

Fostering the Entrepreneurial Mindset in Engineers: A Case Study of the Engineering Statistics and Startups Course

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Abstract

This essay emphasizes the crucial role of the entrepreneurial mindset in engineers, cultivating innovation, problem-solving, and adaptability. It provides a compelling case study of the Engineering Statistics and Startups (ESS) course at the McKelvey School of Engineering, developed in collaboration with the Skandalaris Center. In addition to briefly reviewing the existing literature on the intersection of entrepreneurship education, engineering education, and experiential learning, this essay outlines the course development process of ESS, covering coordination activities, budgeting, curriculum design, and assessment considerations. It discusses the challenges faced during course implementation, including differing communication styles and scheduling issues, and acknowledges the ongoing efforts to refine and enhance the ESS course for future iterations. Moreover, the essay highlights the course's journey towards institutionalization, transitioning from an independent study to a distinct course with its own designation. It underscores the positive feedback received from students, showcasing tangible outcomes, such as students pursuing their startup projects beyond the course and gaining valuable internship experiences. Ultimately, this essay underscores the hope that the ESS course will continue to foster creativity, technical application, and active engagement within the engineering community, fostering a positive learning culture at McKelvey. The essay serves as a powerful reminder of the significance of entrepreneurship education in shaping future engineers, equipping them with the skills and mindset to drive meaningful change and contribute to the ever-evolving technological landscape.

Keywords

Entrepreneurship Education, Experiential Learning, Engineering Education, Startups, Course Development

Introduction

The entrepreneurial mindset is crucial for engineers as it nurtures innovation, problem-solving abilities, and adaptability. Engineers with this mindset are more likely to spot opportunities for creating new products or services, take calculated risks, and turn ideas into practical solutions. This perspective encourages them to consider not only technical aspects but also market needs, business viability, and customer value, making them well-rounded professionals capable of driving meaningful change and contributing to the success of their ventures and organizations.

Given the growing recognition of the significance of entrepreneurship education in cultivating technically proficient engineers with essential entrepreneurial skills, renowned institutions like

Pennsylvania State, Brown, and Duke Universities have enhanced their engineering and entrepreneurship curricular offerings in recent years.

In Spring 2023, the McKelvey School of Engineering and its Division of Engineering Education collaborated with Skandalaris, Washington University in St. Louis's (WashU) Center for Interdisciplinary Innovation and Entrepreneurship, to introduce a one-credit course focused on engineering and entrepreneurship for undergraduate students. The goal was to foster interdisciplinary collaboration, creativity, and business acumen among enrolled students. This course highlights the importance of entrepreneurship in shaping future engineers and emphasizes the value of experiential learning in fostering deep understanding. This paper serves as a case study of this pilot program, exploring its implementation and potential impact.

Overview of the Literature

Over the past decade, there has been substantial interest in the intersection of entrepreneurship education, engineering education, and experiential learning. Entrepreneurship education aims to cultivate an entrepreneurial mindset, fostering creativity, problem-solving abilities, and innovation in students. Integrating entrepreneurship education into engineering curricula empowers students to identify market opportunities, develop viable solutions, and contribute to technology-driven industries. Meanwhile, engineering education emphasizes technical knowledge and skills, with experiential learning playing a crucial role in applying theoretical concepts to real-world challenges, cultivating critical thinking, teamwork, and adaptability.

Combining entrepreneurship education and experiential learning within engineering programs provides valuable opportunities for students to prototype, test, and refine innovations in real-world settings, bridging the gap between academia and industry. These interconnected domains prepare engineers to be well-rounded professionals, empowering them to be innovative, adaptable, and market-ready, able to drive meaningful change and contribute to the ever-evolving technological landscape. These trends align with McKelvey's goals for its students [1].

Development of the Course: Engineering Statistics and Startups [ESS]

McKelvey's Engineering Statistics and Startups course underwent a yearlong iterative process starting in Fall 2022. During this process, course developers addressed various aspects, including coordination activities, budgeting, curriculum development, and assessment needs to structure the course effectively.

The course developers decided to create a one-credit, independent study targeting engineering undergraduates, merging the benefits of entrepreneurial education and experiential learning. They invited students who had prior experience with the Engineering Instructor to participate in the course. At its inception, the course was classified as an elective within the School of Engineering, with potential plans for it to count towards Honors in Innovation and Entrepreneurship, an acknowledgment bestowed by the Skandalaris Center.

The course content was designed to cover essential topics such as the entrepreneurial mindset, team building, value propositions, the St. Louis startup ecosystem, customer discovery, project

scoping, diversity and inclusion in startups, community incubators and accelerators, project presentations, and project reflections. Collaboration with administrators, particularly the registrar, and faculty, specifically the Vice Dean of Undergraduate Education, within McKelvey ensured alignment with the school's mission and pedagogical goals.

