Student Engineering Enrichment from Design to Execution

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Abstract

In today's globalized and rapidly changing work environment, engineering graduates need technical and professional skills to improve their chances of finding a suitable career. In the Gulf region, in particular, due to rapid socio-political transformation and industrialization, engineering graduates must overcome a wider employability gap and compete with an experienced foreign workforce even for entry-level positions. This has necessitated out-of-the-box thinking on part of engineering institutions to bridge the gap by providing students with enrichment opportunities. In fact, emphasis on core competencies and experiential learning are playing a central role in higher education globally and can have a powerful impact on students' experience, development, and achievements before graduation.

The Center for Teaching and Learning at the Qatar branch campus of Texas A&M University initiated the Student Engineering Enrichment (SEE) program in 2017. The program aimed to bridge the skills gaps between academic content and industry-required skills by providing co-curricular offerings to undergraduate and graduate students. The program is designed to provide competencies and skills beyond the engineering curriculum outside the regular classroom setting, emphasizing on experiential learning and essential skills needed by the industry.

The nascent co-curricular program provides trainings and short courses that help students to develop unique skills, which can distinguish them from other engineers in the competitive world. These offerings prepare them for the job market. The SEE has three different components by which the core services are distributed. First, *Management and Leadership*, by complementing their engineering knowledge with the necessary professional and managerial skills. Second, *Emerging Technologies* by embedding practical technical knowledge with an essential bundle of global competencies. Third, *Innovation and Entrepreneurship* by fostering global mindsets and hands-on opportunities. Collaboration with industry and educational institutions, recognized credentials, internationally certified courses, competitions, hackathons, one-on-one consultation, and collaborative workspaces are all integral parts of the initiative.

In this work-in-progress paper and poster, we present the design paradigm of the student program, and elaborate on its execution and key success factors, specifically how this program provides a rich experience and help students to overcome knowledge gaps. We also exhibit how this initiative fosters a comprehensive interdisciplinary and multidisciplinary context, diversity, and distinctive student engagement practices.

Introduction

Higher education, especially engineering institutions are facing unprecedented challenges due to fast and rapidly changing societies and the growing gap between industry needs and curriculum [1]. To better equip the students, it is inevitable for engineering institutions to innovate and improve their curricula and provide them with the necessary trainings that help in their career [2]. Among many changes, the focus is on adding new courses and introducing co and extra-curricular programs that match the industry needs. The premise of these innovations and modifications is to support students' career trajectories, build necessary skills, and help them to

stay updated with recent trends. Also, these innovations allow students to stay competitive in the job market and thrive in challenging work conditions.
These changes are also inspired by national and international policy documents, which emphasize the importance of several essential skills as an integral component for a well-rounded emerging engineer [3]. Besides theoretical content knowledge, practical experience that connects acquired knowledge with real-world examples, technical skills, and professional soft skills all contribute to a competitive engineering graduate ready to adapt to workplace challenges [4, 5, 6, 7]. Also, to introduce these curricular, co and extra-curricular programs, there is a rising discussion on competence-oriented education and experiential learning with its strong impact on undergraduate students' personal and professional development [6,7]. Existing studies emphasize integrating a curriculum that focuses on building skills (personal and professional) to help undergraduate students with the right proficiencies and industry-required skills [8, 9].

Given those challenges and emphasis on personal and professional skills, we initiated a Student Engineering Enrichment (SEE) program at the Center for Teaching and Learning at the Qatar branch campus of Texas A&M University. The program is aimed to bridge the skills gaps between academic content and industry-required skills by providing co-curricular offerings to undergraduate and graduate students. It is designed to provide competencies and skills beyond the engineering curriculum outside the regular classroom setting, emphasizing experiential learning and essential skills needed by the industry. The SEE provides services within three categories; Management and Leadership, Emerging Technologies, and Innovation and Entrepreneurship.

In this work-in-progress, we present the design paradigm of the SEE program. Furthermore, we elaborated on its execution and key success factors, including how this program provides a rich experience. We also discussed how the program and initiatives help students to overcome knowledge gaps and equip them with the necessary skills needed for the job market. Also, our discussion of the program exhibits how this initiative fosters a broad interdisciplinary and multidisciplinary context, diversity, and distinctive student engagement practices.

More specifically, with this work-in-progress paper, we answer the following research questions:

1. What are the design and execution components of the SEE program?
2. How the engineering enrichment program provides a rich experience and helps students to overcome knowledge gaps?
3. How this initiative fosters a comprehensive interdisciplinary and multidisciplinary context, diversity, and distinctive student engagement practices?

