Board 296: Fostering Leaders in Technology Entrepreneurship (FLiTE): Program Goals and First-Year Activities

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Fostering Leaders in Technology Entrepreneurship (FLiTE): Program Goals and First Year Activities

The NSF S-STEM funded program titled Fostering Leaders in Technology Entrepreneurship (FLiTE) at Western Carolina University seeks to cultivate entrepreneurial thinking in engineering and engineering technology students with the goal of creating graduates who bring impactful contributions to industry through the generation of creative technology ideas and new businesses. Over its planned six-year duration, this project will fund scholarships to thirty-six unique full-time students with financial need who are pursuing bachelor's degrees in engineering or engineering technology. The project aims to cultivate skills in entrepreneurial thinking among undergraduates in engineering and engineering technology by involving a cohort of students across academic years in an intensive learning community and bringing their technology-oriented product ideas from concept to market. Scholarship recipients will be linked through cohort teaming sessions with campus resources, local industry partners and experts, and faculty mentors, to propose, critique, select, develop, and implement commercially viable technology products. The novel approach to engineering education developed through this project will serve to enrich the creative potential of new graduates in technical fields and expand small business creation and employment, both of importance to growth regions where there may be fewer large corporate employers. Key dimensions of those who exhibit entrepreneurial thinking include a growth mindset, a regular practice of creativity, and high personal self-efficacy. With entrepreneurism seen as an enabling force to overcome employment and income divides between urban and rural job markets, dimensions of entrepreneurship that may be taught are of high interest. The project will investigate the impacts of the learning community on the learned dimensions of the entrepreneurial mindset and will examine the effects of program interventions on entrepreneurism in scholarship recipients as compared with other students in the host department. This paper will outline activities from the inaugural year of the program including scholar recruitment and demographics, cohort meeting activities and dynamics, invited speaker topics, scholar perceptions of the program to date, and perceptions of their own aptitudes for entrepreneurial thinking. Findings from these activities may inform the prospective structure of similar entrepreneurship programs.

Keywords: NSF, Scholarship Program, Entrepreneurship, Project Based Learning (PBL), Learning Community, Entrepreneurial Mindset, Engineering, Engineering Technology

1. Background

Engineering education has historically emphasized the graduate's technical competence in the engineering sciences, math, and engineering design [1]. As technology changes, however, the needs of the engineering profession continue to evolve [2]. In the traditional learning outcomes of engineering degree programs as formalized by ABET [3], undergraduate coursework that exposes students to leadership, risk and uncertainty, project management, public policy, business, and sustainability are rising in importance [4].

Entrepreneurship education potentially represents a way to facilitate the attainment of this newer class of learning outcomes for engineering students. Entrepreneurship has been taught in business schools in the United States since the 1940s. Entrepreneurship education and related

research now comprise a mature and varied field spanning new venture creation, entrepreneurial finance, small business, family business, free and private enterprise, high technology business, entrepreneurship among women and minorities, professional practice studies, and economic development [5].

2. Program Objectives

Western Carolina University is a regional comprehensive university that enrolls approximately 11,000 students. The region it serves is primarily rural, with sparse STEM-oriented employment opportunities. Many of its students are first generation college students, and most are financially needy with 59% receiving some type of financial aid. At least half of the students need to work during regular semesters to cover their educational expenses. Thus, there is a compelling need for financial assistance, such as scholarships, to facilitate the progress of these talented students. Where possible, the School of Engineering + Technology in which the program is housed, actively seeks to provide financial assistance for technically competent, domestic engineers who in turn will make significant contributions to regional economic growth.

Motivated by the needs of our student population and those of the surrounding region, the FLiTE scholarship program was proposed. The program will take advantage of the School's strengths in Project Based Learning (PBL) and engagement with local industry to help develop an entrepreneurial mindset among talented engineering and technology students with financial need. Successful implementation and development of the FLiTE program will result in a technology-business ecosystem that forms and exposes a student cohort to the innovative culture of entrepreneurs and business leaders, cultivates creative technical problem solving skills and business acumen, and enables in-curriculum development of technology-based product ideas that solve real world problems and create value in the marketplace [6].

