

# Bridging the Gap: Developing Entrepreneurial Competences in Engineering Studies

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## Abstract

*This study aims to address the challenge of integrating entrepreneurial competences development into the traditional engineering curriculum to enhance job creation prospects. A course design intersecting project management and entrepreneurship, employing challenge-based learning, is proposed. Leveraging experiential learning principles, the design aims to foster entrepreneurial competences among engineering students. A pilot test of the course in a Spanish university Project Management program reveals, through a series of assessment tools and statistical analyses, significant enhancement in students' entrepreneurial competences post-course, with minimal gender variations except for heightened autonomy perception among women. This research pioneers the integration of engineering and entrepreneurship, demonstrating how such pedagogical approaches can enrich students' professional and personal development while preserving engineering program knowledge.*

**Keywords:** Higher education; challenge-based learning; entrepreneurial competences; project management.

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## 1. Introduction

Interest in entrepreneurship education has experienced significant growth, driven by societal demands for a workforce capable of fostering innovation and contributing to economic and social progress (Pettersen *et al.*, 2019). Consequently, there is a recognized need to provide entrepreneurship training within higher education institutions to meet these expectations mandate (Reis *et al.*, 2021).

Scholarly literature widely acknowledges the importance of incorporating entrepreneurship education into university curricula to better prepare students for the dynamic demands of the professional world (Akhmetshin *et al.*, 2019; Bejinaru, 2018). While traditional

entrepreneurship education focused on venture creation, it has evolved to encompass a broader range of skills, behaviors, and attitudes essential for overall effectiveness in diverse contexts (Watson and McGowan, 2019). As a result, there has been a proliferation of modules and courses aimed at cultivating entrepreneurial mindsets across various disciplines beyond business and management (Zappe *et al.*, 2023).

Engineering plays a crucial role in wealth creation and innovation, with many groundbreaking companies being led by engineers. Transitioning from conventional engineering to engineering entrepreneurship is deemed essential given the changing landscape of professional demands. Future engineers must possess not only technical competences but also professional skills to address complex challenges effectively (Zappe *et al.*, 2023). However, the integration of entrepreneurship within the engineering curriculum poses challenges attributed to the inflexible nature of syllabi. In instances of such rigidity, the introduction of diverse activities aimed at fostering the acquisition of entrepreneurial competences is strongly advocated.

Various studies have explored different teaching methodologies aimed at nurturing entrepreneurial competences among students, with a particular focus on engineering education. For instance, Bellotti *et al.* (2014) and Mayer *et al.* (2014) have investigated the effectiveness of serious games and game-based principles in cultivating entrepreneurial mindsets and competences. Similarly, Gorlewicz and Jayaram (2020) proposed entrepreneurial minded learning, emphasizing active learning through challenge-based approaches to address real-world problems. Barba-Sánchez and Atienza-Sahuquillo (2018) and Soares *et al.* (2013) among others, underscored the significance of practical experiences, like workshops and competitions, in acquainting students with entrepreneurial processes, and Karim (2016) proposed the use of different teaching methods such as case studies, guest lectures, internships, networking opportunities, business competitions, or entrepreneurial projects. The findings of these works collectively suggest that a combination of diverse methodologies, exposure to real-world challenges, and interdisciplinary collaboration are crucial for effectively fostering entrepreneurial competences among engineering students.

Rooted in this context, the present study reports the experience of a Project Management course within a Master's Degree program that aims at fostering entrepreneurial competences among engineering students. Through various exercises aligned with real-world scenarios, the course integrates entrepreneurial thinking into traditional engineering education. This work is based on a more extensive research recently published by the authors (citation omitted to preserve anonymity).

## **2. Course description**

### **2.1. Context**

Based on challenge-based learning, a course was designed and implemented in a Project Management course for 56 students (18 (32%) female) in the Master's Degree in Management and Operations in Barcelona (Spain). All students had a background in engineering.

### **2.2. Task**

Students in the course selected project topics mirroring real-world scenarios where professionals engage outside the office for ideas and opportunities. Following Bayuo *et al.* (2020), the curriculum aims to empower students as social innovators by aligning projects with UN Sustainable Development Goals (UNESCO, 2017), emphasizing tangible impacts on Barcelona, and securing external partners. This reflects a modern approach to entrepreneurship education, blending theory with practical methods. Projects constituted 85% of the course grade, and were evaluated through in-class activities, weekly progress reports, posters, final reports, and oral presentations. Individual contributions were assessed via self-evaluation, peer evaluation, and professor observation, acknowledging varying levels of motivation and commitment within groups. The remaining percentage of the overall grade considered an individual case study (10%) and the participation in a workshop (5%).