Literature Review

Prior literature studies have identified the role of higher education institutions in shaping societal transitions required for industry revolutions and aligned with industry movements towards skill and knowledge [10]. These studies also emphasize the global challenge to identify and develop the required skills for the workforce for industry [11], including preparing them for a productive life necessary for changing industry landscape [4]. However, it is noted that the gap varies globally from country to country depending on many factors, such as population size, availability of educational institutions, social and political environment, and industry needs. For example, a

technical report by The Institute of Engineering and Technology (IET) reported that the skills crisis in the U.K. keeps rising, with almost 45% of engineering companies experiencing difficulties with a lack of skills within their internal workforce [5]. Similarly**,** EY previously known as Ernst & Young [12] recently reported that there is a fundamental misalignment of needs and expectations where employers struggle to find entry-level engineers with personal and professional competencies in the Gulf Corporation Council (GCC) countries**.** All these reports, including IET, as a worldwide multidisciplinary professional engineering institution, and EY, one of the largest professional services networks in the world, providing credible assurance, consulting, and advisory services, direct the higher education that the skills gap between industry needs and the education system is a global challenge. According to India Today [13], "there is a real mismatch between the industry demand and the labor market offer". In particular, the industry is asking for more agility and flexibility with constantly updated competencies and knowledge.

While studies and reports discussed the need and lack of personal and professional skills in engineers, prior literature also helps establish the common skills and attributes required within the future engineering workforce [1, 10]. For example, The Program for International Student Assessment (PISA) defines and assesses 'Global Competence' in a multi-dimensional way [14]. In addition to cultural awareness and cognitive and interpersonal skills, they emphasized students' socio-emotional skills and attitudes as core global competence indicators. The PISA framework is based on a lifelong learning process that supports sustainable development aspirations. Additionally, the Council for the Advancement of Standards in higher education identified six broad areas that enhance opportunities for student learning and development [15]. These areas include 1) knowledge acquisition, construction, integration, and application, 2) cognitive complexity, 3) interpersonal competence, 4) intrapersonal development, 5) humanitarianism and civic engagement, and 6) practical skills development. These key areas and competencies emphasize the need for activities either integrated in the curriculum or offered as additional experiences for enhancing students' skills and learning [16]. Also, these common skills and attributes can be the benchmark for programs aimed to design future engineering workforce.

This emphasis on these common skills and attributes is further elaborated with research studies that indicate that theoretical knowledge based on conventional curricula is not enough to provide emerging engineers with a competitive advantage [13, 17]. Practical training opportunities and essential exposure to the working environment need to be made available to students throughout their college journey. With the rapid advancement in societies, engineers face unfamiliar pressing problems that require more than technical and analytical capabilities traditionally taught in engineering courses [6]. Engineering is an evolving theme that can be integrated across different disciplines. It is also noted that collaboration with industry is integral in nourishing this concept and giving graduating engineers a glimpse of real-world applications, revealing employment trends and job roles that will help them prepare [18].

The value of Technical vs Non-Technical enrichment skills has been highlighted by different authors [1, 8, 18]. The technical part should align with trending digital literacy, industry-used technical platforms, and rationalized engineering efforts. The non-technical skills are equally important and emphasize professional development by all means, including but not limited to

interpersonal skills, critical thinking, creativity, problem-solving, business, innovation, and teamwork. A recent survey of fresh graduates confirmed that engineering students need increased exposure to both emerging technical skills and professional skills through co-curricular programs and across the curriculum [19]. Artificial intelligence, augmented reality, and additive manufacturing were the most notable inadequately prepared areas, while business skills and critical thinking were the most lacking skills among the respondents [19]. In the same realm, Spang [1] listed the top 15 necessary Knowledge, Skills, and Abilities (KSA) for soon-to-graduate engineers, such as communication skills, physical and engineering science fundamentals, ability to solve engineering problems, systems integration, lifelong learning, motivation, cultural awareness, business acumen, ethical standards, and risk management. In addition to project management, teamwork, entrepreneurship, task management, and critical thinking.

Considering the vast literature and increasing demand for developing students' personal and professional skills, this paper presents the design and execution of an engineering enrichment program at Texas A&M University at Qatar (TAMUQ).