The planners also worked closely with Skandalaris to identify community and alumni partners and develop the curriculum. Budgetary concerns were addressed through voluntary contributions of time and effort or counting the work towards assigned duties. Protocols were established for various curricular activities, discussions on non-disclosure agreements took place, and a Canvas course site was created. Plans are underway for further enhancing the course's development.

Curriculum Considerations

To implement the ESS course, it was necessary to develop student learning outcomes, instructional methods, and assessment activities. These are described briefly below.

Student learning outcomes: Seven learning outcomes were developed for the course based upon stated, internal curricular need.

These are:

1. Students will apply technical, engineering, and statistical skills to create solutions to real-world problems faced by St. Louis startups.
2. Students will engage in professional communication with members of the local entrepreneurial ecosystem.
3. Students will foster business relationships and build lasting connections with local stakeholders.
4. Students will be exposed to the St. Louis entrepreneurial community and be able to evaluate the qualities of entrepreneurial ecosystems.
5. Students will integrate their academic knowledge and communication skills to execute a data-driven solution or startup pitch.
6. Students will reflect on the intersection of and synergistic opportunities between engineering and entrepreneurship and identify the next steps in their individual future engagement around innovation and entrepreneurship.
7. Students will recognize the role that the first employees have in startup organizations and how to achieve success.

Each goal in the ESS course was associated with specific content modules and assessment activities, providing a well-structured and comprehensive learning experience.

Regarding instructional methods, ESS planners devised a plan for the course's first iteration. The instructional team consisted of four individuals: an engineer, an instructional designer, a start-up expert, and an entrepreneurial expert. The first two team members were provided by the McKelvey School of Engineering, while the latter were from the Skandalaris Center. Students eligible to take the course were those who had previously completed Engineering Statistics with Probability or obtained approval from the Engineering Instructor, ensuring a familiar cohort for

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the instructional staff. With a maximum enrollment cap of ten students, the course offered flexibility by not having a fixed schedule.

During the first iteration, two instructional paths were established. Students could either develop their own startup or work with an existing St. Louis startup, specifically uFab, a turnkey PCB manufacturing company founded by a recent McKelvey alumnus. Upon matriculating into the course, students formed two groups, one collaborating with uFab and the other working on their own project that they named OvuMap. Throughout the semester, both groups worked closely with their respective instructional teams, meeting set benchmarks. At the end of the term, each group publicly presented their work and experiences in a poster session, followed by a written reflection on their journey.

To enhance the experiential aspects of the course, students were offered various opportunities by Skandalaris, including:

1. Pitch Madness IdeaBounce: In this bracket-style event, ideas from across WashU's schools were invited. All participants were welcome to pitch their ideas, receive feedback, and network with fellow entrepreneurs and innovators.
2. Olin's Big IdeaBounce: Open to all WashU students, Olin's BIG IdeaBounce is a two-minute video elevator pitch contest.
3. Experts On Call Program: This ongoing program facilitates free connections between students, faculty, and staff with experts in the Skandalaris Center. These interactions aim to inspire innovators on campus, connecting them with subject matter experts for networking and relationship building.
4. Final Poster Session: At the conclusion of the course, irrespective of whether students pursued their own startup idea or worked for a local startup, they were invited to the Skandalaris Center to present their work to an audience comprising local entrepreneurs, academic experts, and alumni. The students delivered their pitch and showcased visuals to the audience, followed by a Q&A session. The event culminated in a networking opportunity for all participants.



Figure 1: OvuMap pitching at Pitch Madness IdeaBounce®, March 29, 2023



Figure 2: OvuMap networking at Pitch Madness IdeaBounce®, March 29, 2023

Assessment Activities: Grading for this course was based on the completion of assignments, and each assignment was tied to a student learning outcome. A loose course schedule was developed for assessments. Those who worked on their own startup idea met with instructors regularly and turned in deliverables to receive feedback on their projects. Those who worked with the local startup received written feedback from the startup owner.

Implementation Challenges

During the first semester of the ESS course offering, the course developers encountered various challenges arising from the collaboration between the School of Engineering and the Skandalaris Center, which revealed differences in communication styles and culture. For instance, constructing the Canvas course site highlighted distinct approaches; the Skandalaris Center instructors tended to post content as needed, while the McKelvey instructors preferred posting well in advance with a high level of granularity and organization. With these differences now recognized, both teams can plan together more effectively.

Initially, the course lacked a designated time, leading to difficulties in coordinating students' schedules. The students' availability was gathered through online surveys, resulting in limited opportunities for all cohorts to meet regularly. Consequently, communication between cohorts was limited throughout most of the semester, impacting the cross-learning experience between those working at uFab and OvuMap.