### **2.3. Course structure**

The course initiation involved presenting the project assignment, followed by the strategic formation of student groups. Building upon Yang *et al.*'s (2022) insight that mere grouping does not guarantee optimal learning outcomes, emphasis was placed on structuring groups based on diverse criteria, including entrepreneurial competences and gender, among others. To assess entrepreneurial competences, and in line with prior research evaluating entrepreneurial competences among students (e.g., Horng *et al.*, 2021; Ishiguro, 2015), the General measure of Enterprising Tendency test (Caird, 2013) ([www.get2test.net](http://www.get2test.net)) was administered, which evaluates dimensions such as achievement, autonomy, creativity, risk-taking, and locus of control. Given that this test does not have right or wrong answers, but rather measures the extent to which each dimension is possessed, taking the test twice in a short interval, as done in other studies, was not considered to introduce bias into the results. Instructors utilized this information for group formation, paving the way for teams to identify project needs and stakeholders, employing lean and agile methodologies, and utilizing various tools to map progress.

The instructional approach encompassed a blend of theoretical and practical elements, including readings, simulations, exercises, and case studies. Striving for a balanced qualitative

and analytically oriented approach, the course aimed to equip students with fundamental project management knowledge. Additionally, by incorporating diverse quantitative methods and tools for data interpretation, students were expected to develop the skills necessary for constructing a robust business plan in the future.

### **3. Results**

The evaluation of the teaching experience encompasses a thorough analysis of the course's effectiveness and utility, employing various methodologies to gauge its impact on students' entrepreneurial competences, academic performance, and satisfaction. Central to this assessment is the examination of changes in students' self-perception of their entrepreneurial competences, facilitated through pre- and post-course evaluations using the Get2Test tool. Results indicate a discernible improvement in overall competence scores after completing the course (the average score pre-course was 66.48% and 69.13% when finishing it), albeit with a noteworthy discrepancy observed in the dimension of autonomy, where students' perceptions lag behind other competences (45.57% pre-course and 48.82% post-course, far behind the second dimension with the lowest level of perception, namely creativity, with 64.82% pre-course and 66.04% post-course). This finding underscores the pedagogical imperative of fostering autonomy, as espoused by the self-determination theory (Deci and Ryan, 2013), to adequately prepare students for the exigencies of professional life. Despite this disparity, the overall enhancement in entrepreneurial competences attests to the efficacy of the instructional strategies employed.

Statistical analyses, including paired t-tests and gender-based examinations, offer nuanced insights into students' competence development. Particularly noteworthy is the differential response observed among female students, who exhibited a more pronounced increase in autonomy (60.63%) compared to their male counterparts (21.93%).

Furthermore, the investigation into the correlation between perceived competence improvement and academic performance yields intriguing but inconclusive findings. While there is an inverse relationship between self-perception and grades, the statistical significance of this association remains ambiguous. This underscores the need for further inquiry to elucidate the intricate interplay between self-perception, competence development, and academic achievement.

Additionally, students' satisfaction with the course is evaluated through a comprehensive survey, revealing a high degree of contentment with the course organization (average score of 4.16 in a scale from 1-lowest to 5-highest) and effectiveness of learning activities (average score: 3.61). This underscores the pivotal role of clear instructions and engaging pedagogical methodologies in facilitating effective student learning.

Moreover, the collaborative ethos cultivated within the course emerges as a significant contributor to student satisfaction, fostering an environment conducive to idea-sharing and effective teamwork. This collaborative approach aligns with contemporary educational paradigms that prioritize cooperative learning and peer interaction as catalysts for enhanced learning outcomes. Overall, the comprehensive assessment of the teaching experience underscores the course's success in fostering students' entrepreneurial competences, albeit with areas for improvement, such as addressing disparities in autonomy development and further investigating the intricate relationship between competence enhancement and academic performance. These insights provide valuable guidance for refining course design and pedagogy to better meet the evolving needs of students in entrepreneurial education.

#### **4. Conclusions**

The study proposes a course design tailored to engineering education to bolster entrepreneurial competences among students. Emphasizing the fusion of engineering and entrepreneurship within university-level curricula, the integration of active learning strategies is advocated to enrich the learning experience. By aligning the objectives of project management courses with the development of entrepreneurial competences, the study seeks to exploit synergies between these disciplines, offering a pragmatic approach without the need for a separate course dedicated solely to entrepreneurship.

The effectiveness of the proposed course was tested through a pilot implementation at a Spanish university, yielding promising preliminary findings. Notably, the course demonstrated improvements in entrepreneurial competences among students, with gender differences being negligible except for heightened levels of autonomy reported by female students. This finding underscores the potential of project-based learning courses to mitigate gender disparities in perceived autonomy, aligning with prior research indicating the positive impact of entrepreneurship education on self-efficacy among women (Wilson *et al.*, 2009).

Furthermore, the study underscores the high level of student satisfaction engendered by the course, aligning with prior research emphasizing the transformative potential of challenging and enriching educational experiences (Karim *et al.*, 2020). Authentic learning experiences, characterized by real-life projects, are found to enhance student satisfaction and motivation while fostering skill development. However, the study acknowledges certain limitations, including the need for a larger and more diverse sample size for generalizability, as well as the exploration of alternative metrics to measure entrepreneurial attitude and individual participation assessment methods. All these aspects should be explored in future research. Nonetheless, the replicability and adaptability of the course design offer promising avenues for future research and educational practice, urging universities to embrace innovative pedagogical approaches to better prepare students for dynamic professional landscapes.

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