Assessing the impact of entrepreneurial innovation training on Portuguese nursing students: A before-and-after study

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Abstract

Nursing students often lack the entrepreneurial competencies needed to drive innovation in contemporary healthcare settings, where creative problem-solving is critical to enhancing client outcomes and service delivery. While nursing professionals are often uniquely positioned to identify gaps in care, they may be underprepared to convert these insights into practical solutions due to insufficient entrepreneurial training.

This study evaluated the effectiveness of a structured educational intervention, grounded in the European Union's EntreComp framework, to enhance entrepreneurial competencies among senior undergraduate nursing students (N=268). The intervention focused on the three core dimensions of "Ideas and Opportunities", "Resources", and "In Action", using a validated self-assessment instrument (α=.951–.978). The intervention, targeting the core dimensions of "Ideas and Opportunities," "Resources," and "In Action," led to statistically significant improvements across all areas.

These findings underscore the practical relevance of integrating entrepreneurial principles into nursing education to cultivate adaptability, innovation, and reflective practice. By enabling emerging professionals to generate viable ideas, mobilize resources effectively, and implement initiatives with tangible impact, this intervention contributes to a workforce better equipped to address complex healthcare challenges. Consequently, the inclusion of entrepreneurial innovation education in nursing curricula may foster a culture of proactive leadership, thereby facilitating sustainable improvements in clinical practice and healthcare service delivery.

Keywords: Competency Development; EntreComp Framework; Entrepreneurship; Higher Education; Innovation.

Introduction

Higher education institutions (HEIs) play a pivotal role in fostering knowledge creation and entrepreneurial activity, contributing significantly to economic growth and societal innovation (Xu et al., 2020). Universities fulfil two primary roles in this field, by diffusing knowledge through teaching and generating new insights through research (Audretsch, 2009). In this context, entrepreneurial innovation education in HEIs seeks to cultivate students' skills, attitudes, and intentions towards entrepreneurship (Maresch et al., 2016). Research shows that students exposed to entrepreneurial innovation education demonstrate greater entrepreneurial intentions than their peers without such training (Dwivedula & Chakrabarti, 2022; Fanea-Ivanovici et al., 2024; Gerba, 2012).

Consequently, innovation and entrepreneurship serve as crucial drivers of economic development (Liu et al., 2019).

In recent decades, entrepreneurial innovation education in HEIs has emphasized developing competencies that prepare students to navigate market challenges (Marques et al., 2018). Boldureanu et al. (2020) highlight that such education enhances students' attitudes, skills, and knowledge while fostering intentions to engage in entrepreneurial activities. Programs using interactive pedagogical approaches — such as simulation, debates, and problem-solving exercises — are particularly effective in bridging theoretical concepts and practical applications in this field (Béchard & Grégoire, 2005). These approaches create immersive learning environments where students can develop real-world skills, preparing them for the complexities of the business environment (Mónico et al., 2021).

HEIs in Portugal have actively supported entrepreneurial innovation education by developing training programs that enhance students' self-efficacy, creativity, and problem-solving skills (Marques, 2019; Mónico et al., 2021). Unlike general entrepreneurship education, which often focuses on launching and managing businesses, entrepreneurial innovation education centers on fostering innovative mindsets and equipping students to address complex, real-world challenges (Mónico et al., 2021; Sousa et al., 2018). These programs enable students to identify and capitalize on opportunities for creating value, both within established organizations and through new ventures (Mónico et al., 2021). Practical components, such as interactions with entrepreneurs and participation in real-world learning spaces like incubators, further enhance the effectiveness of such initiatives (Mele et al., 2024).

A growing number of HEIs have begun to adopt and adapt the European Union's Entrepreneurship Competence (EntreComp) framework — a comprehensive model that delineates the knowledge, skills, and attitudes underpinning entrepreneurial competence across various educational and professional settings (Del Mar Sánchez Vera & Vicent, 2024; Seikkula-Leino et al., 2021). The EntreComp framework structures these competencies into three main areas — Ideas and Opportunities, Resources, and Into Action — enabling educators to design targeted curricula and assessments (Bacigalupo et al., 2016; Dias-Trindade et al., 2020). This systematic approach is particularly relevant in healthcare contexts, where recognizing opportunities, mobilizing resources, and effectively implementing innovations are all essential for driving improvement (Huang et al., 2021). Thus, by providing clear learning outcomes and practical guidance, the EntreComp framework offers a robust scaffold for integrating entrepreneurship education into nursing programs, ensuring that learners acquire not only theoretical insights but also the tangible competencies needed for effective innovation in clinical settings.

