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An education model to empower women in tech entrepreneurship

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Introduction: The gender gap in technology entrepreneurship represents a significant and persistent disparity, with women significantly underrepresented in creating and leading technology start-ups. To address this multifaceted problem, it is critical to research and implement educational models that can foster intrinsic motivation in aspiring female entrepreneurs. Self-Determination Theory (SDT) provides a valuable framework for such an educational approach, emphasizing the importance of satisfying essential psychological needs—autonomy, competence and relatedness—to enhance motivation and commitment. Integrating SDT principles into entrepreneurship education can create supportive environments that empower women, encourage diverse perspectives, and ultimately bridge the gender gap in tech entrepreneurship. Particularly in the case of female students, it is important to understand how to empower their behavior choices to make possible different professional paths, with tech entrepreneurship being one of them. This gender gap has not yet been addressed through an education model proposal. Much has been said to characterize and identify it, but there is no proposal to change the higher education system in the STEM area, which is the research goal achieved in this paper: we need to analyze the gender gap in HEI and its relation to becoming entrepreneurial and understand how HEI may support the tech entrepreneurial behavior. To answer these questions we are going, in pursuit of the intrinsic motivations to support more entrepreneurial behavior in STEM female students.

Methods: A quantitative approach was designed to collect data to identify the gender gap in five European higher education institutions (HEI) in five different countries. In April, surveys were launched to female students, allowing a descriptive, exploratory factor analysis and structural equation modeling to test the SDT intrinsic motivation constructs.

Results: The results confirmed that there is a gender gap to overcome and that the teaching-learning process may help to potentiate the female student's capacities of self-knowledge and self-value for female students. The autonomy need was identified as the most influential construct on students becoming entrepreneurs, not dishing the effect the competences and relatedness have. Understanding this reality allows for further development of the education model proposed and discussed.

Conclusion: Higher education lectures, particularly in STEM programs, can improve their teaching processes to become more inclusive and promote an effective entrepreneurial mindset. Understanding what will change helps engage in a different paradigm of education in technology, demystifying the concepts of entrepreneurship and allowing inclusion and gender equality in the higher education system.

KEYWORDS

gender gap, tech entrepreneurship, self-determination theory, education model, STEM education

1 Introduction

There is a notable gender imbalance in Science, Technology, Engineering, and Mathematics (STEM) fields, with women being underrepresented at various stages of career development. Additionally, there is a higher dropout rate and a shortage of female participation in these fields (Gonzalez-Rogado et al., 2021). This underrepresentation serves to highlight the existence of gender biases and systemic disadvantages within social structures. There are several gendered barriers and constraints upon and enablers for the activity of STEM women entrepreneurs that remain under-researched. Furthermore, the dissuasion of women from pursuing or remaining in STEM careers is a consequence of gendered stereotypes. There is also an economic loss resulting from lower rates of STEM entrepreneurship by women (Treanor, 2022). There are similar challenges faced by STEM women entrepreneurs compared to other novice entrepreneurs.

The field of entrepreneurship in the STEM sector is confronted with a number of challenges, particularly due to the limited participation of female STEM faculty members. Despite this, there is considerable potential for STEM-based entrepreneurial initiatives to enhance economic development and social mobility (Shekhar et al., 2024). Shekhar et al. (2024) identified six core themes underlying women STEM faculty's engagement in entrepreneurship programming. These are: limited knowledge about women STEM entrepreneurs' growth strategies; a success definition that better represents women entrepreneurs' definition of success; women's motivation to become entrepreneurs; a non-discriminatory relationship with financial institutions; work–family conflicts; and an understanding of a country's family and economic policy, labor market, social norms and culture. It is evident that these authors perceive a lack of access to resources, gender bias, and societal expectations regarding women in STEM fields as significant barriers to their engagement in business creation.

Blume-Kohout (2014) states that the gender gap in STEM fields' entrepreneurship cannot be addressed with a single, monolithic strategy. The underlying issues have implications for policy across a wide range of individual STEM fields and disciplines. These include gender differences in graduate training environments, employment sectors and typical work activities, professional seniority, and the impact of patenting activity on subsequent entrepreneurship. In certain fields, the rate of small business ownership among female PhDs is approaching that of their male counterparts. Consequently, the apparent discrepancy in entrepreneurship can be attributed primarily to the lower proportion of women earning PhDs in that field. In other fields, there is a significant divergence between the typical work activities of men and women who hold PhDs in the same field. Women are more likely to pursue academic careers than men, and women faculty members are disproportionately employed in less research-intensive departments and occupations, often in roles such as adjunct instructors, lecturers, or teaching faculty. On other grounds, the gender gap in patenting appears to be diminishing, with research-focused female PhD becoming more prevalent but still concentrated in postdoctoral and junior faculty positions (Blume-Kohout, 2014). As the majority of fields exhibit elevated rates of entrepreneurship and associated activities with increasing time since PhD completion, it is probable that the gender gap in STEM entrepreneurship for these fields will persist and narrow as women attain senior positions. In addition to these key differences across fields, Blume-Kohout (2014) also identifies significant discrepancies between male and female STEM PhD in the relative influence of research funding sources in their graduate and postdoctoral training environments and in the role of patenting in stimulating subsequent entrepreneurship.

The application of a postmodern feminist theoretical lens facilitates a more profound comprehension of the manner in which the metanarrative of economic growth impedes the conceptualization of female entrepreneurs (Dean et al., 2019). There is a striking association between female entrepreneurs and underperformance, which serves to reinforce the image of the female entrepreneur as problematic and inferior to her male counterpart (Cetindamar et al., 2019; Langevang et al., 2015). The likelihood of identifying female entrepreneurs in sectors characterized by high levels of knowledge intensity is 25% higher in countries that reached gender equality in science education than in countries that have not (Cetindamar et al., 2019). However, the dearth of data concerning technology entrepreneurship by women makes it exceedingly difficult to identify the obstacles that impede women from participating in or founding science and technology-related businesses. Despite the existence of evidence indicating that business performance is enhanced with an increase in the level of education among female entrepreneurs (Milovanović, 2023).

In terms of the family business group and the start-up group of women entrepreneurs, the two groups constructed separate entrepreneurial identities. The former group focused on gaining respect in a male-dominated environment, whereas the latter emphasized self-determination and independence (Fernandes and Mota-Ribeiro, 2017). This notion is further substantiated by the assertion that female-owned enterprises tend to exhibit inferior economic performance, characterized by smaller scale, lower profitability, slower growth, and elevated closure rates (Fernandes and Mota-Ribeiro, 2017). Women often have lower growth ambitions than men, preferring a "slow and steady" business approach rather than pursuing rapid or high-risk growth (Carranza et al., 2018). It is evident that the aforementioned authors have identified several constraints that impede the growth of female entrepreneurship. These include social and institutionalized gender barriers, the undervaluation of professional qualities and individual attributes, the tendency for male business partners to assume visible leading roles, and specific forms of gender discrimination related to organizational cultures and financial/institutional support (Fernandes and Mota-Ribeiro, 2017; Carranza et al., 2018; Sobhan and Hassan, 2024).