The Entrepreneurial Mindset

The term *entrepreneurial mindset* has been used to describe individuals who possess the ability to identify opportunities, consider alternative options, and take action in uncertain conditions. They persevere through uncomfortable situations by willingness to accept and learn from possible failure. The Kern Entrepreneurship Education Network (KEEN) introduced the term *entrepreneurially minded engineers* to indicate people who "appreciate societal values of products they create and persist in an orientation towards customer needs," [7] and "have high entrepreneurial self-efficacy and show tendency towards risk taking, persistence, autonomy, achievement, and leadership" [8].

To successfully develop an entrepreneurial mindset, students must be placed into experiential and project-based learning situations that compel them to think differently about their roles in the creative process. In research on the *theory of effectuation*, Sarasvathy [9] found that entrepreneurs who had started businesses multiple times, exhibit certain characteristic thinking patterns that directly contribute to their success. The research demonstrated that entrepreneurship may be taught, and that it may be possible to train students away from narrow, ineffective channels of thought by emphasizing essential elements of the entrepreneurial mindset.

There are many views on what makes up the mindset of an entrepreneur. Three characteristics typically stand out as critical. These include: 1) a growth mindset, 2) a habit of creativity and 3) entrepreneurial self-efficacy. Individuals with a growth mindset believe that dedication and hard work produce opportunity and success. They consider education as an opportunity to enhance their present qualities and abilities that contributes to their success. Individuals with a habit of creativity possess "the capacity to produce ideas, insights, inventions, products, or artistic objects that are considered to be unique, useful, and of value to others" [10]. Those with entrepreneurial self-efficacy believe in their ability to succeed and are more likely to persevere through adversity thrown against their ideas and efforts.

Dimensions of an entrepreneurial mindset profile have been divided between those which may relate more to individual personality versus those which are skills-based (and thus, perhaps more malleable). Personality traits may include independence, preference for limited environmental structure, nonconformity, acceptance of risk, being action-oriented, having passion for one's work, and the need to achieve. These are seen to be relatively stable. Skills-based attributes may include being future-focused, prone to generating multiple ideas, generating action plans, having self-confidence, being optimistic, persistence, and possessing significant sensitivity for the well-being of coworkers [11], [12].

By recognizing the importance of an entrepreneurial mindset, the FLiTE program will provide engineering students with an educational program that nurtures the development of a growth mindset, regular practice of creativity, and building higher levels of self-efficacy. The program aims to add distinctive engineers to the workforce who are better able to identify opportunities for innovation, and to create new business ventures and value-added products.

Regional Significance

Entrepreneurship has long been viewed as a way for rural communities to grow and thrive. Western North Carolina is no exception. This region has mountainous terrain with 78% of the region considered rural, and 50% of the counties designated at the lowest economic tier [13] Current statistics indicate that 96% of businesses in the area have fewer than 50 employees [14].

While job growth in Asheville, the regional hub city, is robust, the more rural surrounding counties suffer from a lack of high wage-earning opportunities, and poor infrastructure. In addition, the mountainous topography of the region does not lend itself to the recruitment of large manufacturing/technology businesses. These challenges have led counties' economic development agencies to regard entrepreneurship as their vision for the future economic development of this region. It is expected that entrepreneurship will be the catalyst for the development of new products and the creation of innovative, high-tech companies, thus motivating the need for a qualified entrepreneurial engineering and technology workforce.

3. Program Description

The FLiTE program is designed around the creation of a vertically integrated cohort learning community. The program will ultimately span six academic years, engaging twelve incoming freshmen annually over three academic years as shown in Table 1 for a total of thirty-six

students. A total of 144 student-years of award funds will be disbursed. WCU's past experience with the NSF-funded SPIRIT program [15] showed that vertical integration of students across academic years is a productive means of facilitating peer mentorship. By pacing recruitment in this way, scholars in all but the first year of FLiTE will benefit from cohort interactions with peers of higher academic years.

Table 1 – Planned scholar headcounts by academic and program year.

