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From Classroom to Startup: Integrating Entrepreneurial Projects, Labs, and SDG Challenges into Engineering Curricula

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Abstract: To meet the demands of a rapidly evolving job market and align with the Sustainable Development Goals (SDGs), engineering education must transcend traditional disciplinary silos. This paper presents a curricular model piloted at the University Name that integrates startup labs, SDG-aligned innovation challenges, and industry co-mentorship into engineering and interdisciplinary programs. Drawing on frameworks developed by the university's Strategic Committee on Entrepreneurship & Innovation, the model embeds entrepreneurial pathways into Capstone and Vertically Integrated Projects (VIP), equipping students to translate technical solutions into scalable, purpose-driven ventures. Emphasis is placed on real-world problem solving, teamwork, and leadership development, with students engaging in ideation-to-market processes guided by both academic mentors and industry practitioners. Outcomes from the pilot phase demonstrate enhanced student engagement, cross-functional learning, and improved innovation readiness, making this a promising model for institutions aiming to transform project-based engineering education into entrepreneurial ecosystems.

1. Introduction

In recent years, the global landscape of engineering education has undergone a significant shift. As technological disruption accelerates and sustainability imperatives intensify, engineering programs are increasingly called upon to go beyond technical skill development and foster entrepreneurial mindsets, social responsibility, and innovation readiness among students ([1],[2]). Institutions are recognizing that equipping graduates to solve complex societal challenges such as those framed by the United Nations Sustainable Development Goals (SDGs) have become a compelling framework guiding university-industry-society partnerships to pursue purpose-driven innovation [3]. This requires integrative learning environments that blend theory with action, and classroom rigor with real-world relevance [4].

This paper presents an applied curricular model developed and piloted at the University Name, designed to embed entrepreneurship, SDG alignment, and innovation capacity into the core of engineering education. Positioned within the University's broader strategic direction, the initiative builds on the work of the university's Strategic Committee on Entrepreneurship and Innovation, which has championed cross-disciplinary and cross-school collaboration as a foundation for cultural transformation. The resulting model integrates startup labs, industry co-mentorship, and innovation challenges into existing Capstone and Vertically Integrated Projects (VIP+), transforming them into incubators of purpose-driven entrepreneurship. Rather than creating new standalone courses, the model restructures existing Capstone and VIP formats to incorporate structured SDG alignment, industry co-mentorship, and venture translation pathways. Drawing from institutional frameworks and implementation experiences, this paper examines the design principles, operational

mechanisms, and educational impacts of the model's pilot phase. Special attention is given to the process of project ideation and selection, engagement with industry partners, and the governance mechanisms that enable faculty mobilization across schools. This contribution is submitted as an Engagement in Practice paper. It does not present a traditional hypothesis-driven study but rather shares a replicable curricular framework with documented outcomes, strategic insights, and implementation lessons. The aim is to inform institutions seeking to move from project-based pedagogy toward institutionally embedded innovation ecosystems. Section 2 provides relevant context from the literature and institutional background, followed by a detailed breakdown of the model in Sections 3 and 4. Implementation logistics are covered in Section 5, with results and reflections discussed in Sections 6 and 7.

2. Context and Related Practice

The transformation of engineering education to meet contemporary societal and economic challenges has become a key concern across global higher education systems [5]. In particular, the growing demand for innovation-driven, socially responsible graduates has prompted universities to reconsider traditional curricula and embed entrepreneurial competencies into engineering programs [6]. The convergence of entrepreneurship education with sustainability objectives, especially those articulated in the United Nations Sustainable Development Goals (SDGs), has accelerated this shift, emphasizing the need for interdisciplinary problem-solving, systems thinking, and community impact [7].

2.1 Project-Based Learning and Entrepreneurial Ecosystems

Project-based learning (PBL) has long been recognized as a means to foster active learning and practical skills in STEM education [8] and have emerged as effective mechanisms to build real-world problem-solving skills [9]. These projects emphasize teamwork, iterative design, business modelling, and systems thinking [10]. However, moving from PBL to fully-fledged entrepreneurial ecosystems within universities requires strategic scaffolding. Frameworks such as the Entrepreneurial Mindset (EM) approach, championed by the Kern Entrepreneurial Engineering Network (KEEN), and the Innovation Corps (I-Corps) model developed by the U.S. National Science Foundation, provide structured pathways to embed entrepreneurship into technical education [11]. These initiatives focus not only on student ideation and prototyping but also on value creation, customer discovery, and venture scalability where these elements are often missing from isolated course-based projects.