The discrepancy in wellbeing between genders appears to be more pronounced in countries where gender inequality is more prevalent, financial development is less advanced, and traditional gender roles are more strictly adhered to (Love et al., 2024). Moreover, female entrepreneurs with lower levels of education, greater numbers of children, and a tendency to avoid risk are more likely to report lower levels of wellbeing. Cultural and social norms harm women's participation in the labor market and their entrepreneurial activities. This results in a range of challenges, including limited resources, discrimination and other constraints (Sobhan and Hassan, 2024; Field et al., 2010; McAdam et al., 2020). The institutional environment surrounding female entrepreneurship is characterized as a double-edged sword, conferring legitimacy and freedom while simultaneously imposing constraints on women's business activities (Langevang et al., 2015; Terrell and Troilo, 2010).

Several studies have identified a range of challenging environments for women entrepreneurs, including unfavorable business and economic and political contexts (Panda, 2018). Notwithstanding the absence of entrepreneurship-related training or personality-based constraints (Panda, 2018), the primary constraints on female entrepreneurship in academic spin-offs are a dearth of recognition and support for transfer activities, work–family conflict, financial limitations, inflexible organizational strategies and practices, a lack of managerial support, and challenges in technology development (Müller-Wieland et al., 2019; Panda, 2018; Field et al., 2010).

A comparative analysis of the literature reveals that gender dynamics receive comparatively less attention in innovation research than in entrepreneurship research (Brush et al., 2022). There are several areas of concern regarding gender and innovation. These include the presence of gender biases in innovation funding, the influence of women in Small and Medium Enterprises (SMEs) on innovation, and gender gaps and stereotypes in patent sales and crowdfunding. There appears to be a dearth of attention devoted to the role of women entrepreneurs in fostering innovation. There is a notable scarcity of research exploring the ways in which innovation motivates women to embark on entrepreneurial ventures and how they initiate and expand innovations in the marketplace. Additionally, there is a tendency to prioritize women's contributions to innovation performance in larger, well-resourced companies rather than within the context of entrepreneurship.

The 21st century has witnessed a surge in female entrepreneurship, particularly in developing countries (Ahmetaj et al., 2023). Recent studies have revealed a significant discrepancy in the level of support women entrepreneurs receive from their families and partners compared to those who have inherited their entrepreneurial spirit from their families. However, these studies still identify constraints that were previously highlighted a decade ago. These include the intersectionality of gender, family status, and culture in influencing entrepreneurial intentions and the significant impact of normative barriers on women's entrepreneurial activities (Karim et al., 2023).

Female entrepreneurs in the fields of science, technology, engineering, and mathematics must navigate a complex landscape of contradictory feminist perspectives in order to achieve a sense of entrepreneurial belonging. It is imperative to consider the gendered substructures that are inherent to entrepreneurial ecosystems, as highlighted by (Birkner, 2020). Education, family size, time dedicated to entrepreneurial activities, and firm size all contribute positively and significantly to entrepreneurial income compared to household income. Nevertheless, it is imperative that policy attention, educational initiatives, relevant experience, communication campaigns, and training options for entrepreneurs in developing countries be provided (Ge et al., 2022).

This educational role is associated with promoting intrinsic and extrinsic motivation (Ryan and Deci, 1985). It can be argued that education policies have the potential to exert a significant influence on students' intrinsic motivation, particularly in terms of shaping the learning environment, assessment methods and the overall educational experience. The impact of these policies on extrinsic motivation is variable, with the potential to influence student behavior, performance, and overall educational outcomes. It is, therefore, essential to understand the different types of motivation, their contributing factors, and how intrinsic and extrinsic motivations relate to the essential human needs for autonomy, competence, and relatedness. It is paramount to emphasize the role of social contextual conditions in supporting intrinsic motivation and facilitating the internalization and integration of extrinsically motivated tasks (Ryan and Deci, 2020).

SDT constitutes a framework for understanding human motivation and personality. The theory employs traditional empirical methods and is anchored in an organismic metatheory, underscoring the pivotal role of humans' innate psychological resources in personality formation and behavioral self-regulation (Ryan et al., 1997). This theory conceptualizes human motivation as an inherently proactive phenomenon. The overarching metatheory of SDT posits that individuals are innately predisposed to growth, resilience, and the integration of novel experiences. However, a supportive environment is a prerequisite for fully realizing these developmental tendencies. As Guay (2022) observes, in numerous social contexts, including educational settings, these tendencies are frequently impeded, resulting in non-compliance, oppositional behaviors and disengagement (Guay, 2022).

The SDT suggests that three fundamental psychological needs drive human motivation and behavior: competence, autonomy, and relatedness (Ryan and Deci, 2020). These needs are considered universal and apply consistently across age, gender, culture, and socioeconomic status. These three fundamental psychological needs are interdependent and form the foundation for self-motivation and personality integration. Accordingly, SDT posits that an individual's psychological wellbeing and functionality level is contingent upon the degree to which these needs are satisfied (Deci and Ryan, 2000).

The fundamental need, autonomy, reflects the fundamental human desire to perceive one's self-selected actions and experience psychological freedom in one's activities. In accordance with SDT, autonomy is understood as a subjective experience of freedom and psychological choice during engagement in an activity rather than as a characteristic inherent to the task itself. While task-related autonomy may contribute to psychological freedom, individuals may also experience satisfaction with autonomy when depending on others or following others' requests. Therefore, individuals may exhibit either autonomous independence or autonomous dependence on others. The need for autonomy is closely linked to the concept of the self, which serves as the active centre of integration, initiation and spontaneous engagement within the social environment. In accordance with SDT, the integrative process is of paramount importance to the self, encompassing novel functions, values, experiences, and inclinations (Deci and Ryan, 2000; Ryan et al., 1997). The second need identified by Deci and Ryan (2000) is competence. The term denotes the intrinsic human aspiration to experience efficacy in one's interactions with the external environment. This need is evident in the inclination to explore and manipulate the environment and undertake challenging tasks to develop and demonstrate one's abilities. The satisfaction of this need enables individuals to adapt to complex and evolving environments. Conversely, frustration with this need can result in feelings of helplessness and diminished motivation (Ryan and Deci, 2000; Deci and Ryan, 2000). In contrast, the need for competence represents an intrinsic drive, encompassing a more expansive emotional perception of efficacy derived from successfully completing a task. The third identified need is relatedness (Deci and Ryan, 2000; Ryan and Deci, 2000). This is satisfied when individuals experience a sense of communion and develop close, intimate relationships with others. This need implies that individuals are

naturally inclined to integrate into social structures and benefit from receiving care. Without this need, it would be challenging to comprehend why individuals readily adopt behaviors and strategies that facilitate effective and amicable interactions within their social groups.