Program Year	Freshmen	Sophomores	Juniors	Seniors	Graduating	Continuing
2022-23	12				0	12
2023-24	12	12			0	24
2024-25	12	12	12		0	36
2025-26		12	12	12	12	24
2026-27			12	12	12	12
2027-28				12	12	0

Project Based Learning

The FLiTE program will make use of the well-established five-course Project Based Learning (PBL) curriculum in the School of Engineering + Technology at WCU. All students in the host department are required to take the PBL sequence. The philosophy in this approach is to develop knowledge and skills common to all disciplines including project management, verbal and written communication, teaming, problem solving and the engineering method, engineering design, self-directed learning, appreciation of global concerns, and professional ethics.

As students progress through their respective programs, the PBL courses require that they undertake projects that move from being relatively structured to those that are very open-ended. The course sequence is shown in Table 2.

Table 2 – PBL course sequence.

Year	Course
Freshman	ENGR 199 – Introduction to Engineering Principles and Practices I
Sophomore	ENGR 200 – Engineering Principles and Practices II
Junior	ENGR 350 – Engineering Principles and Practices III
Senior (fall semester)	ENGR 400 – Engineering Capstone I
Senior (spring semester)	ENGR 450 – Engineering Capstone II

In ENGR 199 and ENGR 200, students learn essential elements of problem solving and project management in scenarios that are commensurate with their current limited technical knowledge and skills. ENGR 350 is structured as a product development course, where students propose product ideas that become the projects for the semester. The capstone sequence consists of ENGR 400 and ENGR 450. In the capstone sequence, student teams are formed to work on an industry-sponsored project, where the first semester is dedicated to the design of a product or solution and the second semester is used to implement, test, and document the solution.

Curriculum Integration

The FLiTE program will consist, broadly, of two phases: 1) the *Nest phase*, and 2) the *Flight phase* (Figure 1). In the Nest phase, freshman and sophomore students will learn essential engineering and project management skills through the PBL courses ENGR199 and ENGR200. Each of these courses includes an open-ended design project as its culminating assignment. FLiTE scholars will be working with peers from the general population of the department while in class. However, they will be coached during weekly cohort meetings to take lead roles in the execution of these projects. They will also be asked to bring the class team's design ideas or their own design ideas forward in weekly FLiTE cohort meetings and submit them for constructive criticism by the cohort and the directors in ideation (or *hatching*) sessions. Design ideas will be assessed for success potential, and scope. In this way, the scholars' leadership, and confidence in risk-taking and advancing their ideas will be fostered. It is expected that the scholar cohort will also grow in camaraderie and cohesion through these sessions.

During the Flight phase, scholars will develop stronger engineering skills in junior and senior level coursework. The ENGR350 and ENGR400/450 courses (taken by juniors and seniors, respectively) will demand project ideas that are of greater magnitude and abstraction than earlier efforts. The most promising projects put forth in ENGR350 will be subjected to hatching sessions similar to those employed in the Nest phase and will be carried forward for further development in ENGR400/450. Scholars will also be funded by the FLiTE program to further develop their product prototypes during the summer between their junior and senior years. In the senior year, those projects which have stood out as likely candidates to be successful products in the marketplace will be advanced as ENGR400/450 capstone projects. The projects may also be targeted for commercialization through WCU's Corporation for Entrepreneurship and Innovation (CEI, https://www.wcucei.com/).

