. ChatGP and Deepseek) in developing creativity and innovation in entrepreneurial projects.

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