Building on the EntreComp framework, competency-based approaches to entrepreneurial innovation education further emphasize real-world problem-solving and collaboration with industry professionals, thereby enhancing the relevance and impact of academic programs. Such approaches, which align academic training with labor market demands, have proven to be particularly impactful (Morris et al., 2013), promoting adaptability, resilience, and creativity, which are skills essential in today's dynamic professional environments (Almaleh et al., 2019). This alignment is particularly relevant in nursing, where professionals are uniquely positioned to translate innovative competencies into impactful healthcare solutions.

Nurses are the backbone of every healthcare system in the world. As the largest professional group in the health sector across Europe, they are primarily responsible for care delivery across all levels of the healthcare system, from primary to tertiary care. Nurses' unique and privileged contact with patients, families, and communities positions them ideally to identify emerging health needs and devise practical and sustainable solutions. Thus, the relevance of entrepreneurial innovation education is increasingly recognized in nursing, where the growing complexity of healthcare systems demands creative and adaptive solutions.

Nurses equipped with entrepreneurial innovation competencies can identify service gaps, propose innovative solutions, and implement these ideas through start-ups or intrapreneurial initiatives within healthcare

organizations (Bagheri & Akbari, 2018; Wilson et al., 2012). Such competencies empower nurses to design novel care models, including autonomous clinics or specialized health education programs, thereby improving patient outcomes and service delivery (Parreira et al., 2018). Beyond technical skills, entrepreneurial innovation education cultivates leadership, decision-making, and resource management — attributes critical for addressing evolving challenges in healthcare systems (Béchard & Grégoire, 2005). Despite increasing recognition of the importance of entrepreneurial innovation in nursing, research on training programs specifically tailored to nursing students remains limited. While Europe is home to leading nursing education institutions and research organizations, the nursing profession lags behind others in fostering a cohesive innovation agenda. This disparity is evident in the comparatively lower emphasis on activities such as licensing, patenting, and new venture creation within the field.

Addressing this gap is essential as entrepreneurial innovation education equips nurses with the competencies required to navigate intricate healthcare systems, devise creative interventions, and spearhead meaningful change in practice. This study aims to advance the field by examining the impact of a tailored educational program, underpinned by the EntreComp framework, on senior undergraduate nursing students' perceptions of their entrepreneurial innovation competencies. By situating this study within the EntreComp framework, we provide a structured lens through which to evaluate the development of essential entrepreneurial skills in future nursing professionals, thereby fostering a new generation of nurses proficient at translating innovative ideas into tangible healthcare solutions.

Methods

Study Design and Setting

This before-and-after study was conducted at the Nursing School of Coimbra in Portugal, the oldest nursing institution in the country and one of the leading nursing schools in Europe.

In 2023, a group of senior lecturers with expertise in entrepreneurial innovation developed an educational program titled "Innovation and Entrepreneurship in Health", which was later integrated into the nursing bachelor's program as a mandatory. The program consisted of 54 total hours, including 30 contact hours (14 theoretical and 16 practical) and 24 hours of autonomous work, spanning over an academic semester, from November 2023 to January 2024.

Participants and Study Size

All fourth-year nursing students (n = 268) enrolled in the bachelor's program were invited to participate, as the newly introduced educational program was integrated into their curriculum. A convenience and purposive sampling strategy was applied to include those most likely to benefit from and complete the program. Eligibility criteria required that participants be full-time students, regardless of prior degrees or formal training. Part-time students and those in short-term mobility programs were excluded to minimize post-test bias. Students who did not provide consent were also excluded. Recruitment occurred during the opening session of the educational program, immediately before the baseline (t0) data collection.