Moreover, curricular challenges emerged as the course progressed. Students developing their startup ideas had clearer deliverables and goals, leading to a greater understanding of the entrepreneurial mindset in their final presentations. In response, instructors intend to rigorously pursue this curricular path and bolster cocurricular opportunities to foster networking and onsite activities within the St. Louis startup ecology.

The instructors identified several areas for curricular growth, emphasizing the need for mediating the strengths and differences between the engineering and entrepreneurial mindsets.

Additionally, there are opportunities to enhance technical skills, particularly in customer discovery, project scoping, and prototyping. Overall, these challenges and opportunities contribute to ongoing efforts to refine and enhance the ESS course for future iterations.

Institutionalizing the Course

Throughout the first iteration of the course, both qualitative and quantitative data were collected to understand student learning issues and implement improvements in the course.

Following the initial implementation, the course was institutionalized, transitioning from an independent study to a distinct course with its own run number and registrar designation. The instructors engaged with engineering stakeholders, including design faculty and the Undergraduate Curriculum Committee, to identify curricular needs that the course could fulfill. Areas of focus for improvement include:

1. Strengthening ties with McKelvey Development to enable students pursuing startup ideas to compete for engineering-specific funds, leading to increased award recognition.
2. Establishing or reigniting the McKelvey Discovery Competition, thereby providing engineering undergraduate students with a platform to explore entrepreneurial interests,

develop solutions for real-world problems, and compete for financial resources to support their ideas. The competition has been inactive since 2019.

3. Creating more explicit public speaking opportunities to develop students' communication skills in alignment with curricular needs and ABET (Accreditation Board for Engineering and Technology) requirements.
4. Facilitating intentional opportunities for students to interact with members of the local startup community and integrating these experiences into assessments.
5. Forging stronger connections with design faculty, enabling students to carry forward their project ideas into capstone design courses.
6. Collaborating with the MakerSpace to offer students better access to prototyping and mockup resources.
7. Developing stronger ties with McKelvey Studio for video production purposes.
8. Designing the course as a rider to specific engineering courses, similar to laboratories, allowing students to apply concepts from particular, technical courses within the one-credit space of the ESS course.
9. Establishing a stronger relationship with the Scholarship of Teaching and Learning (SOTL) and the Institutional Review Board (IRB) to conduct more robust data collection for further scholarly exploration.

Conclusion

The course has received positive feedback from students after its first year of implementation. Notably, two students are taking their OvuMap project into Biomedical Engineering Senior Design, while another student completed an internship at uFab over the summer. Additionally, student evaluations did not indicate any negative feedback, and engineering faculty continue to support the course's efforts.

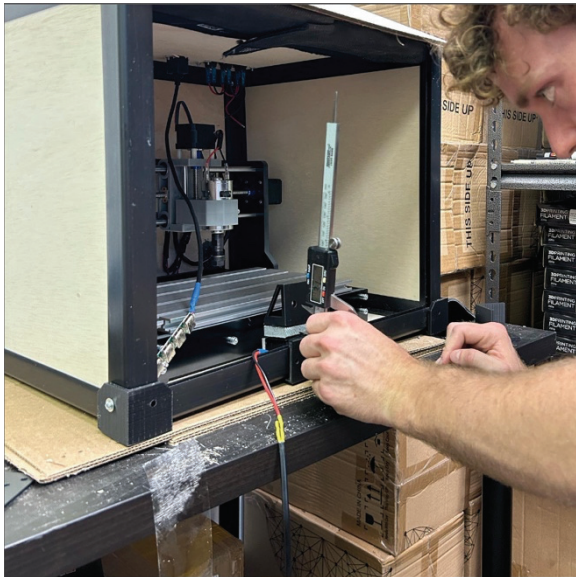


Figure 3: Student Interning at uFab Summer 2023 [2]

The course's popularity is evident, as it has built-in demand, requiring students to seek it out and meet specific prerequisites for entrance. Furthermore, the St. Louis startup ecosystem is increasingly becoming aware of the course and the talents of its students.

Developed with the aim of enhancing student learning, the course has shown early signs of success in student outcomes and end-of-term reflections. While the completion of student learning outcomes has been tentatively successful, the developers are more encouraged by the trend of enduring engagement with the projects. They hope that this course provides students with opportunities for creativity and technical application, fostering stronger engagement with engineering as a profession and the St. Louis community. The developers envision such courses as potential contributors to a positive learning culture at McKelvey.

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- [2] Richards, Tyler [ufab_stl]. “T-REX.”* *Instagram*, Allen, Christopher, July 1, 2023, <https://www.instagram.com/p/CuKsfbtumnN/>.

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