Given the distinctive functional and experiential attributes of self-motivation compared to external regulation, SDT has focused on offering a nuanced perspective on motivation by examining the specific type of motivation-driving behavior in any given situation. By examining the factors that influence individuals' actions, SDT has identified various types of motivation, each with specific implications for learning, performance, personal experience, and wellbeing (Ryan and Deci, 2000) SDT makes a clear distinction between the various forms of motivation that are driven by different reasons or goals. The most fundamental distinction can be made between intrinsic motivation, whereby individuals engage in activities due to their inherent interest or enjoyment, and extrinsic motivation, which is driven by the pursuit of separable outcomes (Ryan and Deci, 1985).

Cognitive Evaluation Theory (CET), as proposed by Ryan and Deci (1985) as a sub-theory of SDT, aims to identify the underlying factors contributing to the observed variations in intrinsic motivation. The CET examines the manner in which social and environmental conditions either facilitate or impede intrinsic motivation. The theory operates on the premise that intrinsic motivation, being an inherent quality, will flourish naturally when individuals are in environments conducive to its expression. The theory places particular emphasis on the essential needs of competence and autonomy. The theory suggests that socio-related events (such as feedback, communication, and rewards) that foster feelings of competence during activities can increase intrinsic motivation for those actions.

As Ryan and Deci (2000) state, empirical evidence suggests that implementing tangible rewards, threats, deadlines, commands, evaluative pressure, and imposed objectives diminishes intrinsic motivation by fostering an external perception of causality. Conversely, facilitating choices, recognizing emotions, and enabling self-directed opportunities to have boosted intrinsic motivation by nurturing a heightened sense of autonomy. The CET framework suggests that social circumstances can either enable or inhibit intrinsic motivation by supporting or impeding individuals' inherent psychological needs. Research shows significant relationships between intrinsic motivation and fulfilling the needs for autonomy and competence. Furthermore, some evidence indicates that the satisfaction of the need for relatedness, albeit indirectly, may also be associated with intrinsic motivation.

SDT has significant relevance and applicability across various domains, yet it has not been adequately explored in entrepreneurship research (Al-Jubari, 2019). It is not uncommon for entrepreneurs to encounter challenges and setbacks during the initial stages of a business venture, which may result in a lack of motivation to persist with the venture. The SDT posits that autonomously motivated individuals demonstrate greater task persistence, irrespective of the difficulties and adversities they encounter (Ryan and Deci, 1985). Entrepreneurs who possess a robust sense of autonomy are inclined to innovate, take risks and persevere through challenges. Such individuals are driven by the chance to mold their ventures according to their personal vision and values.

SDT offers a conceptual framework for elucidating the influence of intrinsic motivation and autonomy on entrepreneurial behavior. It is recommended that organizations and policymakers implement measures to foster these factors, intending to create environments that encourage innovation and entrepreneurial success. In the context of social relationships, relatedness in SDT encompasses entrepreneurs who seek connections with mentors, partners, customers, and communities. The establishment of supportive networks in these domains has the potential to markedly enhance motivation and wellbeing, which in turn can facilitate the success of their businesses (Ryan and Deci, 2020).

Due to the exposed it is possible to understand that there is a possibility to contribute to the development of an educational model to help the STEM female students to overcome gender constraints and be entrepreneurs by influencing intrinsic motivation constructs. This research goal is, therefore, to propose an educational model based on the SDT. To reach this objective, it is necessary to identify the female gap in female students to understand the influence of each motivation constructs that has more impact on the entrepreneurial behavior intended to promote STEM female students. Research questions to be answered are:

> Is the gender gap felt in the HEI, particularly on the possibility to become entrepreneur?
>
> How can HEI support and promote entrepreneurial behavior on STEM female students?

2 Materials and methods

The research employed a quantitative methodology to elucidate the interrelationship between the intrinsic motivational triggers identified by SDT and the educational model, which was delineated by students from diverse universities across Europe. Consequently, a survey was constructed comprising closed-ended and Likert scale questions based on the SDT model, with the objective of gathering data that would enable the research goal, as outlined in Appendix 1, to be achieved while ensuring compliance with all General Data Protection Regulation (GDPR) data-collecting regulations. The first group of questions (part 1—questions 1, 2 and 3) were intended to identify the gender gap perception on HEI to become an entrepreneur, and the second group were based on the SDT constructs to assess the student's perceptions on autonomy (part 2—questions 1, 2 and 3), competences (part 2—questions 4, 5 and 6) and relatedness (part 2—questions 7 and 8). The survey was launched between April and May in four higher education institutions (HEIs): the University of Gdansk (Poland), the Polytechnic of Guarda (Portugal), the Polytechnic of Torino (Italy), and the University of Macedonia (Greece). A total of 768 students participated in the survey, of whom 427 identified as female.

A preliminary descriptive statistical analysis was conducted to characterize the sample and observe its distribution, with the objective of describing the central tendencies and dispersion within the data (Stehlik-Barry and Babinec, 2017).

The reliability of the scales was assessed using Cronbach's Alpha, which measures the internal consistency of a set of items on the measurement scale. A Cronbach's Alpha value approaching 1 indicates a high degree of internal consistency among the scale items, with

values exceeding 0.7 typically deemed acceptable. It may be inferred from very low alpha values that there is an insufficient correlation between items, suggesting the need to either revise or remove some items. This reliability analysis results are interpreted to ascertain whether the scale is consistent and reliable for measuring the desired construct (Schrepp, 2020).

A factor analysis was employed to examine the underlying patterns or relationships among a multitude of variables and ascertain whether the data could be condensed into a smaller set of factors. The analysis was exploratory in nature, as the software was permitted to determine the optimal number of factors for reduction. Consequently, a multivariate random process generated new variables derived from the original variables, typically in smaller numbers, representing the process's commonalities. To ascertain the viability of employing factor analysis on a given data set, the Kaiser-Meyer-Olkin (KMO) test is conducted. A KMO value between 0.5 and 1.0 signifies that factor analysis is an appropriate statistical approach, whereas a value below 0.5 indicates that the analysis is inadequate. The factors were identified and defined by assigning names to them in accordance with the highest correlation values observed in the principal component matrix (Sürücü et al., 2024).