Tailored Education Program

The educational program was meticulously developed to address the specific needs of nursing students, fostering competencies in the cognitive, reflective, metacognitive, operative, and psycho-affective domains. The primary objective of the program is to prepare students for the complex and rapidly evolving demands of healthcare innovation, equipping them with essential skills to tackle real-world challenges and contribute to value creation in society. This focus aligns with the broader aim of empowering students to integrate creativity and strategic thinking into their professional nursing practice.

Given the absence of a pre-existing structured curriculum in innovation and entrepreneurship within the healthcare domain, the program was designed based on a comprehensive analysis of national and international programs in these fields. Subsequently, the content was adapted to the healthcare context. This process drew

on the extensive practical expertise of the faculty, which includes up to 37 years of experience in nursing, ensuring contextual relevance and alignment with evidence-based practices.

Program Structure

The curriculum was structured to provide a balanced blend of theoretical instruction, theoretical-practical sessions, and autonomous student work, totaling 54 hours. This comprehensive approach ensured that students gained both foundational knowledge and hands-on experience, fostering a deep understanding of the subject matter. The program used a multidisciplinary approach, seamlessly integrating theoretical frameworks with practical applications to prepare students for real-world challenges in entrepreneurship and innovation within the healthcare sector.

Key topics covered in the program's curriculum included the entrepreneurial process, from the initial stages of idea generation to the goal of value creation. Students are introduced to various ideation and creative techniques, such as brainstorming, SCAMPER, design thinking, and brainwriting, to equip them with tools to generate innovative solutions. The curriculum also included business plan development, encompassing essential components like SWOT analysis, PESTEL analysis (Political, Economical, Social, Technological, Environmental, and Legal dimensions), and financial planning. Additionally, students explore critical aspects of intellectual property and legal considerations, including patent registration, utility models, design, trademarks, and copyrights, ensuring they understand the legal landscape of innovation. The evaluation of Technology Readiness Levels (TRL) was also a focal point, enabling students to assess the maturity of their technological solutions. Practical examples drawn from clinical practice further enriched the learning experience, with a particular emphasis on the development of medical devices and innovative solutions tailored towards the social and healthcare sectors. These examples were carefully selected to inspire students to identify entrepreneurial opportunities that directly enhance patient safety, quality of care, and overall healthcare outcomes.

To achieve these goals, the program adopted a participatory and constructivist pedagogical approach, emphasizing active and collaborative learning. The methodology was designed to engage students through a variety of interactive and practical activities. Interactive lectures, supported by audiovisual resources, introduced fundamental concepts in an engaging manner, while group dynamics and case studies foster teamwork, critical thinking, and creative problem-solving. Text analysis and practical exercises allowed students to examine real-world case studies and articles, contextualizing theoretical knowledge within practical scenarios. A significant component of the program was the development of innovative project ideas, where students were guided through a structured template to articulate their concepts. This template included a summary description of the innovative idea, highlighting its primary characteristics and degree of innovation; identification of the problem or unmet need, supported by theoretical foundations and evidence from databases, reports, or market studies; a detailed value proposition, including competitor analysis and the strengths and weaknesses of the proposed solution; a market study and future perspectives, identifying target audiences and analyzing growth potential; and a strategic plan, incorporating SWOT analysis, marketing strategies, and financial projections.

To further support students, the program provided personalized mentorship, with groups of 5 to 8 students receiving continuous guidance from faculty members. This mentorship ensured that students receive constructive feedback and tailored advice to refine their projects, fostering a supportive learning environment that encourages innovation and excellence. Through this complex but engaging approach, the program equips students with the skills, knowledge, and mindset necessary to become effective entrepreneurs and innovators in the healthcare sector.

The assessment framework was meticulously designed to evaluate both individual and collective performance, ensuring a comprehensive integration of theoretical knowledge with practical applications. Central to this framework was the Innovative Idea Project, which accounted for 15 points and involved a written evaluation of the final proposal. Students were required to follow a structured template, demonstrating their ability to articulate theoretical concepts effectively while developing innovative and practical solutions to real-world challenges. This component emphasized not only the depth of their understanding but also their capacity to translate ideas into actionable proposals.