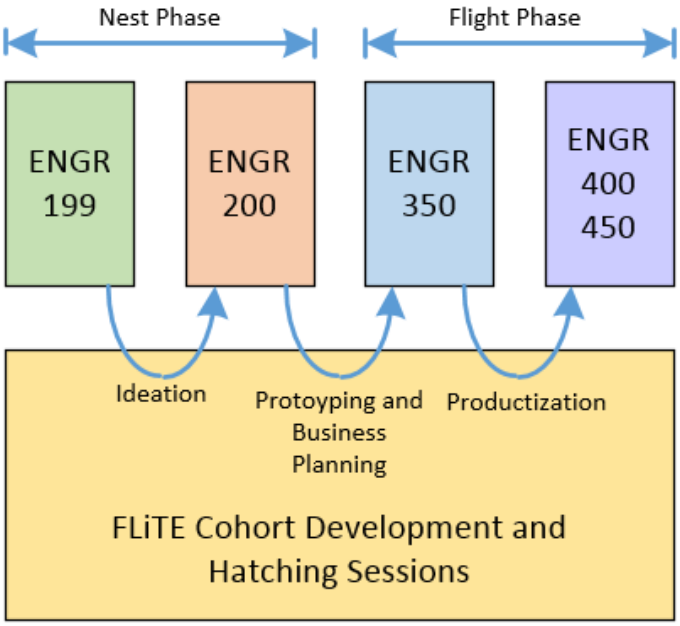

Figure 1 – Integration of the FLiTE program with the PBL course sequence.

Research Goals

The FLiTE program aims to develop entrepreneurism among department graduates and across the surrounding geographic region. Additionally, the program aims to extend the state of the art in engineering pedagogy, particularly with respect to entrepreneurism. Thus, the following research questions will be considered.

1. What effects does the FLiTE program have on development of specific dimensions in the entrepreneurial mindset of FLiTE scholars? Pre- and post-assessments will be conducted to assess scholar development in the targeted areas.

2. Does early intervention in entrepreneurial thinking increase the originality and quality of projects in an open-ideation forum (e.g. ENGR 350)? Instructors for the ENGR 350 course will be interviewed to assess differentiation of FLiTE-influenced projects versus those of the general student population.

3. Does the FLiTE program promote diversity in the regional technology-entrepreneurial workforce, particularly among native Appalachian students, who are typically underrepresented in STEM fields? FLiTE scholars will be interviewed over the course of the program to assess their perceptions of the program's influence on their degree satisfaction and career path. Where possible, FLiTE program participants will be tracked post-graduation for their career placements and job selection.

Data collected will include the following.

1. Scholar demographic data
2. GPA, and PBL course grades.
3. Data on retention within the School, the FLiTE program, and degree attainment.
4. Written scholar reflections, and cohort/small group interaction summaries.
5. Interview notes or transcripts with scholars at key points in their degree progression.
6. Surveys to assess dimensions of entrepreneurism.

Sustainability

Sustained practices and benefits of the program may be viewed in the three categories. First, the program may lead to the establishment of entrepreneurial pedagogy applied to program curricula within the host department and at large. Past experience in the areas of mentorship, undergraduate research, and project management [16], [17], [18] related to engineering pedagogy has shown these to be high-impact practices which would extend well to the pedagogy of entrepreneurship. They will be actively integrated into the PBL curriculum.

Second, the program will encourage the development of an entrepreneurial culture which propagates and passes on to current and future students. Peer observation of entrepreneurial success may be expected to generate widespread and ongoing enthusiasm for self-launched technology enterprises.

Third, the program will foster the creation of a community of business and industry alumni of the program who may lend guidance to future students through guest lectures, mentoring, and hiring. If successful in the areas, the FLiTE program will form a model for entrepreneurism in engineering and engineering technology curricula that would be of benefit to other programs and regions.

4. First Year Results

Recruitment and Demographics

NSF awarded the FLiTE grant to WCU by NSF in January 2022. In March 2022, recruitment of the first class of scholars began with the goal of selecting twelve incoming freshman students with declared majors in the School of Engineering + Technology to join FLiTE as the inaugural class of scholars. Based on financial need information provided by WCU's Office of Financial Aid, 163 incoming freshmen were solicited to apply to the program. Solicitations occurred by both email and US mail notifications. Applications consisted of essay responses provided through a Qualtrics survey to the following four questions.

1. Describe your activities/hobbies outside of school.

2. What does the term "innovation" mean to you? Describe situations in which you have demonstrated an innovative approach to some aspect of your life.

3. Provide an example of a situation when you had to persist to overcome adversity or achieve a long-term goal.

4. Are you interested in starting a business, or have you started one in the past? Describe your motivation for doing so, and what the business is or would be like.