An analysis was developed using the Structural Equation Model (a technique employed in both observational and experimental research) to examine the relationship between the various constructs and the probability of becoming entrepreneurs over the long term. This approach may facilitate investigating the different aspects of a phenomenon by examining the causal relationships between them. The causal structures indicate that specific patterns should emerge regarding the observed variables. This enables the estimation of the magnitudes of the proposed effects and tests the alignment between the observed data and the hypothesized causal structures (Pearl, 2009). This model combines aspects of factor analysis and multiple regression, examining complex causal relationships among observed and latent (unobserved) variables (Zhang et al., 2021).

Various analytical tools were employed to examine the data set, including SPSS 29 and AMOS 23 software.

3 Results

Of the 768 respondents, 241 stated that they were or have been involved in an entrepreneurship experience, of which 119 identified as belonging to the female gender.

Frequency analysis was used to understand the distribution of the variables since calculating occurrences allows one to understand the structure of the data, identify patterns, and make informed decisions (see Figure 1).

The results in Figure 1 show that the distribution of the respondents' answers did not follow a normal distribution in almost every characteristic feature except for gender (55.6% female, 42.3% male, 1.4% prefer not to answer, and 0.7% non-binary). Even in the university distribution analysis, it is possible to observe that there is a higher percentage of answers from the students at the University of Macedonia (27.9%), Polytechnic of Guarda (24.3%), and Politecnico of Torino (20.2%) than from the other institutions (University of Salamanca—16.3%, and University of Gdansk—11.2%). The students' nationality is distributed according to the university where the survey was launched. Still, it is interesting to observe that there is a wide range of nationalities since the HEI have students from all over the world. The respondents were the majority from the area of study of technology (43.2%) and engineering (21.4%). They were undergraduates (85.4%) and therefore between 18 and 21 years of age (65%).

On the answer's description analysis (see Figure 2), it was possible to observe that students feel that the major gender issues to overcome

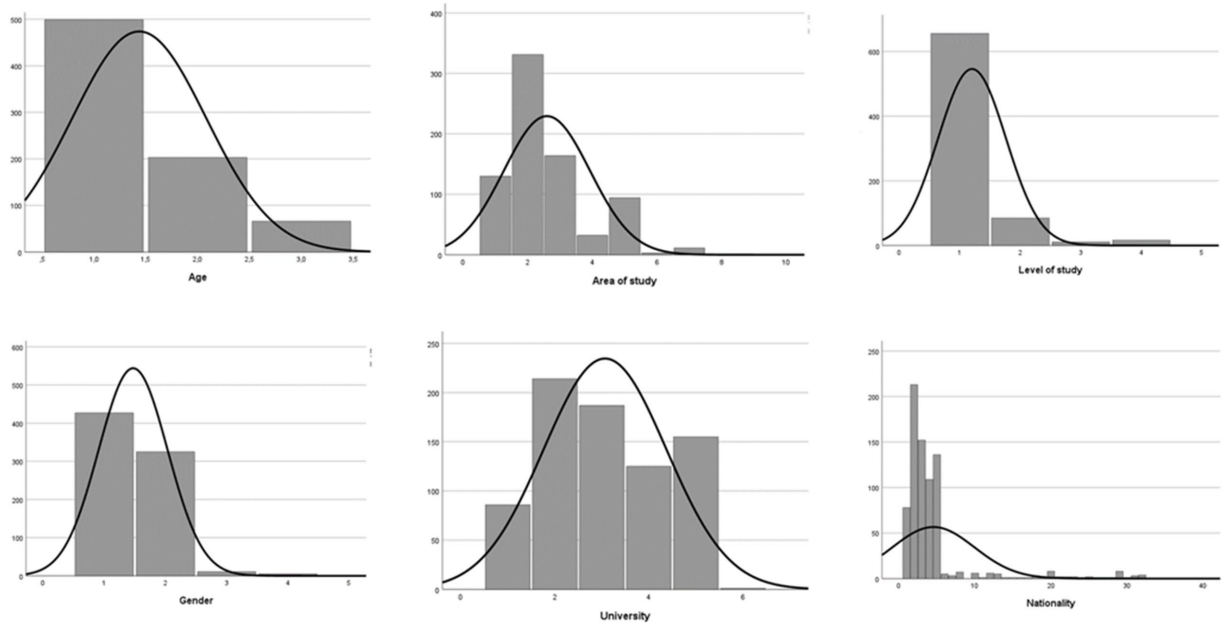

FIGURE 1
Histograms of the frequency analysis of the student's survey responses.

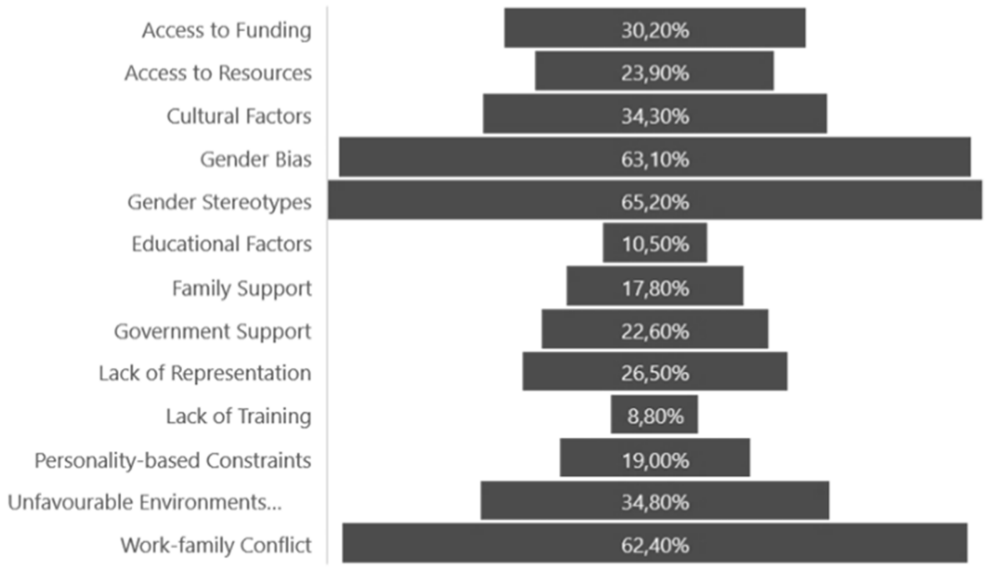

FIGURE 2
Main challenges faced by women entrepreneurs in the student's perspective.

in terms of entrepreneurship are gender bias (63.10%) and stereotypes (65.20%) of society, the unfavorable environments (34.80%) (Business, economic, and political), and the work–family conflict (62.40%). These results typically demonstrate what must be overcome to become an entrepreneur despite all the challenges of creating and developing a business. There seem to be strong contextual and cultural reasons for the gender gap identified.