2.2 Sustainable Development Integration

While many engineering programs have incorporated SDG awareness through elective or co-curricular activities, integrating these goals meaningfully into project-based curricula remains a challenge. Effective SDG-aligned curricula emphasize not only technical feasibility but also ethical responsibility, social equity, environmental sustainability [2] and increased student motivation and institutional relevance [12]. This holistic orientation aligns well with the VIP (Vertically Integrated Projects) model, which allows students across years and disciplines to contribute to long-term research or applied projects with societal relevance ([13]-[15]). The enhanced version adopted at the University, VIP+, goes a step further by embedding entrepreneurial objectives and industry co-mentorship into the process.

2.3 Institutional Drivers: The Strategic Committee on Entrepreneurship & Innovation Agenda

At the University Name, the push for curricular innovation is grounded in a multi-pronged institutional strategy emphasizing entrepreneurship, innovation, and sustainability as cross-cutting priorities. Spearheaded by the Strategic Committee on Entrepreneurship & Innovation (E&I), this agenda advocates for integrative models that break disciplinary silos, mobilize faculty across schools, and foster deeper engagement with external stakeholders. The VIP+ framework, as discussed in this paper, is one of the primary vehicles for translating this vision into academic practice. This model differentiates itself by focusing not only on capstone-level interventions but on creating continuous innovation pipelines across the undergraduate journey, connecting early ideation, applied experimentation, and real-world venture translation. The approach prioritizes long-term team structures, multi-cohort continuity, and intentional project alignment with institutional and global impact themes. In this context, the following sections detail the University VIP+ engagement framework and implementation model, offering a practical blueprint for institutions aiming to build innovation capacity within engineering education while maintaining academic rigor and strategic alignment.

3. Engagement Framework and Implementation Model

While Capstone and VIP formats are already project-based by design, the innovation of this model lies in the systematic integration of SDG alignment as a formal project selection and evaluation criterion. Rather than simply conducting technical projects, students are required to demonstrate measurable contribution to at least one SDG domain. To meaningfully integrate entrepreneurship into engineering education, University Name developed an engagement framework that unites curricular innovation, strategic partnerships, and institutional capacity building. The framework draws upon the strategic work of the Entrepreneurship & Innovation (E&I) Committee and leverages project-based learning formats like Capstone and the Vertically Integrated Projects Plus (VIP+) initiative. This section presents the four pillars of the model: (1) cross-school strategic coordination, (2) SDG-integrated innovation tracks embedded within existing project-based formats, (3) community and industry partner integration, and (4) faculty and resource mobilization.

3.1 Cross-School Strategic Coordination

Strategic alignment between the School of Engineering and the School of Business was foundational. Through the E&I Committee, cross-functional task forces mapped existing entrepreneurship-related initiatives, identified gaps in course offerings, and coordinated between Capstone, VIP+, and business incubator tracks. The framework also supports cross-school co-teaching arrangements and joint supervision of student projects, facilitating entrepreneurial thinking as a shared institutional goal rather than a siloed initiative [16].

Central governance is provided through a strategic oversight group that meets quarterly to align efforts across schools and external stakeholders. This group facilitates curricular redesigns, approves cross-listed courses, and identifies synergies between labs, SDG priorities, and innovation pipelines.

3.2 SDG-integrated innovation tracks

Project-based learning is already embedded within Capstone and VIP courses. However, in traditional formats, project themes are often technically driven without structured sustainability framing. In this model, SDG alignment becomes a required evaluation dimension. A central innovation of the framework is the integration of UN SDG-aligned challenges into student projects. Within both Capstone and VIP+ formats, students engage in multi-semester, interdisciplinary teams to address real-world problems related to clean energy, sustainable cities, digital health, and other SDG domains.

Each project undergoes a structured process:

- **Stage 1: Ideation and Scoping** — Students are introduced to a curated list of industry/community challenges or propose their own, provided they align with identified SDG themes.
- **Stage 2: Validation and Iteration** — Projects are assessed based on technical feasibility, market relevance, social impact, and innovation potential.
- **Stage 3: Development and Prototyping** — Supported by university labs and incubators, students prototype their solutions using agile and lean methodologies.
- **Stage 4: Presentation and Acceleration** — Teams present to faculty-industry panels and are offered pathways for incubation or grant support if merited.

This scaffolded pathway ensures that students move beyond academic deliverables toward solution-oriented, market-aware, and impact-driven outputs [4].