In addition to the written component, the assessment included an Oral Presentation, valued at 3.5 points, which took the form of a pitch. This element was designed to evaluate students' communication skills, clarity of expression, and their ability to defend their ideas convincingly in an academic setting. The pitch format encouraged students to present their proposals succinctly and persuasively, mirroring real-world scenarios where the ability to communicate complex ideas effectively is paramount.

Furthermore, the framework incorporated a Participation in Activities component, worth 1.5 points, which employed qualitative criteria to assess students' active engagement in group dynamics and classroom debates. This aspect of the evaluation emphasized the importance of collaboration, critical thinking, and constructive dialogue. To complement this, students were required to submit a critical written reflection on the curricular unit, providing insights into their learning journey, their contributions to group activities, and their personal growth throughout the process. Together, these components created a holistic assessment approach that not only measured academic and practical competencies but also fostered a culture of active participation, reflection, and continuous improvement.

In addition to technical proficiency, the program places a strong emphasis on fostering interpersonal skills such as teamwork, leadership, and effective communication. These competencies are crucial for collaborating across diverse teams and leading initiatives that drive meaningful changes in healthcare. Furthermore, the program nurtures a culture of entrepreneurial innovation, encouraging students to think creatively and strategically. This mindset not only enhances their ability to address current challenges but also empowers them to create value for society by anticipating and leveraging emerging opportunities.

Thus, by aligning with the best pedagogical practices and integrating cutting-edge innovation methodologies, the program positions students as key agents of transformation in the healthcare sector. It equips them with the tools and mindset necessary to thrive in complex and dynamic environments, preparing them to tackle pressing challenges and seize opportunities that contribute to the advancement of healthcare systems globally. Through this holistic approach, the program aims to develop future leaders who are not only skilled and knowledgeable but also deeply committed to driving positive changes in the field of healthcare.

Variables and Data Sources

The study primarily focused on assessing students' entrepreneurial innovation competencies, using the European Union's Entrepreneurial Competence Framework (EntreComp) as a guide. EntreComp outlines 15 competencies divided into three domains: Ideas and Opportunities (D1), Resources (D2), and In Action (D3) (Bacigalupo et al., 2016). According to the original authors, these 15 competencies are interrelated and should be considered as a cohesive whole.

To measure these competencies, an anonymized, paper-based self-assessment questionnaire was administered to students at two points: during the first session (before the educational intervention) and at the final session (after the groups had presented their projects). The questionnaire consisted of two sections. The first section gathered sociodemographic information, including details about previous training in entrepreneurial innovation and any close contact students may have had with entrepreneurs within their families or communities. The second section was based on the competency descriptors of EntreComp, comprising 60 closed-ended questions scored on a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Internal consistency ranged from .951 (Ideas and Opportunities) to .978 (In Action), with a Cronbach's alpha of .968 for Resources. The questions were based on the previously official translation to European Portuguese of EntreComp (Dias-Trindade et al., 2020).

Final scores were interpreted using a level progression model, where lower scores indicated a foundation level of competency, and higher scores reflected an expert-like development in entrepreneurial innovation (Table 1). The average time to complete the questionnaire was approximately 30 minutes.

Table 1: Threshold values for profiles by dimension.

Profile	D1	D2	D3
No defined profile	0–24	0–23	0–24
Foundation	25–53	24–63	25–63
Intermediate	54–89	64–103	64–103
Advanced	90–124	104–140	104–146
Expert	125–142	141–156	147–161

Source: Developed by authors.

Statistical Methods

The statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS, version 29.0; SPSS Inc., Chicago, IL). The normality of the variables was assessed using skewness (Sk) and kurtosis (Ku) coefficients, with thresholds set at $|Sk| < 3$ and $|Ku| < 10$, as per established guidelines for large-sample data. No variables were found to violate the assumption of normality during this preliminary assessment, ensuring the suitability of parametric statistical techniques.

Inferential analysis was conducted to evaluate the impact of the training program on participants' performance across the three skill domains: ideas, resources, and action. This analysis compared pre-test and post-test average scores to determine whether the observed differences were statistically significant and reflected meaningful improvements.

To address missing data, a regression imputation method was employed to estimate and replace missing values (Refaat, 2007). This approach leverages relationships among the observed variables to predict missing values, preserving the integrity and consistency of the dataset.