An Exploratory Factor Analysis (EFA) was developed to investigate latent patterns or relationships for a large number of variables and determine whether the information can be summarized to a smaller set of factors. The exploratory nature of the study was due to the fact that the software was permitted to ascertain the number of factors that were to be reduced. Consequently, a multivariate random process generated new variables derived from the original variables, typically in smaller numbers, which represented the process's commonalities. In order to ascertain the viability of employing factor analysis on the given data set, the Kaiser-Meyer-Olkin (KMO) test was conducted for the purpose of measuring the sampling adequacy. The KMO value was 0.833, indicating a high level of sampling adequacy. Furthermore, Bartlett's Test of Sphericity was significant (Approximately Chi-Square = 1,351,317, df = 36, Sig. < 0.001), confirming the suitability of the data for factor analysis. The commonalities exhibited a range from 0.276 to 0.596, indicating a variation in the extent of shared variance among the variables.

The EFA revealed that two components were extracted, which collectively explained 48.668% of the total variance. The initial component designated "Autonomy" (FAC1_1), accounted for 36.495% of the total variance and encompassed items pertaining to the autonomy to select projects, establish objectives, and shape pedagogical approaches. The second component named "Competences and Recognition" (FAC2_1), accounted for 12.173% of the variance and comprised items pertaining to professional confidence, the competencies acquired through the course, and a sense of belonging with peers. The rotated component matrix, which was subjected to Varimax rotation, provided further clarification regarding the distinct separation of these items into two factors. The autonomy-related items exhibited a strong loading on the first component, while the competence and recognition-related items demonstrated a loading on the second.

In regard to the variables that may be used to characterize the intrinsic motivation for becoming an entrepreneur, the KMO measure for this analysis was 0.806, indicating that the sampling was adequate, and Bartlett's Test of Sphericity was significant (Approximately Chi-Square = 464,104, df = 21, Sig. < 0.001). The communalities ranged from 0.280 to 0.605. The Exploratory Factor Analysis (EFA) extracted a single component that explained 45.859% of the variance. This component designated "Entrepreneurship—I may be an entrepreneur" (E), encompassed all the items, indicating that the intrinsic motivations for entrepreneurship among the students were not differentiated into distinct subcategories but rather constituted a unified factor.

Structural equation analysis was used to examine the relationship between the identified factors and the long-term intention to become an entrepreneur. As illustrated in Figure 3, the results confirm that the test significantly impacts entrepreneurial intentions.

The results indicate a statistically significant estimate of 0.314. This indicates a positive and meaningful relationship between the latent variable "Autonomy" (FAC1_1) and the observed variable "Entrepreneurship - I may be an entrepreneur" (E).

The low standard error and high critical ratio provide further evidence of this relationship's robustness (see Table 1). However, it is important to note that the model does not account for other variables or factors that may influence the results. The standardized regression weight and squared multiple correlation values provide insight into the potential for measurement errors.

The Intercept Estimate of 3.150 for Entrepreneurship (E) is statistically highly significant, as indicated by the critical ratio of 77.384 and the $p < 0.001$. This indicates that Entrepreneurship (E) possesses a robust baseline value, even when all other variables within the model are set to zero. The precision of the estimate, as indicated by a low standard error, reinforces the reliability of this finding.

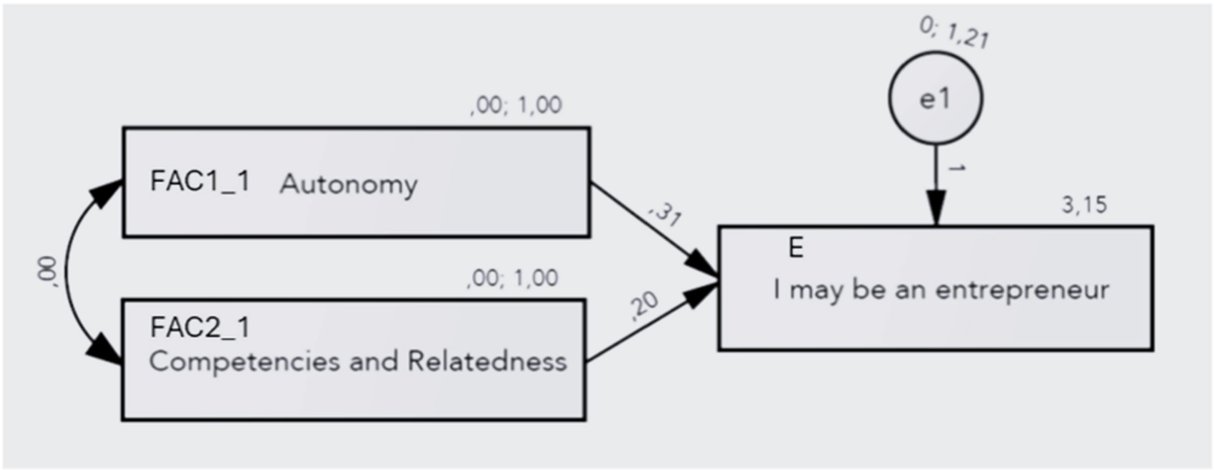

FIGURE 3
Structural equations analysis between factors analysis and the possibility of becoming entrepreneurs.

TABLE 1 Structural equation analysis between factors analysis and the possibility of becoming entrepreneurs.

Maximum likelihood estimates				
Regression weights	Estimate	Standard error	Critical ratio	P label
Entrepreneurship (E) ← Autonomy (FAC1_1)	0.314	0.041	7.702	***
Entrepreneurship (E) ← Competences and Relatedness (FAC2_1)	0.198	0.041	4.861	***
Standardised regression weights				
Entrepreneur (E) ← Autonomy (FAC1_1)	0.270			
Entrepreneurship (E) ← Competences and relatedness (FAC2_1)	0.170			
Intercepts				
Entrepreneurship (E)	3.150	0.041	77.384	***
Squared multiple correlations				
Entrepreneurship (E)	0.102			

***Value less than 0.001, showing that statistics is significant at a very high level of confidence.

TABLE 2 Model fit for factors analysis and the possibility of becoming entrepreneurs.