3.3 Community and Industry Partner Integration

Industry and community engagement is embedded across the lifecycle of student projects. Rather than treating external partners as mere sponsors or passive observers, the model emphasizes co-mentorship and co-creation. Partners participate in problem definition and challenge scoping, mid-term reviews and feedback loops, and final evaluations and pathway acceleration. This engagement benefits both sides: students receive domain-specific guidance, while partners access fresh ideas and potential collaborators. Notably, the Industrial Hub at the University has played a pivotal role in facilitating these partnerships and bridging students with startups, corporations, NGOs, and public-sector stakeholders. Examples include collaborative projects on logistics optimization, IoT-enabled sustainability solutions, and AI-driven customer service enhancements each anchored in real-world needs and joint learning environments.

3.4 Faculty and Resource Mobilization

Sustaining this framework requires intentional investment in faculty support and workload distribution. A “Teaching-Research-Engagement” (TRE) model was adopted, wherein faculty involved in VIP+ or Capstone co-mentorship receive structured workload credit or research synergy incentives.

Additional measures included:

- Creating a shared teaching assistant pool for large project-based courses
- Offering summer workshops on design thinking, startup methods, and SDG frameworks
- Establishing a digital platform for project tracking, milestone reviews, and stakeholder inputs

These mechanisms alleviate common bottlenecks in scaling entrepreneurial education within technical curricula [17]. Faculty autonomy is respected, but collaboration is institutionally scaffolded through internal grants, teaching load flexibility, and recognition in promotion criteria. Faculty contributors receive recognition via TLE (Teaching Load Equivalent), and support structures are in place for managing shared labs, prototyping budgets, and coordination meetings. Special emphasis is placed on ensuring that faculty innovation is incentivized and student advising roles are institutionally valued [18]. To illustrate the full ecosystem, Figure 1 presents the *Innovation Engagement Pipeline*, showing the integration of university structures, project phases, and stakeholder involvement. This visual emphasizes how the process flows from cross-school strategy to project incubation, capturing the dynamic interconnections that support entrepreneurship in engineering education.

Figure 1. The Innovation Engagement Pipeline

4. Project Ideation and Selection

Transforming engineering education into an entrepreneurial ecosystem requires a structured and transparent model for project ideation, selection, and staffing. This section outlines a phased approach adopted at the University, designed to embed innovation, real-world relevance, and interdisciplinary collaboration into every project. The model operates at the intersection of faculty, students, industry, and strategic committees, ensuring alignment with institutional goals and sustainable development priorities.

4.1 Project Ideation: From Problems to Opportunities

Project ideation begins by mapping challenge areas aligned with both local community needs and global priorities, especially the UN Sustainable Development Goals (SDGs). The Strategic Committee on Entrepreneurship & Innovation, where Schools are represented, collaborates with the Industrial Hub, Spark Incubator, and external partners to identify key opportunity spaces. These are then translated into problem briefs and innovation prompts across several domains (e.g., clean energy, food security, health tech, circular economy).

Faculty members and industry mentors co-develop these briefs during planning workshops, ensuring technical feasibility and entrepreneurial relevance. In parallel, students are invited to propose ideas through competitive pitch rounds, allowing bottom-up innovation to complement top-down challenges. This dual-source approach creates a rich pool of project possibilities grounded in both lived experiences and strategic foresight.

4.2 Project Selection Criteria

A rigorous yet flexible evaluation process guides the selection of projects for Capstone and VIP+ tracks. The criteria, which is refined over pilot cycles, include:

- **Innovation and Value Proposition:** Is the solution novel and purpose-driven?
- **Technical Feasibility:** Can the problem be addressed using existing student capabilities and available lab resources?
- **Entrepreneurial Viability**: Does the project show potential for real-world deployment or startup translation?
- **SDG Alignment**: How clearly does the project contribute to one or more SDGs?
- **Cross-Disciplinary Potential**: Can students from business, engineering, or other disciplines collaborate meaningfully?

Projects scoring highly on these dimensions are greenlit for development. Lower-scoring ideas may be redirected toward extracurricular tracks or refined for future cycles.

4.3 Staffing and Supervision Logistics

Project execution requires thoughtful staffing that balances faculty bandwidth, student interests, and partnership dynamics. Faculty supervisors are matched with projects based on their expertise and availability. At the same time, efforts are made to incorporate new faculty into the VIP+ model each semester to build institutional capacity. Students are placed on teams via a structured matching system that accounts for their skills, preferences, and disciplinary backgrounds. For example, an IoT-based energy monitoring project might combine electrical engineering seniors, a business analytics student, and a mentor from the Industrial Hub. To ensure sustainable supervision, workload credits or TLE (Teaching Load Equivalents) are negotiated in advance, particularly for faculty managing high-complexity or multi-term VIP+ projects. This administrative foresight supports consistent mentorship while avoiding burnout.