Design of Engineering Enrichment Program

Aligned with common skills and attributes, and to provide a comprehensive and holistic skillset to undergraduate engineering students for making them ready for the industry, the Center for Teaching and Learning at Texas A&M University at Qatar initiated a program called the Student Engineering Enrichment (SEE). The purpose of the program is to equip undergraduate and graduate engineering students with the right set of skills that will distinguish them among others and better prepare them for the workplace. Since its inception in 2017, the program has offered numerous workshops that supported students in specific academic areas that expanded their engineering knowledge beyond the curricula. Also, it provided students with opportunities to enrich their knowledge in specific platforms that complement and improve their coursework. Combining this effort with the actual needs of skills development and the goal of minimizing the industry skills gap, SEE provides co-curricular opportunities for engineering students to develop a skillset that is competitive and distinguishes them from others. This program prioritizes the development of a knowledge-based economy and offers enrichment services through three components exhibited in Figure 1 as focus areas. The first component is *Management and Leadership*, which is essential to develop a background in the given topics to complement the students' engineering knowledge with the necessary professional and managerial skills. The second, *Emerging Technologies*, embeds practical exposures vital for developing a solid technical competency and getting updated with the market. The third, *Innovation & Entrepreneurship*, nurture students' curiosity, connect with industry, and develops their global competence.

Figure 1: SEE focus areas and students' professional development services.

Engineering enrichment activities include short training programs in technical and non-technical skills, student consultation services, awareness programs about the importance of skills alignment and industry needs, and hackathons fostering innovation and entrepreneurial mindset. The fundamental part of SEE is a comprehensive repository of short training courses varying from half a day to 5 days. Offered during the semester breaks, these short courses give students the flexibility to choose when, what, and how to engage with the programs and the topics offered. Along these lines, student consultations take place to guide them with their career trajectory and help them choose their personal and professional development tracks based on their needs, interest, and career goals. The program evolved given its high student demand and to effectively align with industry needs.

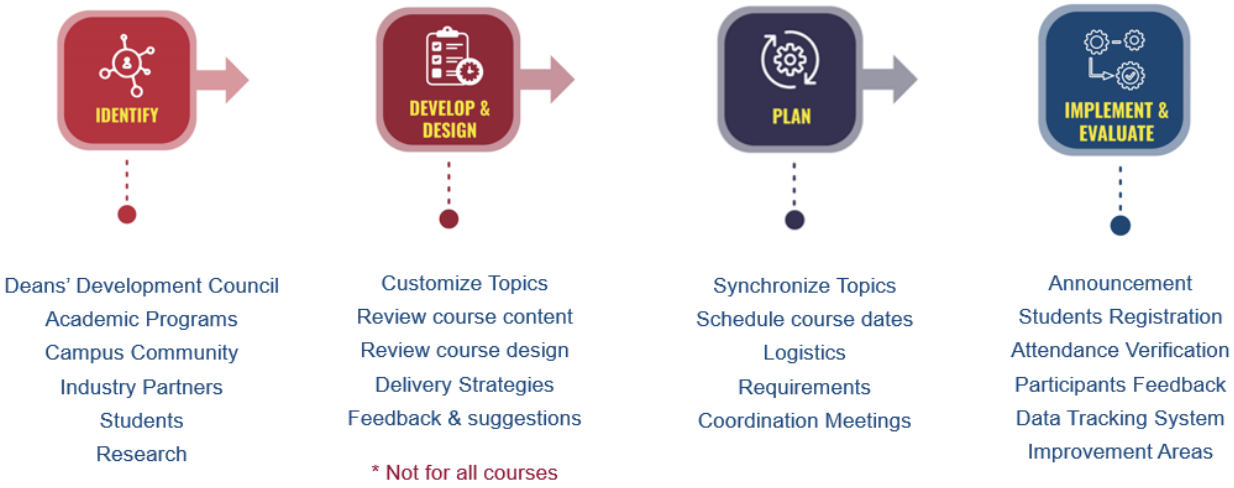

Figure 2: The systematic approach of SEE courses

Also, with the design rigor, the SEE program is continuously improved and updated based on industry needs. Due to which, the course topics within workshops, varied over time. Also, new and more courses were added need-based. These topics and course identification and offerings follow a systematic process. Please refer to Figure 2 for the approach, which explains the steps to identify topics, develop and design the training courses customized for the engineering context,

plan their implementation, and offer them to students. The concurrent process ends with an evaluation of effectiveness through students' feedback.
These course topics are identified based on recommendations from the Dean's development council and industry partners, the academic engineering programs on campus, students' requests, and in-depth research about engineering graduate needs. Following identification, topics get filtered based on priority and get customized to the engineering context. Given that these courses are optional, the engineering enrichment consultants contribute to the course content, design, and delivery strategies to make sure it comprises important transformative teaching and learning elements such as hands-on experience, student engagement activities, and real-world examples. The implementation process includes student registration, assessment, and course evaluation. In this stage, a data tracking system has been designed and employed to store and report student participation numbers in addition to providing students with a Student Involvement Record (SIR) that validates the list of high-impact activities successfully completed during their undergraduate studies journey and complements their resumes with practical experience and industry engagement.