Ethics

This study adhered strictly to the ethical principles outlined in the Declaration of Helsinki, ensuring the protection of participants' rights, dignity, and well-being throughout the research process. Participation in the study was entirely voluntary, and students were provided with a detailed briefing about the study's objectives, procedures, potential risks, and benefits prior to their enrollment. Written informed consent was obtained from all participants, affirming their understanding of the study and their willingness to take part.

To maintain confidentiality, measures were implemented to safeguard participants' data. Anonymity was ensured by not collecting any personally identifiable information, and data were analyzed in an aggregated format to prevent the identification of individual responses. Additionally, participants were informed of their right to withdraw from the study at any time, without providing justification and with no consequences to their academic standing or participation in related coursework. Researchers made every effort to minimize any potential discomfort or burden on participants, emphasizing transparency and respect throughout the study process.

Results

During the initial phase of the study (t0), a total of 268 students from four different senior year classes agreed to participate by completing the self-assessment questionnaire. This cohort represented approximately 87.0% of the entire senior year population, ensuring a robust and representative sample for the baseline assessment. The high initial participation rate reflects the students' interest and the relevance of the study's objectives to their academic and professional development.

However, due to the burden associated with the response time required for the comprehensive self-assessment scale, it was deemed necessary to limit the post-assessment (t1) phase to a more manageable subset of participants. To address this, one class was randomly selected from the original cohort to complete the

questionnaire after the educational intervention. This decision aimed to reduce the potential fatigue and time burden for the entire cohort while maintaining the validity and reliability of the study's findings.

As a result, 52 students (19.4% of the original cohort) from the randomly selected class participated in the post-intervention self-assessment. This smaller sample size was deemed sufficient to provide meaningful insights into the changes in students' scores across the three assessed skill domains. Random selection ensured that the subgroup was representative of the broader cohort, minimizing selection bias. Detailed results for each subgroup, organized by study phase, are presented below.

This approach reflects a balanced consideration of logistical constraints, participant well-being, and the integrity of the study design. By focusing the post-intervention assessment on a random sample, the study was able to maintain its methodological rigor while respecting the time and effort required from participants.

Assessment Before the Educational Intervention

The average age of respondents was 22.47 years (SD = 4.81), indicating moderate variability around the mean (Table 2). Gender distribution revealed a predominance of female participants (*n* = 229; 85.4%), consistent with demographic trends in Portuguese nursing programs.

A total of 69 students (25.7%) reported having family members who are entrepreneurs, while 67 students (25.0%) identified themselves as entrepreneurs. Similarly, 65 students (24.3%) indicated they had previously conceived an innovative idea, reflecting a reasonable degree of creativity and opportunity recognition within the group. Among those who had innovative ideas, 15 (23.1%) had successfully implemented them, highlighting a moderate transition rate from ideation to execution. This finding suggests an opportunity to explore potential barriers to innovation and implementation within this cohort.

Furthermore, 252 respondents (94.0%) acknowledged being exposed to entrepreneurship concepts within their HEI, indicating widespread availability of entrepreneurship-related education and resources in their academic setting.

Table 2: Demographic and background characteristics by group.

	Mean (SD) Min-Max	**p-value G1 vs G2**
Age	22.47 (4.81) 20–56	.834[1]
	n (%)	**p-value G1 vs G2**
Nationality (*n* = 268)		.707[2]
Portuguese	256 (95.5)	
Brazilian	12 (4.5)	
Gender (*n* = 268)		.124[2]
Male	38 (14.2)	
Female	229 (85.4)	
Rather not say	1 (.4)	
Marital status (*n* = 268)		.951[3]
Single	251 (93.7)	
Civil partnership (*união de facto*)	5 (1.9)	
Married	11 (4.1)	
Widower	1 (.4)	
Experience with mobility programmes, yes (*n* = 268)	67 (25.0)	.074[3]
Entrepreneurs in the family, yes (*n* = 268)	69 (25.7)	.829[3]
Professional activity (*n* = 268)		.122[3]
No	228 (85.1)	

Yes, as an employee	25 (9.3)	
Yes, self-employed	15 (5.6)	
Do you consider yourself an entrepreneur, yes (n=268)	67 (25.0)	.721[3]
Have you ever had an innovative idea, yes (*n* = 268)	65 (24.3)	.561[3]
Did you implement that idea, yes (*n* = 65)	15 (23.1)	**.014**[3]
Have you heard about entrepreneurship in your institution, yes (*n* = 268)	252 (94.0)	.754[3]

[1] Pearson correlation; [2] Student's t-test; [3] Chi-Square test

Source: Developed by authors.