Twenty-two applications were received. These were reviewed by the program directors. Although academic achievement (based on high school GPA) was considered, the quality of essay responses was viewed as evidence of entrepreneurial and creative potential of the applicants and thus given greater weight. Ten applicants were selected to participate in Year 1 of the program. The scholar class included seven male and three female students. Three students reported their race as other than white/Caucasian.

Degree program interests of the scholars consisted of 20% in the Bachelor of Science in Electrical and Computer Engineering Technology (BSECET), 10% in Bachelor of Science in Electrical Engineering (BSEE), 60% in the Bachelor of Science in Engineering (BSE - Mechanical Engineering concentration) and 10% the Bachelor of Science in Engineering Technology (BSET).

The financial need of the scholars was determined from data reported by WCU's Office of Financial Aid. Eight of ten scholars received the maximum budgeted award of $6,300. The average award was $6,202.

During a focus group meeting several mentioned that they were unsure if the scholarship offer was legitimate, because there was nothing official on WCU's website about it at the time. Future scholars should feel more confident in this as the program is now loaded into the University's official scholarship portal. Several of the scholars also noted that they were unsure about the full scope of program expectations when accepting the scholarship and did not realize the level of active participation that would be asked of them.

Cohort Meetings and Ideation Sessions

The FLiTE scholars met weekly during the Fall 2022 semester. Initially, scholars were asked to complete an intake survey designed to gauge their level of identification with various qualities of entrepreneurial thinking and self-efficacy. Data from this survey was intended to be a *pre*-image of the scholars' attitudes and self-perceptions. The data will be compared with responses collected periodically throughout the program, and with awardees of subsequent years.

Meetings included a combination of speakers, group activities, tours of WCU's prototyping and machining labs, and product ideation sessions. Presentations related to entrepreneurship and growth mindset were given by the directors as well as invited entrepreneurs, both active and retired. Topics presented included design thinking, the entrepreneurial (growth) mindset, opportunity identification, business formation dynamics, failure analysis, team characteristics, and intellectual property protection and patenting.

Toward the development of a regular habit of creative thinking among scholars, cohort meetings typically included product ideation sessions. In preparation for these sessions, scholars were tasked with bringing product ideas of their own conception to meetings as the subjects of one-minute pitches and cursory business analysis followed by group discussion. Each scholar was expected to look at their daily circumstances as a university student and take note of a *point of pain*, or need, among their peers or faculty. Based on their observations, they would bring a potentially marketable idea to each of three weekly meetings and present it to the group in the form of a one-minute pitch. This series generated a total of 29 product ideas.

Scholars were then divided into three groups of 3-4 individuals, with each group tasked to advance the top three ideas from an assigned group of 9-10 ideas using a forum of frank and constructive criticism. In a following session, the scholars were once again divided into groups of three to choose a top idea from those that had been previously advanced. Scholars were asked to speculate about business aspects of their chosen ideas such as cost, development schedule, and market positioning. This exercise is expected to be a recurring mechanism for idea screening and team building as the program progresses.

Evaluation of Scholars

As a condition of participation, FLiTE scholars were required to sign a contract pledging their commitment to actively engage in the program, and to maintain a 3.25 grade point average. Weekly attendance at meetings was closely monitored, and grades were examined at waypoints during and following the semester.

The program directors conducted a mid-year review of the program and the scholars' progress in early January 2023. The directors reviewed student performance and associated artifacts. Factors considered included semester GPA, FLiTE contract assessments, and scholars' interactions with the directors during mentorship conversations. Most scholars participated enthusiastically as observed during weekly meetings, though some required individualized guidance to encourage their engagement. Four scholars were placed on *at risk* status for Spring 2023 due to GPAs falling below the 3.25 floor specified in the participation contract. These students will be supported through focused advisement by the directors and monitored through 5th-week and 8th-week semester grade updates. One scholar left the university. Of those retained, the average GPA was 3.287.

External Review

The program underwent external review at the end of the first academic semester in December 2022. The reviewer was provided with information on all program activities to date. The reviewer interviewed program personnel, toured WCU's facilities including prototyping labs and classrooms, and conducted a focus group with the scholar cohort. The reviewer generated a formative evaluation of the program based on the logic model shown in Figure 2.