Execution of the SEE program

The SEE program has evolved over the years. In the early years of the program, 8 courses were designed and offered with an average participation of 61 unique students. Today, around 220 unique students participate in 29 engineering enrichment courses, which represents 39% of the total full-time, degree-seeking student population at TAMUQ. Due to the nature of the courses, their offerings are now arranged into different enrichment cycles throughout the year, avoiding duplicates. In just 5 years, the SEE is exceeding the expected number of student participants every year. The courses are offered in both technical and non-technical classifications. Table 1. provides the list of top engineering enrichment courses. Figure 3 (A, B) provides information on SEE program offerings of the last 5 years and indicates an incremental increase in offerings and participants (51% females and 49% male participants).

Table 1. List of top courses offered by SEE

Technical	**Non-Technical**
Data Analysis	Communication
Advanced programming such as Python, MATLAB, LabVIEW	Emotional Intelligence
SOLIDWORKS	Project Management
Augmented Reality	Critical Thinking
Artificial Intelligence	Problem-solving and Decision Making
Cybersecurity	Public Speaking
Additive Manufacturing	Presentation Skills
Cloud Computing	Innovation & Entrepreneurship
Printed Circuit Board Fabrication	Leadership for Emerging Leaders
Laser Scanning and Cutting	Globally recognized Safety Courses
Machine Learning	Teamwork

The program emphasizes the holistic learning journey of the student. The aspects that make the SEE program unique, novel, and innovative include a specific focus on 1) targeted and up-to-date students' professional development, 2) training in technical and non-technical domains, 3) industry-driven, and collaborated offerings, 4) free-of-charge program, 5) emphasis on diversity and inclusivity, 6) providing experiential learning experience, 7) endorsed certifications, and 8) provision of interdisciplinary work with engineering and non-engineering majors.

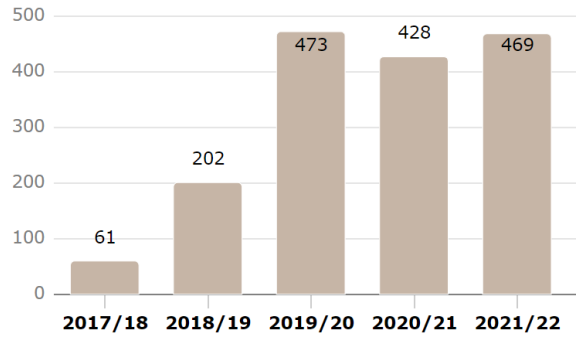

Figure 3 (A). Participants per academic year

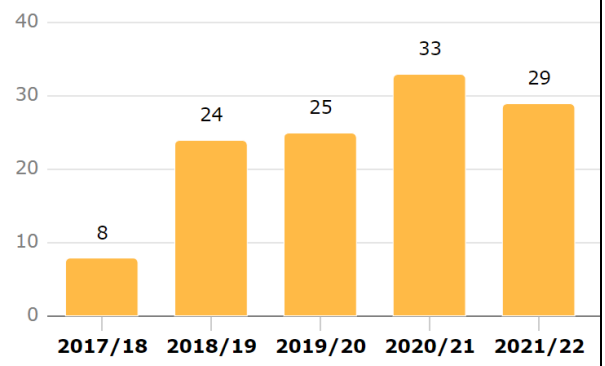

Figure 3 (B). SEE courses per academic year

Students' Feedback on the SEE Program

At the end of each engineering enrichment course, students fill out a feedback form sharing their overall learning experience. In the academic year 2021-22, 380 participants out of 469 responded to the feedback survey. The results in Figure 4 indicated that 84% were highly satisfied with the overall quality of the courses. 80% valued the importance of the engineering enrichment programs in developing their technical and non-technical skills. Also, 80% confirmed that attending these courses was a great learning experience, from knowledge gained to professional development and co-curricular support. Additionally, 87% urged their colleagues to take part in such courses.