In the initial assessment, students scored an average of 56.17 (SD = 24.59) in the *Ideas and Opportunities* domain (D1), with scores ranging from 0 to 128. The distribution of profiles showed that most students were in the foundational profile (44.4%, *n* = 119), followed by the intermediate profile (38.4%, *n* = 103). A smaller proportion of students self-assessed themselves at the advanced (9.7%, *n* = 26) and expert (0.7%, *n* = 2) levels.

In the *Resources* domain (D2), the average score was 65.68 (SD = 30.00), with scores ranging from 0 to 156. Here, half of the students (50.0%, *n* = 134) were in the foundational profile, while 33.2% (*n* = 89) were at the intermediate level. A smaller proportion achieved the advanced (10.8%, *n* = 29) or expert (1.5%, *n* = 4) levels.

In the *In Action* domain (D3), students had an average score of 73.41 (SD = 34.34), with a range from 0 to 152. The distribution of profiles showed 38.4% (*n* = 103) at the foundational level, 31.0% (*n* = 83) at the intermediate level, and 23.5% (*n* = 63) at the advanced level. Only 1.5% (*n* = 4) of students self-assessed at the expert level in this domain.

Assessment After the Educational Intervention

Among the sub cohort that scored the questionnaire for a second time (*n* = 52), the distribution of profiles in each domain showed a predominance of intermediate-level students. For the *Ideas and Opportunities* domain (D1), 42.3% (*n* = 22) of students were at the intermediate level, followed by 30.8% (*n* = 16) at the advanced level and 21.2% (*n* = 11) at the foundational level. In the *Resources* domain (D2), 48.1% (*n* = 25) were at the intermediate level, 28.9% (*n* = 15) at the advanced level, and 21.2% (*n* = 11) at the foundational level. Concerning the *In Action* domain (D3), 44.3% (*n* = 23) were intermediate, 34.6% (*n* = 18) were advanced, and 19.3% (*n* = 10) were at the foundational level. Expertise was minimally represented, with only 3.8% (*n* = 2) achieving expert-level self-assessment in the *Ideas and Opportunities* domain, and no students reaching the expert level in the *Resources* or *In Action* domains.

A comparison of the average EntreComp scores for this post-intervention cohort with those of the initial sample revealed no statistically significant differences between the two groups (Table 3).

Table 3: Comparison of scores between the one-assessment and two-assessment groups before the educational intervention.

	Mean (SD)[1] Group 1	Mean (SD)[2] Group 2	t	p-value	Cohen *d*
t0 - Ideas and Opportunities	56.88 (24.95)	53.21 (23.03)	.966	.335	.153
t0 - Resources	66.02 (30.19)	64.23 (29.40)	.386	.700	.060
t0 - In action	74.71 (34.95)	68.02 (31.44)	1.262	.208	.201

[1] n = 216;[2]n = 52

Source: Developed by authors.

Before and After the Educational Intervention Comparison

The inferential statistical analysis, conducted exclusively on students who completed both assessments, revealed significant differences before and after the educational intervention. As detailed in Table 4, we found statistically significant differences in students' self-assessment scores across all three EntreComp domains.

Table 4: EntreComp scores comparison before (t0) and after (t1) the educational Intervention.

	n	Mean (SD) Min-Max	difference between t0-t1			
			t	p-value	*d*	*d* CI 95%
D1	52	76.54 (28.16) 18-131	-5.51	<.001	-.764	-1.071; -.452
D2	52	81.31 (30.13) 22-139	-4.38	<.001	-.607	-.901; -.308
D3	52	86.94 (31.00) 22-146	-4.50	<.001	-.623	-.918; -.323

D1 — Ideas and Opportunities; D2 — Resources; D3 — In action

Source: Developed by authors.

