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DRIVING INNOVATION AND ENTREPRENEURSHIP IN ENGINEERING: INSIGHTS FROM THE TRIANGLE EIT HEI PROJECT

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Abstract. Innovation and entrepreneurship are increasingly vital in engineering education and practice, driven by global challenges and rapid technological change. This paper examines the contribution of the TRIANGLE EIT HEI project, an interdisciplinary initiative designed to foster entrepreneurial mindsets and innovation capacity in higher education institutions within its partner countries (Albania, Greece, Cyprus, and Spain). While TRIANGLE is not limited to a specific discipline, evidence shows that many participating startups operate in IT and engineering domains, making its outputs especially relevant for technological and engineering contexts. By integrating real-world co-creation environments, interdisciplinary collaboration, digital and green skills training, and an AI-powered participation platform, TRIANGLE contributes to building inclusive innovation ecosystems that support students, academics, and entrepreneurs. These outcomes are of particular value for engineering, where the ability to combine technical expertise with entrepreneurial competences is essential for addressing complex societal and technological challenges.

Keywords: Innovation; Entrepreneurship; Engineering; Digital Transformation; TRIANGLE Project

1. Introduction

The engineering profession is evolving rapidly in response to pressing global challenges such as digital transformation, sustainability, and climate change. Engineers are no longer expected to be only technical problem-solvers; they must also be innovators and entrepreneurs capable of translating ideas into market-ready solutions and sustainable ventures (Barba-Sánchez & Atienza-Sahuquillo, 2018). This shift requires higher education institutions (HEIs) to embed innovation and entrepreneurship into their curricula, research agendas, and collaboration frameworks. Recent work in engineering education argues for design-thinking-

based, action-oriented models tailored to engineers' distinct learning styles and evolving needs (Ilyas et al., 2024) and provides empirical evidence that such courses measurably develop key entrepreneurial/entrepreneurship competencies among engineering undergraduates (Suto et al., 2025).

The European Institute of Innovation and Technology (EIT) has addressed this need through the EIT HEI Initiative, which supports projects that strengthen the innovation and entrepreneurial capacity of universities (EIT HEI Intitiative, 2021). Among these, the TRIANGLE project (Transforming Research, Industry and Academia into Networks for Growth and Leadership) offers a compelling example of how interdisciplinary ecosystems can foster innovation across Europe (TRIANGLE EIT HEI, 2025).

Although TRIANGLE is not confined to a single academic discipline, its strong engagement with startups in IT and technology demonstrates particular relevance for engineering. The project develops entrepreneurial competences, digital and green skills, and collaborative practices that are central to preparing the next generation of professionals to act as leaders of change.

2. TRIANGLE Framework and Methodology

The vision of TRIANGLE is to build, by 2030, a resilient and inclusive pan-European innovation ecosystem that integrates academia, industry, and society. This is achieved by focusing on three general objectives (TRIANGLE EIT HEI, 2025):

– *Enhanced knowledge and talent exchange* by strengthening collaborations between academia and industry to enable co-created innovations and knowledge transfer.

– *Skill development for innovation and entrepreneurship* by equipping students, graduates, and researchers with digital, green, and entrepreneurial competences to successfully launch startups and scale innovations.

– *Boosted entrepreneurial ecosystems* by empowering local hubs and regional initiatives to cultivate sustainable entrepreneurial communities across Europe.

Methodological pillars

– Real-world co-creation environments: TRIANGLE establishes innovation labs, pilot programs, and mentoring frameworks where students, researchers, and startups can co-develop and validate solutions in practice. As emphasized by Nagel et al. (2020), drawing on earlier works (Fry & Pistrui, 2011; Kleine & Yoder, 2011), the development of entrepreneurial mindsets among engineering students requires coordinated ecosystems that combine curricular activities, co-curricular initiatives, and dedicated learning spaces such as fabrication labs and maker spaces. These insights strongly resonate with TRIANGLE's approach, where innovation labs and co-creation platforms act not only as physical spaces but also as pedagogical infrastructures that foster curiosity, opportunity recognition, and entrepreneurial value creation in engineering education.

– **Entrepreneurial training and mentoring**: The project runs blended programs, both online and in-person, with structured sprints in entrepreneurial skills, business model design, and technology adoption. Research by Shekhar et al. (2021) shows that participation in entrepreneurship education programs is influenced by access to mentoring, resources, and social support, which in turn strengthen students' entrepreneurial self-efficacy. TRIANGLE's model reflects this evidence by ensuring that training activities are closely tied to practice-oriented contexts. Through guided sprints and mentoring sessions, engineering students not only acquire knowledge but also gain confidence, communication skills, and the ability to translate innovative ideas into viable ventures.

– **AI-powered participatory innovation**: The Deliberate platform integrates artificial intelligence to support inclusive consultations and decision-making, fostering transparent and human-centred innovation. This is consistent with emerging practices in participatory and co-design approaches where learners and educators collaboratively shape their educational experiences (Pozdniakov et al., 2025). By embedding AI in this participatory way, TRIANGLE enables engineering students to act as co-creators of solutions rather than passive users. This approach reflects the Quadruple Helix model of innovation, ensuring that technological progress is inclusive and aligned with societal needs.