CMIN model	NPAR	CMIN	DF	P	CMIN/DF
Independence model	3	77.773	6	0.000	12.962
RMSEA model	RMSEA	LO90	HO90	PCLOSE	
Independence model	0.125	0.101	0.150	0.000	
Baselines comparations	TLI rho2	CFI			
Independence model	0.000	0.000			

When reported in a model fit summary (see Table 2), Chi-Square Minimum Discrepancy Function (CMIN) typically includes the Chi-square value, its associated degrees of freedom, and the *p*-value. This is a crucial indicator of how well the proposed model fits the observed data. The elevated chi-square value (CMIN = 77.773) in conjunction with the low degrees of freedom (DF) (DF = 6) gives rise to a high CMIN/DF ratio (12.962), which signifies an inadequate fit. Additionally, the *p*-value of 0.000 indicates that the model does not adequately fit the data. This conclusion is corroborated by the elevated Root Mean Square Error of Approximation (RMSEA) and the low PCLOSE (*p*-value for Test of Close Fit), which indicate that the model does not adequately represent the observed data. The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) both yield a value of 0.000, indicating an extremely poor fit. This is further corroborated by the RMSEA and the Probability of Close Fit (PCLOSE), which also suggest a poor fit. It can thus be concluded that the model is not a well-fitting one, with significant discrepancies between the hypothesized model and the observed data. It would be prudent to

undertake a revision of the model structure with a view to improving the model fit. This might entail the addition or removal of paths, a re-evaluation of the measurement model, or an exploration of alternative model specifications.

The tested model was also subjected to an analysis of its original variables. The results indicated that the likelihood of pursuing an entrepreneurial career is influenced by three key factors: the ability to select study goals, a sense of confidence, and the perception of belonging among peers. These findings are illustrated in Figure 4.

The results indicate that only path E (I may become an entrepreneur-Entrepreneurship) ← C1 (I feel confident), with an estimate of 0.069, is statistically significant. This is evidenced by the critical ratio of 1.593 and the $p < 0.001$. This indicates that C1 has a significant positive impact on E. The precise estimate and high significance level suggest that C1 explains a meaningful portion of the variance in E in this model (see Table 3).

Notably, despite the relationship's lack of significance, C3 exhibits a modest negative correlation with E. The Intercept Estimate of 1.318 for E is statistically significant, as evidenced by a critical ratio of 4.769 and a $p < 0.001$. This indicates that the baseline value of E is 1.318, independent of the influence of other predictor variables. The Intercept provides crucial insight into the baseline level of E in the model.

Nevertheless, the model fit analysis yielded comparable outcomes to those previously observed, with CMIN, RMSEA, TLI, and CIF indices indicating a relatively weak model fit (Table 4). This may be attributed to the presence of a biased sample, which exhibits a non-normal distribution in certain variables, as previously described.

The structural analysis results indicated a robust interdependence between the identified factors and the likelihood of pursuing entrepreneurial endeavors over the long term, with a particularly pronounced interdependence observed in the context of the autonomy factor. A comprehensive examination of the variables constructed for the survey pertaining to the Self-Determination Model reveals that this correlation persists. It is noteworthy that the Autonomy variable, which represents "and the Competence variable, which represents "have a more pronounced impact on the likelihood of becoming entrepreneurs over the long term.

It is regrettable that the model fit generated in both structural analyses was unsatisfactory due to the bias of some of the sample variables.

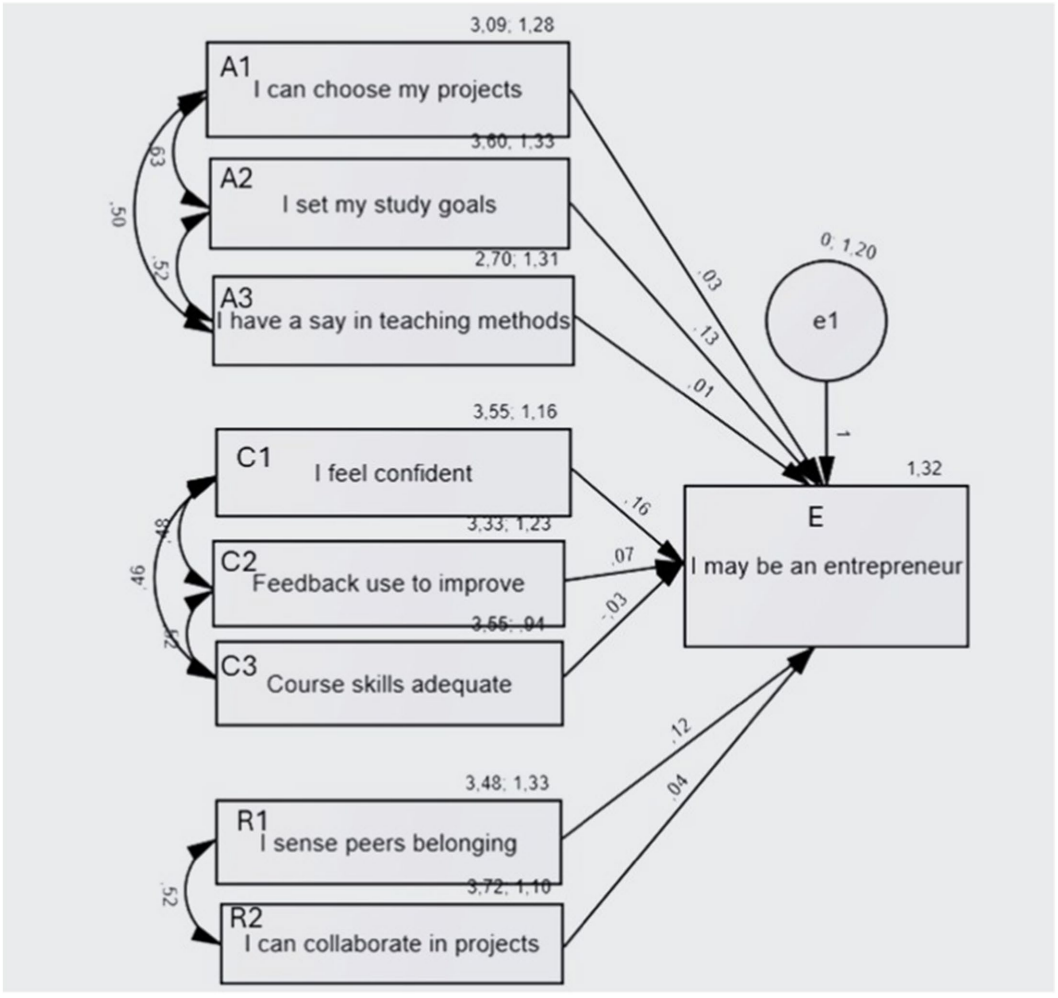

FIGURE 4
Structural equation analysis between self-determination variables and the possibility of becoming entrepreneurs.

TABLE 3 Structural equation analysis between self-determination variables and the possibility of becoming entrepreneurs.