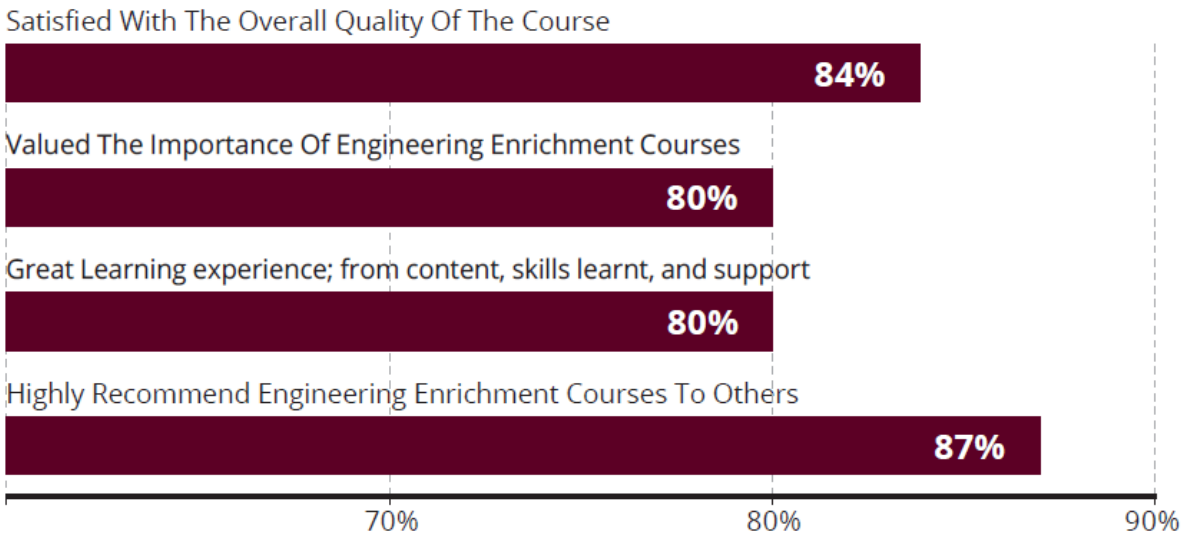

Figure 4. Compiled feedback survey responses from different engineering enrichment courses in the academic year 2021-22

Students in general appreciate the contribution of the SEE program through various courses and skill-building. For example, a senior mechanical engineering student said that *"Engineering Enrichment courses are exciting and diverse: from technical courses such as 3-D Printing and Laser Cutting to courses developing our soft skills such as Project Management and Public Speaking. With every course I take, I learn something new that allows me to continue to grow as a person. Besides learning new things and having a good time, you have a chance to meet students from other Universities in Qatar's Education City, network with the best people from the industry, and stay up to date on recent trends and technologies".*
Similarly, a graduate engineering student mentioned *"Industry-led enrichment topics covered gave me a strong foundational framework for leadership in the corporate realm. Despite the extensive range of topics, common themes started emerging which served as connective tissue, which ensured that the material was incorporated into my thinking."*
The students also appreciated the program for boosting their confidence in their skills and preparing them for the job market. For example, a junior chemical engineering student stated "*I always found the transition from being a full-time student to an employee to be frightening. However, throughout my involvement in several Engineering Enrichment cycles, my knowledge regarding real-world situations kept growing and with it grew my confidence."*

Conclusion

The SEE program is a unique initiative undertaken by the Qatar campus of Texas A&M University. Through industry collaborations, the SEE program is helping students in novel and unique ways, which are appreciated by industry collaborators and students alike. For example, one of the industry collaborators appreciated the efforts of the program and said "*We truly stand by our belief in the importance of collaboration and inspiring young talent to be most confident when it comes to their professional journey. The program provides unique people-to-people opportunities to expand understanding between industry experts and students and work toward a*

common goal. It was inspiring to see how young future professionals from different backgrounds engage on the topic of finance.

Besides the industry collaboration, the program is highly driven by recent research guidelines on key skills [1, 10], grand engineering challenges [3, 15], and national policy documents [2, 10], the program provides unique opportunities to diverse students for professional and personal skills. With highly positive attendance patterns and appreciative students' feedback, the program is continuously growing to create high-impact experiences for students.

This paper focused on sharing the journey of creating and executing the program. In future papers, we will share the impact of the individual courses and how the impact varies for diverse students (e.g., students in different majors, gender variation, and different stages of the degree program). Also, future papers can elaborate that how this program was received by industry liaison, and how alumni of the program evaluate the strengths and weaknesses of the SEE courses.

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