4.4 Iterative Feedback and Milestone Reviews

Projects are organized around clear milestone checkpoints: Ideation → Prototype → Stakeholder Feedback → MVP Testing → Pitch or Publication. At each stage, faculty and external mentors provide structured feedback using rubrics co-developed by the E&I Committee. This ensures transparency, supports quality control, and encourages entrepreneurial mindset development at every step.

As a result, staffing is dynamic, project teams may grow or change based on pivot needs, new partnership opportunities, or student graduation cycles. The overall model prioritizes agility, innovation-readiness, and learning continuity.

5. Partnerships and Community Engagement

Robust university-industry-community collaboration lies at the heart of the University's evolving entrepreneurship-driven engineering education model. By cultivating a diverse ecosystem of partners, from tech startups and NGOs to municipal bodies and regional industry clusters, the University ensures that student projects are grounded in relevance, purpose, and mutual value creation.

5.1 Partner Typologies and Value Exchange

The partnership model spans three key categories:

- **Industry Partners**: SMEs, technology companies, and established firms co-develop challenge briefs, serve as technical mentors, and in some cases, co-sponsor prototyping activities or internships.
- **Community-Based Organizations (CBOs) and NGOs**: These partners contribute challenge areas closely tied to social justice, sustainability, and underserved community needs. Their insights ensure human-centered innovation and localized impact.
- **Public Sector and Governmental Agencies**: Municipal offices and public utilities serve as implementation partners for SDG-aligned projects (e.g., electricity/water monitoring systems, traffic optimization tools), giving students a platform for civic engagement.

The exchange is twofold: students benefit from exposure, mentorship, and real-world complexity; partners receive tailored solutions, early-stage prototypes, and access to emerging talent.

5.2 Modes of Engagement

Capstone projects operate within a single academic semester/year, typically 15 weeks. In contrast, VIP+ projects are designed as multi-semester engagements, allowing students to participate for several years across different stages of project development. This structure enables continuity, knowledge transfer between cohorts, and deeper technical maturity. Partnerships are integrated into the curriculum through structured touchpoints:

- **Co-Mentorship**: Partners are invited to mentor student teams through bi-weekly feedback sessions, pitch days, or technical consultations. This co-supervision model mirrors real-world startup incubation.
- **Guest Lectures and Clinics**: Industry experts and NGO leaders participate in thematic sessions that anchor technical work in practical realities (e.g., ethical tech design, sustainability challenges, or lean startup practices).

- **Challenge Sourcing**: At the beginning of each semester, partners submit problem briefs for Capstone tracks. For VIP+ projects, partner engagement may span multiple semesters, particularly for projects requiring iterative validation or field deployment. These are vetted through the project selection criteria (see Section 4.2) and refined collaboratively.

This recurring cycle ensures continuity, relationship deepening, and multi-semester engagement, particularly important for complex or systemic challenges.

5.3 Integration into the Institutional Fabric

To avoid fragmentation, the University's Strategic Committee on Entrepreneurship & Innovation and the Industrial Hub play a coordination role. Together, they maintain a Partner Pipeline Database that includes:

- Organizational profiles and partnership history
- Areas of interest mapped to SDGs
- Engagement formats and outcomes from previous projects

This database informs future matchmaking efforts and provides institutional memory that outlives individual faculty or student transitions. Additionally, the University's Annual Innovation Showcase brings together students, partners, and faculty to present outcomes, gather feedback, and explore next-stage opportunities (e.g., incubation, funding, implementation).

5.4 Challenges and Lessons in Partner Management

While beneficial, partnership development is not without its challenges:

- **Time Commitment**: Some partners struggle to maintain long-term engagement due to operational constraints.
- **Expectation Management**: Clarifying the level of prototype maturity and the scope of student capabilities is essential.
- **Alignment**: Balancing academic schedules with business timelines requires advance planning and flexibility.

Through pilot cycles, the University has learned the importance of setting early expectations, offering partnership guides, and maintaining consistent communication touchpoints throughout the semester.

6. Outcomes, Challenges, and Lessons Learned

The piloted integration of entrepreneurial labs, industry co-mentorship, and SDG-aligned projects into engineering education at the University yielded promising early outcomes across several dimensions of student engagement and institutional innovation. However, the implementation process also exposed structural, logistical, and cultural challenges that warrant careful consideration for future scaling.