Maximum likelihood estimates				
Regression weights	Estimate	Standard error	Critical ratio	P Label
E (I may become an entrepreneur-Entrepreneurship) ← A1 (I can choose my projects)	0.030	0.042	0.707	0.480
E ← A2 (I set my study goals)	0.126	0.041	3.046	0.002
E ← A3 (I have a saying in the teaching methods)	0.013	0.040	0.323	0.747
E ← C1 (I feel confident)	0.158	0.043	3.686	***
E ← C2 (Feedback use to improve)	0.069	0.043	1.593	0.111
E ← C3 (course skills adequate)	−0.025	0.050	−0.502	0.616
E ← R1 (sense peers belonging)	0.116	0.039	2.991	0.003
E ← R2 (I can collaborate in projects)	0.040	0.043	0.933	0.351
Standardised regression weights				
E ← A1	0.030			
E ← A2	0.128			
E ← A3	0.013			
E ← C1	0.150			
E ← C2	0.067			
E ← C3	−0.021			
E ← R1	0.118			
E ← R2	0.037			
Intercepts				
E	1.318	0.276	4.769	***
Squared multiple correlations				
	0.073			

***Value less than 0.001, showing that statistics is significant at a very high level of confidence.

TABLE 4 Model fit for self-determination variables and the possibility of becoming entrepreneurs.

CMIN model	NPAR	CMIN	DF	P	CMIN/DF
Independence model	9	1,441,237	45	0.000	32,027
RMSEA model	RMSEA	LO90	HO90	PCLOSE	
Independence model	0.201	0.192	0.210	0.000	
Baselines comparations	TLI rho2	CFI			
Independence model	0.000	0.000			

4 Discussion

The promotion of gender equality within the field of entrepreneurship is not only a crucial factor in fostering innovation and economic growth but also in addressing significant gaps in research and practice. Notwithstanding the acknowledged significance of gender diversity in entrepreneurship, particularly in the context of STEM fields, a notable research gap persists within the extant literature. In particular, there is a dearth of educational models that are specifically designed to address the constraints that impede women from becoming entrepreneurs in STEM fields.

It is imperative that this gap be addressed, as it entails the formulation of targeted educational frameworks and interventions that equip women with the requisite skills, knowledge, and support to flourish as entrepreneurs in STEM. Concentrating on creating and implementing efficacious educational models can dismantle the obstacles that impede women's entry and success in these fields. This approach not only serves to enhance gender equality but also enriches the entrepreneurial ecosystem with diverse perspectives, thereby driving further innovation and societal advancement. In contemporary educational discourse, fostering environments that enhance student motivation, engagement, and wellbeing has become an increasingly pivotal concern.

Furthermore, an education model that is firmly rooted in SDT provides a comprehensive framework for achieving these objectives, particularly within the context of STEM education. By integrating the principles of SDT (which posits that human motivation and personal growth are deeply rooted in the fulfillment of three basic psychological needs: autonomy, competence, and relatedness), educators can create learning environments that not only support academic achievement

but also promote holistic development, intrinsic motivation, entrepreneurial thinking, and gender equality among students.

A fundamental tenet of this SDT-based education model is the assumption that when students feel autonomous, they are more likely to engage in learning activities with genuine interest and enthusiasm. Teaching practices that are autonomy-supportive empower students to assume responsibility for their own learning, make meaningful decisions, and pursue their own interests. In the context of STEM education, the fostering of autonomy can be further facilitated through the implementation of entrepreneurial projects, which allow students to investigate innovative solutions to real-world problems. Developing critical thinking and problem-solving skills is facilitated by engaging students in projects that align with their interests and passions. These skills are essential for success in both STEM fields and entrepreneurial ventures, and they transcend gender boundaries. By allowing students to pursue their interests and demonstrate their abilities, educational institutions can foster a more equitable environment for all learners.

The issue of competence is addressed by structuring educational experiences in a way that presents students with appropriately challenging tasks and provides opportunities for them to demonstrate their abilities and achieve mastery. When students experience success and observe that their efforts result in concrete improvements, their sense of efficacy and motivation to learn are markedly enhanced. In the context of STEM education, this entails engaging students in hands-on projects, collaborative experiments, and iterative design processes that mirror the challenges and rewards of entrepreneurial activities. This model encourages the utilization of formative assessments and feedback that prioritize growth and development over grades and outcomes. This approach cultivates a mindset that is oriented toward continuous improvement and innovation. By fostering an inclusive environment where all students can demonstrate their competence, educators can help reduce gender gaps in STEM fields and encourage more girls to pursue STEM careers.

The concept of relatedness, which represents the third pillar of SDT, emphasizes the significance of establishing a supportive and inclusive learning environment. Forming positive relationships with educators and fellow students is conducive to developing a sense of belonging and emotional security, which are essential for effective learning. In the context of STEM learning, establishing a collaborative culture, wherein students engage in team-based entrepreneurial projects, cultivates interpersonal competencies and a sense of collective purpose. When students feel a sense of connection and belonging within their learning environment, their engagement and motivation are further reinforced, leading them to contribute creatively and collaboratively to group projects. By cultivating an inclusive environment where diverse perspectives are respected, educators can advance gender equality and ensure that all students feel equally supported and empowered.

The implementation of an SDT grounded education model is not only consistent with the natural developmental tendencies of students but also addresses the broader educational objectives of nurturing well-rounded individuals who are motivated, capable, and socially connected. By integrating this model with entrepreneurial activities in STEM education, students can be prepared to become innovative thinkers and problem solvers, equipped with the requisite skills and mindset to excel in the rapidly evolving global economy. Moreover, the model's emphasis on gender equality guarantees that all students, irrespective of gender, are afforded equal opportunities for success and flourishing.

The Education Model for Women Entrepreneurship in STEM (see Figure 5) provides a framework for understanding the key principles that can enhance autonomy, competence, and relatedness.