Discussion

Based on a detailed analysis of the sample's descriptive statistics, it is possible to observe specific characteristics that help to contextualize and interpret the effects of the training. Firstly, most students report little previous experience in entrepreneurial environments, with only 25.0% considering themselves entrepreneurs and 25.7% reporting a family history of entrepreneurship. This data suggests that the students started the training with limited knowledge of entrepreneurship, which may have intensified the impact of the intervention, as the training introduced new skills and approaches for most of the participants. Family experience in entrepreneurship, when present, acts as a moderating factor, strengthening students' self-confidence and efficacy during entrepreneurial training. This relationship can positively influence the response to training, especially among students who do not have a previous solid foundation in entrepreneurship, making them more receptive to the new skills acquired (Sousa et al., 2018). In addition to this aspect, some studies indicate that entrepreneurship training has a more significant effect on individuals with little or no previous business experience. This is because intensive training introduces skills and increases self-efficacy among participants who initially have limited knowledge, favoring the absorption of new practices and concepts (Lyons & Zhang, 2018; Michaelides & Davis, 2016).

In addition, the demographic composition of the sample demonstrated a predominantly young and studying full-time, with an average age of 22.47 years and 85.1% not working, indicating a profile of students still in the early stages of their careers. This profile may influence their receptiveness and plasticity to new learning and skills, particularly in areas that have not yet been explored, such as entrepreneurship in the context of nursing. The lack of professional experience may paradoxically have facilitated the adoption of entrepreneurial skills, since the students were less anchored in pre-established practices. Training young entrepreneurs, especially those without significant professional experience, tends to have a more profound impact, as they are less anchored in established practices and more open to new approaches. This youthful profile favors a cognitive plasticity that facilitates the internalization of entrepreneurial skills, as suggested by studies that observe that youth and a lack of consolidated experiences amplify the positive effect of training on self-efficacy and innovation (Gielnik et al., 2017; Urban, 2020).

The predominance of female students (85.4%) is in line with the profile present in Nursing, which is also relevant given that some studies suggest gender differences in self-efficacy and entrepreneurial intentions. This predominant female profile, combined with low prior exposure to entrepreneurship, may have influenced both the initial response to the training and the self-critical reassessment of their competences after the intervention (Molino et al., 2018; Polin, 2022).

Regarding the impact of the training, the results show significant gains in the average scores of all three EntreComp domains ("Ideas and Opportunities", "Resources" and "In action") after the intervention. These

findings are in line with the literature, namely the study by Boldureanu et al. (2020), which indicates that entrepreneurship education plays a central role in the development of innovative skills, attitudes and behaviors, especially when programs are structured to explore specific skills in real contexts. The finding that all three domains benefited from the training suggests that the program was effective in providing a balanced educational experience that enables students to develop both the ability to Ideas and Opportunities and to mobilize resources and act innovatively.

This improvement in multiple practical competences is also consistent with the arguments of Béchard and Grégoire (2005), who argue that training based on competency models - especially that focused on solving concrete problems and interacting with the professional environment - generates a deeper and more lasting impact on the development of competences. The practical application of knowledge, combined with interactive and dynamic methodologies such as projects and simulations, facilitates an effective transition from theory to practice, which is reflected in the students' gain in competences in the three EntreComp domains.

Additionally, the results support the notion that exposure to teaching methodologies based on challenges and problem-solving allows for growth that transcends technical competences, including the development of a resilient and adaptable mindset. This is particularly relevant to the field of nursing, where the ability to innovate and identify creative solutions becomes essential in a constantly changing healthcare environment. Nursing students who take part in entrepreneurial training develop a broader perception of healthcare, visualizing new possibilities for implementing changes and improvements, both in traditional clinical settings and in broader entrepreneurial initiatives.