6.1 Student Learning and Engagement Outcomes

Across the Capstone and VIP+ tracks, students involved in entrepreneurship-integrated projects reported significantly higher levels of engagement and self-efficacy in tackling complex, real-world challenges. Qualitative feedback indicated increased motivation due to the tangible impact of their work on societal or industry problems, especially those aligned with SDG targets such as climate resilience (SDG 13), sustainable cities (SDG 11), and quality education (SDG 4). Furthermore, participants exhibited growth in cross-disciplinary collaboration skills, pitching and communication competencies, and familiarity with early-stage business modelling. Notably, several projects progressed into early-stage startups or were absorbed into partner organizations' innovation pipelines. Examples include asset-tracking solutions for agri-tech applications and AI-powered chatbot prototypes developed in collaboration with industrial partners. These cases underscore the potential of embedding entrepreneurship as a pedagogical catalyst, not merely a post-graduation aspiration.

6.2 Institutional and Operational Challenges

Despite these achievements, challenges emerged at the operational and structural levels. Faculty workload remained a critical constraint. While the model emphasized team supervision and co-mentorship from industry, managing multiple interdisciplinary teams with divergent timelines and external demands strained faculty time and institutional scheduling systems. Additionally, integrating SDG framing into technical curricula required ongoing faculty development, particularly for those less familiar with social impact frameworks. Another key difficulty was establishing sustained and equitable industry partnerships. While several successful collaborations were forged, partner expectations around project timelines, intellectual property, and student deliverables required negotiation and trust-building. Creating a shared language between academia and industry remains an ongoing task. Finally, assessment frameworks struggled to balance technical rigor, entrepreneurial creativity, and impact orientation. Traditional grading systems did not fully capture the added value of user-centered design, iterative prototyping, or entrepreneurial mindset development.

6.3 Strategic Lessons for Broader Replication

Several strategic lessons emerged from this initiative:

- **Early Partner Engagement**: Co-designing project scopes with industry and community partners during the ideation phase improved alignment and reduced midstream scope drift.
- **Faculty Support Structures**: Institutional recognition of interdisciplinary teaching and entrepreneurial supervision, through adjusted teaching loads, stipends, or support staff, was essential to sustaining engagement.
- **Flexible Credit and Recognition Models**: Allowing students to pursue project continuity across multiple semesters or integrate entrepreneurship electives created more organic venture trajectories.

- **Embedded Innovation Literacy**: Workshops and modules on business model innovation, IP strategy, and funding ecosystems, delivered in collaboration with business faculty, helped ground technical innovation in real-world viability.

By acknowledging these challenges and acting on the lessons learned, the University continues to refine a scalable model for embedding entrepreneurship into engineering education, where innovation is not an add-on but an integrated cultural and pedagogical asset.

7. Conclusion and Recommendations

This paper presented a cross-school innovation integration model that infuses entrepreneurial thinking and SDG-oriented problem-solving into engineering curricula through project-based learning. Drawing on the experience of the University Name and the Strategic Committee on Entrepreneurship and Innovation (E&I), the framework showcased how Capstone and Vertically Integrated Projects (VIP/VIP+) can serve as launchpads for real-world innovation, student empowerment, and institutional transformation.

The integration of startup labs, interdisciplinary collaboration, and community or industry co-mentorship equips students not only with technical proficiency but also with the mindset and tools to identify market needs, build prototypes, and navigate early-stage entrepreneurial journeys. These outcomes reflect a shift from knowledge transmission to experience-driven learning, preparing graduates to become changemakers in an evolving economy driven by sustainability, technology, and impact.

We conclude with the following recommendations for institutions aiming to adopt or scale similar models:

- **Embed Entrepreneurship as a Core Competency:** Entrepreneurial literacy should be recognized as a foundational skill, embedded across disciplines, and reflected in learning outcomes and program structures.
- **Strengthen Institutional Governance Across Schools:** Establish cross-school strategic committees or task forces to oversee entrepreneurship integration, enabling alignment between academic programs, industry needs, and innovation priorities.
- **Invest in Long-Term Industry and Community Partnerships:** Sustainable collaborations with stakeholders create mutual value, provide contextual learning opportunities, and ensure that student work addresses authentic societal challenges.
- **Redesign Faculty Incentives and Workload Structures:** Encourage faculty participation in experiential programs by recognizing supervision, mentoring, and innovation-related activities as legitimate scholarly contributions.
- **Expand Project-to-Incubation Pathways:** Develop venture support infrastructure—such as innovation hubs, seed funding, and mentoring networks—to help promising student projects transition into startups or social enterprises.

As engineering education continues to evolve, aligning pedagogy with entrepreneurship and sustainability imperatives is no longer optional. Institutions that proactively adapt through integrative frameworks like the one presented here can better prepare their graduates for a world that demands innovation with purpose.

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