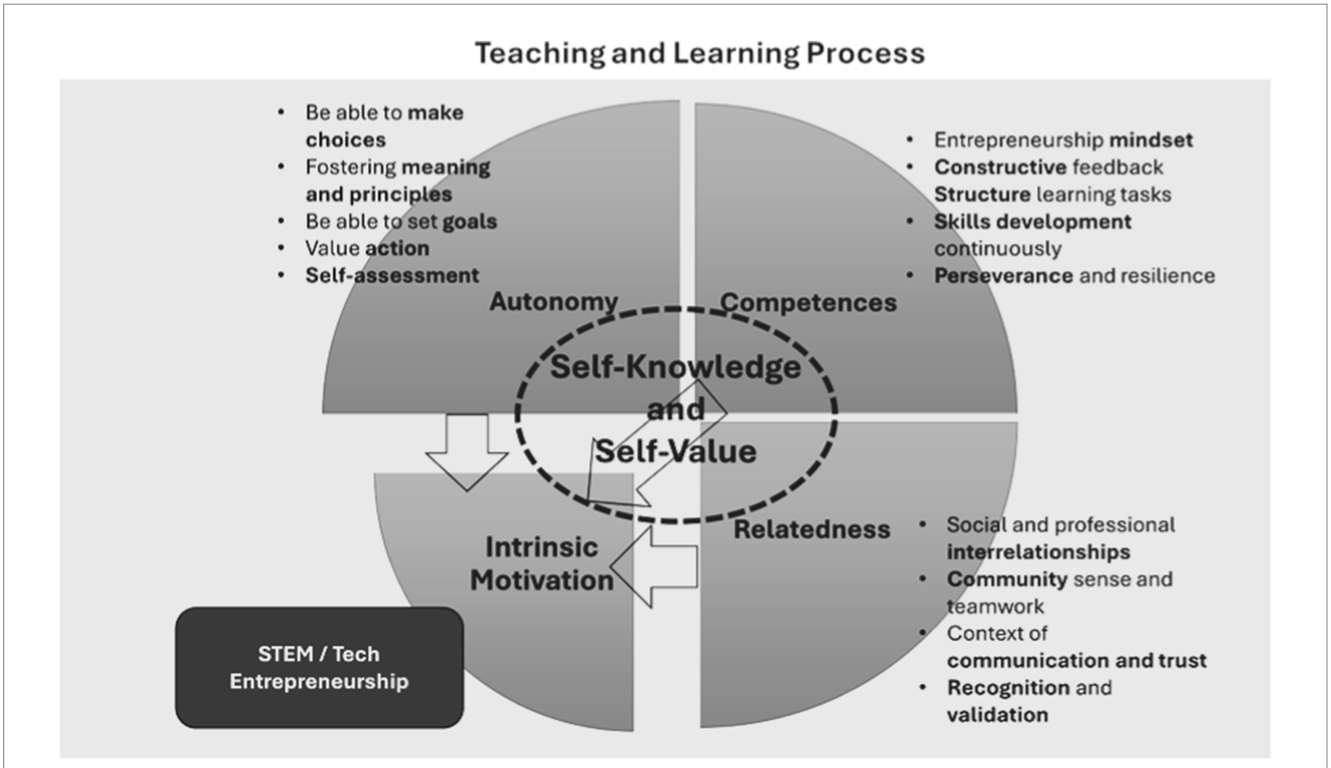

FIGURE 5
Education model guidelines toward women entrepreneurship in STEM.

To promote autonomy among female students, it is essential that lecturers are encouraged to provide students with choices and opportunities for self-direction. This will enable students to choose and achieve personal relevance in learning activities. This entails allowing students to participate in formulating their learning objectives, activities, and assessment methodologies. It is also essential to facilitate comprehension of tasks' relevance and importance and foster a sense of meaning and value that lectures can promote. This is crucial for developing a sense of autonomy and for the coexistence of different learning styles. Moreover, effective communication regarding the objectives of assignments facilitates students' comprehension of the relationship between their efforts and the desired outcomes. Ultimately, equipping students with the tools for self-assessment and minimizing superfluous external pressures and rewards facilitates a sense of responsibility and decision-making, thereby empowering them.

The advancement of competence, particularly within the domain of entrepreneurship, is of paramount importance in fostering an entrepreneurial mindset. Incorporating creative thinking, critical analysis and applying problem-solving techniques within the curriculum enables students to perceive the practical applicability of their studies. It is similarly important to promote constructive feedback, provide guidance on learning tasks and offer opportunities for skill development, given that lectures are crucial in creating a learning environment that supports students in developing and demonstrating competence. The emphasis on the intrinsic rewards of learning and the inherent satisfaction of mastering a skill or understanding a concept will facilitate a search for continuous improvement, foster curiosity and encourage students to explore topics of interest. Furthermore, it is vital to instill the belief that skills can be developed through effort and perseverance in the context of entrepreneurship.

The research findings indicated that social and professional relationships within the classroom (between peers) are crucial in fostering a sense of relatedness. Lectures can facilitate the formation of a sense of community by fostering collaboration, teamwork, and positive social interactions within a context of trust, open communication, and accountability. Recognizing and validating students' perspectives, interests, and contributions foster a positive relationship between students and lecturers.

5 Conclusion

Promoting gender equality in entrepreneurship, particularly in STEM fields, has been demonstrated to foster innovation and drive economic growth. Notwithstanding its acknowledged significance, a conspicuous research gap persists regarding developing educational models specifically designed to support women entrepreneurs in STEM fields. Creating bespoke educational frameworks is essential to address this gap and equip women with the requisite skills and resources.

The proposed educational model, based on the principles of SDT, seeks to foster the development of autonomy, competence, and relatedness among students engaged in STEM subjects. This approach is designed to cultivate intrinsic motivation and an entrepreneurial mindset. It aims to establish inclusive learning environments that address gender disparities in STEM and provide all students with the tools to succeed in the global economy.

These findings reveal that SDT complies with the entrepreneurial mindset development pursuit in Europe and in the HEI education strategies. Still, it is far from being implemented by the majority of the teachers or, at least, impacting the students' learning process and competence achievement. A different paradigm of understanding the HEI system is needed for the lectures to incorporate entrepreneurship as a transversal skill across the content of the courses, programs, and curriculum.

To be tested, this model has to design a training program focused on the results achieved. Therefore, this is a limitation of the present research. However, different programs and pedagogies can be combined to help lecturers understand and implement these concepts in their classrooms. Many projects are being developed to promote entrepreneurship education in female students (e.g., Academy for Women Entrepreneurs; ACT on Gender) but are isolated efforts that are not integrated within an education model as this paper proposes. So, the positive contributions to the education discussion and definition of policies/strategies are key to potentiating and effectively impacting a new way of looking at HEI education, particularly in the STEM area, which is still too concerned about program and curriculum compliance (Rifandi and Rahmi, 2019).

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of the Polytechnic Institute of Guarda. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

TP: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. TF: Methodology, Resources, Writing – original draft, Writing – review & editing. CA: Methodology, Resources, Writing – original draft, Writing – review & editing. NG: Methodology, Resources, Writing – original draft, Writing – review & editing. SS: Formal analysis, Investigation,

Writing – original draft, Writing – review & editing. MS: Formal analysis, Investigation, Writing – original draft, Writing – review & editing.

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Conflict of interest

SS and MS were employed by the INOVA+, Innovation Services S.A.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2024.1474584/full#supplementary-material

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