However, the reduction in the Expert profile at time t1 reveals a relevant phenomenon: while the average score increased, the number of students who self-identified at the Expert level decreased. This effect may reflect a more critical and realistic self-perception, something that is common in training contexts that challenge students to reflect deeply on their competences (Liu et al., 2015; Liu et al., 2019). Exposure to new concepts and the need to reflect on specific assessment criteria for each domain may have led students to adopt a more cautious and considered stance in their self-assessment. This change in self-perception, which often occurs in professional maturation processes, demonstrates that the training not only increased competence, but also promoted greater self-awareness, in line with Crespí et al. (2022) study about the challenge and impact of project-oriented entrepreneurial education.

Limitations

Our study provides promising evidence of the impact of innovation and entrepreneurship training on the development of entrepreneurial innovation skills and mindset in nursing students, showing significant improvements across the three EntreComp domains. However, data collection after the educational intervention was only possible for approximately one fifth of the initial sample. This limited follow-up may introduce bias, as the characteristics of this subgroup could have influenced the results, reflecting both sample-specific and contextual factors.

While these limitations do not undermine the findings, it highlights the need for further research in this field. We believe that conducting multicenter studies across various HEIs would enhance the external validity of these results, providing a more nuanced understanding of how contextual factors (e.g., pedagogical approaches, student demographics, and prior experiences) influence the development of entrepreneurial innovation skills and mindset in nursing education. Additionally, based on our experience, it is important that future studies develop specific measures to increase the potential adherence to the data collection.

Finally, our findings reflect students' self-perceptions of their entrepreneurial innovation skills and mindset, which may be influenced by individual and contextual factors. Future studies should complement self-assessments with objective measures of actual competency to provide a more accurate evaluation of students' entrepreneurial skills and mindset.

Practical Implications

Training in innovation and entrepreneurship proved to be effective in promoting an entrepreneurial mindset among nursing students, an area in which such skills are increasingly valued. The gains in the three domains (Ideas and opportunities, Resources and In action) point to a potential practical application of these competences in healthcare contexts. The skills developed enable nurses to identify gaps in care, propose creative solutions and contribute to the continuous improvement of health services, whether in traditional clinical settings or in entrepreneurial projects such as independent clinics or specialized home care initiatives (Loke, 2019).

The increase in self-awareness suggested by the reduction in the Expert profile can be seen as a practical advantage: nurses with a realistic assessment of their competences are more likely to identify areas for improvement and continuous training, increasing the quality of the services they provide. These results suggest that the inclusion of entrepreneurial training in nursing programs can not only increase technical competence, but also foster a critical and reflective stance, essential for professional practice in complex and rapidly evolving environments.

Implications for Education

This study reinforces the importance of pedagogical methodologies that integrate theory and practice in entrepreneurship training. Evidence suggests that interactive approaches, such as solving real problems and simulating innovation scenarios, are particularly effective for developing entrepreneurial skills (Béchard & Grégoire, 2005). By reducing the gap between theory and practice, these methodologies provide a robust learning experience that prepares students for professional practice.

The results of this study also highlight the role of entrepreneurial education in nursing as a vehicle for increasing students' confidence in making informed decisions and implementing creative solutions (Gielnik et al., 2017; Urban, 2020). Training in innovation and entrepreneurship in nursing programs not only prepares students to respond to traditional healthcare challenges but also gives them the tools to innovate and contribute to the evolution of the sector.

The training, by integrating EntreComp principles with a practical and interactive approach, seems to have enabled students not only to achieve greater technical knowledge, but also to incorporate entrepreneurial attitudes and behaviors that are central to meeting the current challenges of the healthcare sector. Thus, this study contributes to the understanding of how a solid and applied entrepreneurial education can be transformative, equipping future nurses with the necessary tools to innovate, lead and respond adaptively and effectively to the complex demands of the sector.

Conclusion

This study's findings suggest that a tailored educational program focused on innovation and entrepreneurship, grounded in the EntreComp framework, effectively enhances senior undergraduate nursing students' perceptions of their entrepreneurial innovation competencies. The observed improvements across the three EntreComp domains indicate that the program not only imparted technical knowledge but also fostered a critical and innovative mindset crucial for modern nursing practice. The shift in self-assessment from an expert/advanced profile to more balanced competencies highlight a mature, reflective understanding of entrepreneurial roles and expectations, preparing students to meet the evolving demands of the healthcare sector.

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Ethical Statement

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