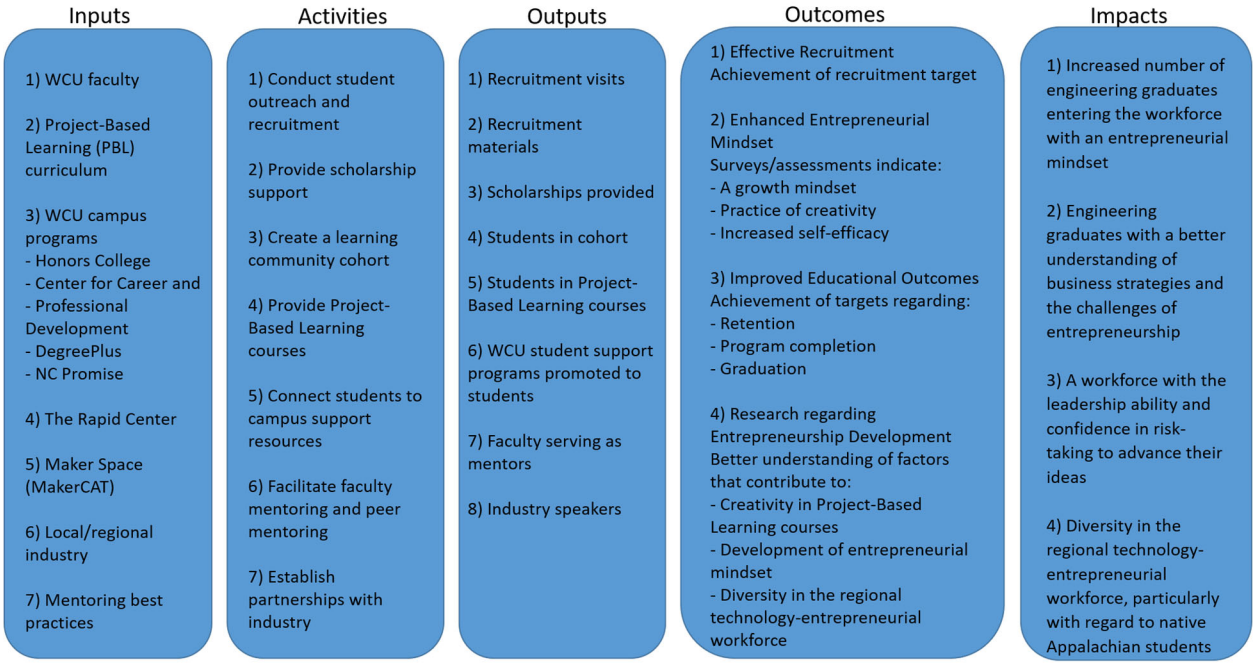

Figure 2 – The FLiTE program logic model.

In general, feedback from the evaluation were positive. Of particular interest were the evaluator's notes from a focus group discussion with the scholar cohort. Findings from that meeting indicated that scholars were interested in a deeper personal engagement with the program including informal meetings with fellow scholars, field trips, and a road map of coming semesters to facilitate better preparation.

5. Conclusions

The FLiTE grant, becoming active in January 2022, was not available until late in the cycle for incoming students. The applicant pool, and thus the initial recruiting class was not as deep as hoped. The FLiTE scholarship program began its second semester with nine of twelve budgeted awards having been accepted. Scholar participation has been positive and energetic during the program's first semester. Enthusiasm for future activities is encouraging.

Speakers at weekly cohort meetings have been of high quality. Speaker's presentations have engaged the scholars and helped the cohort to envision themselves in the role of business founder, and even as future startup billionaire. Such sessions have allowed the small, and increasingly cohesive group to freely ask questions and converse with experienced entrepreneurs in ways that are not available to other students within the department.

As ideation sessions have progressed, so has the quality of student proposals. With scholars being new freshmen with little technical background, their early product ideas typically ran at the level of household gadgets. As their individual confidence has risen with accumulated program exposure, and a measure of academic success to their credit, it is apparent that the horizon for these future entrepreneurs has broadened as their ideas have increased in complexity and technical depth.

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