– **Pilot-to-scale model**: TRIANGLE follows an agile methodology, beginning with pilot programs in Albania, Greece, Cyprus, and Spain, and expanding towards a pan-European initiative. Similar strategies can be observed in the Kern Entrepreneurial Engineering Network (KEEN), where early pilot activities were scaled into a broad institutional network (Fry & Pistrui, 2011). TRIANGLE adopts this pilot-to-scale trajectory to demonstrate how small-scale interventions can be systematically expanded, enabling sustainability and long-term impact. At the same time, the model prioritizes capacity building for faculty, equipping academic staff to embed entrepreneurship in teaching and research and to strengthen academia–industry collaboration. This ensures that engineering graduates are better prepared for entrepreneurial careers and for leading innovation-driven transformations.

2. Interdisciplinary scope, engineering relevance

TRIANGLE's methodology spans science, business, social sciences, and engineering. Because many of the participating startups focus on IT, Industry 4.0, and manufacturing, the project's outputs are of particular importance for engineering education and practice. The project highlights how interdisciplinary ecosystems can directly benefit technological entrepreneurship and engineering innovation.

3. Findings and Evidence Relevant to Engineering

Evidence from TRIANGLE's pilot and ongoing activities demonstrates its impact on engineering and technology domains:

– *Enhanced entrepreneurial competences*

Engineering-oriented students and early-stage entrepreneurs report clear gains in entrepreneurial thinking, project management, and innovation design. Entrepreneurship education tailored to engineers helps them develop opportunity recognition, decision-making under uncertainty, interpersonal skills, and a strong learning-by-doing approach (Ilyas et al., 2024). Students also strengthen key skills such as financial and economic literacy, marketing, and strategic thinking, which are essential for turning innovative ideas into viable ventures (Suto et al., 2025).

– *Applied learning in real-world co-creation environments*

Engineering startups in areas such as AI, smart mobility, and digital infrastructure benefit from hands-on mentoring and co-design programmes. These experiences help participants move beyond theoretical knowledge and prototypes, supporting the development of viable business models ready for market.

– *Capacity building for faculty*

Academic staff enhance their ability to integrate innovation and entrepreneurship into teaching and research. This enables engineering faculties to link technical knowledge with entrepreneurial practice, preparing students more effectively for industry and startup contexts.

– *Strengthened academia – industry collaboration*

TRIANGLE builds partnerships between universities and SMEs, helping academic research translate into market-ready solutions. For engineering, this creates stronger pathways for technology transfer, commercialization, and practical application of research outputs.

– *Inclusive innovation ecosystems*

The project prioritizes diversity and inclusivity, ensuring access for underrepresented groups in STEM. This broadens participation in engineering entrepreneurship and supports the development of innovations that reflect diverse perspectives and societal needs.

4. Discussion

The TRIANGLE project illustrates the role of interdisciplinary ecosystems in advancing innovation and entrepreneurship within higher education. Although its activities span multiple disciplines, the strong involvement of technology-oriented startups highlights its particular relevance for engineering.

– Engineering in the age of entrepreneurship

Engineering solutions increasingly require entrepreneurial approaches to be sustainable in the market. TRIANGLE demonstrates that embedding entrepreneurial training and co-creation practices within HEIs can enhance both employability and societal impact. This aligns with global calls for engineers who are not only technically proficient but also capable of leading innovation for sustainable development (Barba-Sánchez & Atienza-Sahuquillo, 2018; Ilyas et

al., 2024; Suto et al., 2025). These findings are consistent with research showing that entrepreneurship education increases engineering students' motivation and readiness to pursue entrepreneurial careers, reinforcing the value of embedding such training within HEIs (Barba-Sánchez & Atienza-Sahuquillo, 2018).

– Human-centred and interdisciplinary innovation

TRIANGLE's emphasis on human-centred design and real-world co-creation environments underscores the importance of aligning technological innovation with societal needs. For engineering, this cultivates professionals who can balance technical feasibility with user-driven and societal perspectives, ensuring responsible and sustainable innovation. This approach resonates with the Quadruple Helix model of innovation, which expands the traditional Triple Helix by integrating civil society as an active participant alongside universities, industry, and government, thereby fostering legitimacy, inclusivity, and social robustness in innovation systems (Schütz et al., 2019; Roman et al., 2020).

– Contribution to Industry 4.0 and SDGs

By supporting startups in digital, green, and industrial technologies, TRIANGLE contributes to Europe's competitiveness in Industry 4.0 sectors. At the same time, its alignment with the Sustainable Development Goals (SDGs) ensures that engineering innovations are framed within global sustainability and inclusivity agendas.

5. Conclusions and summary

This paper presents the TRIANGLE EIT HEI project as a case study in how interdisciplinary initiatives can contribute to driving innovation and entrepreneurship in engineering (TRIANGLE EIT HEI, 2025). While TRIANGLE is not explicitly designed for engineers, its outputs are highly relevant for engineering education and practice due to the strong representation of IT and technology startups.

Key contributions include:

– Strengthening entrepreneurial competences among students and staff in technical domains.

– Providing real-world co-creation environments that link academia with industry for applied innovation.

– Promoting inclusive, human-centred approaches to entrepreneurship with clear implications for engineering.

Future work should focus on scaling these practices across engineering HEIs and sustaining innovation ecosystems beyond project funding. Ensuring long-term impact will require institutional commitment and policy support to integrate entrepreneurial competences systematically into engineering curricula and maintain innovation ecosystems after the funding cycle. By doing so, Europe can prepare a new generation of engineers who are not only problem-solvers, but also capable of leading technological and societal transformation.

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