



## Assessment and Evaluation of Villanova University's Engineering Entrepreneurship Minor Program

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# **Lessons Learned from a Decade of Offering the Engineering Entrepreneurship Minor at Villanova University**

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## **Abstract**

Villanova University has been offering an engineering entrepreneurship minor program for ten years. This 16 credit minor program starts with idea generation, proceeds through feasibility and prototyping courses and culminates in a business plan preparation course. There are also three practicum courses included in the minor that provide focused experiences for students in related themed areas.

The program has graduated over 100 students and continues to see a robust enrollment of about 12% of the engineering students and is the largest subscribed minor in the College of Engineering. After a decade of offering the engineering entrepreneurship minor, the program was evaluated to identify its strengths and determine if any modifications needed to be made.

The program evaluation was based on the collection and analysis of several forms of data including course syllabi, focus groups with current students, and surveys of alumni. This paper will share the significant lessons learned from offering the Entrepreneurship Minor as a curricular option within the Engineering Curriculum for the past decade. In doing so, the paper will highlight the ways in which Villanova University's program is unique among Engineering Entrepreneurship Minors located at other universities.

## **History of the Minor**

Villanova University started an engineering entrepreneurship minor program in the fall 2008 semester. At the time, an entrepreneurship minor was offered in the Business School and a group of engineering faculty members had been considering offering a minor to engineering students but the initiative did not gain traction until a seed grant was provided by the Kern Family Foundation to establish an engineering entrepreneurship minor program in the College of Engineering.

At the time, the structure of the entrepreneurship minor in the Villanova School of Business (VSB) was a 12 credit hour minor concentrated into one semester. During this semester students took four classes that counted towards the minor and were expected to develop and start a business venture during this semester. This minor was typically taken in the junior year of the Business students' curriculum.

It was decided that such a structure would not work for the engineering students because of the need to take several engineering courses each year to stay on schedule to graduate with their engineering degrees in a reasonable time period (4-5 years). A curriculum was therefore devised for the engineering entrepreneurship minor in which the engineering students start the program in the fall semester of their sophomore year and take one course per semester through the end of the fall semester senior year. In the second semester sophomore year and the two semesters of their junior year, the students also take a practicum course. Unlike the requirement for starting a business as a part of the VSB entrepreneurship minor curriculum, no such requirement was placed on the engineering students taking the engineering entrepreneurship curriculum. The philosophy of the engineering entrepreneurship minor program was on instilling the entrepreneurial mindset rather than starting business ventures.

The Engineering Entrepreneurship Minor program is a 16 credit hour minor. The curriculum for the minor consists of the following sequence of prescribed courses and practicums:

*Engineering Entrepreneurship Minor Curriculum (16 credits)*

EGEN 2100 – Creativity and Innovation (1 cr)

EGEN 2200 – Opportunity Identification and Business Principles (3 cr)

EGEN 2300 – Entrepreneurship Practicum I (1 cr)

EGEN 3100 – Feasibility Analysis for Entrepreneurship (3 cr)

EGEN 3200 – Product and Service Prototyping (3 cr)

EGEN 3300 – Entrepreneurship Practicum II (1 cr)

EGEN 3400 – Entrepreneurship Practicum III (1 cr)

EGEN 4100 – Market, Finance, and Venture Plan (3 cr)

The Engineering Entrepreneurship Minor is open to students in all disciplines within the College of Engineering. Students generally declare the minor in sophomore year and complete the requirements by fall semester of senior year. The program has graduated 110 students and continues to attract new registrants. For instance, the fall 2017 section of the first course in the sequence, "Creativity and Innovation," contained nearly 30 new students.

### **Engineering Minors at Other Universities**

Several universities offer engineering entrepreneurship courses/minors, but they tend to include a more limited number of courses. Some of these programs are described below.

At the University of Pennsylvania, a 2-course sequence is offered to engineering students. The first course includes topics such as intellectual property, evaluating risk, acquiring financing for a new venture, and leadership. The course incorporates classroom lectures, case study

discussions and guest speakers. The second course is focused on planning a high tech venture with the goal of preparing a business plan by the end of the term. These two courses are open to students of either junior or senior standing. A similar program structure is also offered at the University of Colorado.

More in-depth programs are offered at Cornell University and at the University of Tennessee, Knoxville. Cornell Engineering offers a more in-depth program starting with an Introduction to Entrepreneurship for Engineers course at the sophomore level. The minor requires 18 credits and includes courses on Ethics, History of Capitalism and Technology, Accounting and Finance, Ideation and Design Thinking and a capstone entrepreneurship project. An experiential learning experience through a summer internship or coop program is encouraged but not required.

The engineering entrepreneurship minor at the University of Virginia is comprised of three required courses and one elective. The three required courses are Business Fundamentals, Engineers as Entrepreneurs, and Entrepreneurial Finance. An elective course is also required which may be chosen from a list of courses including Start Up Strategies for Entrepreneurs, Intellectual Property and Entrepreneurs and the State.

The Pennsylvania State University offers a number of courses that may be taken to fulfill an engineering entrepreneurship minor including:

Mgmt. 215	Entrepreneurial Mindset
Eng. 310	Entrepreneurial Leadership
Mgmt. 425	New Venture Creation
Eng. 407	Technology-Based Entrepreneurship
Eng. 411	Engineering Business Basics
Eng. 415	Technology Launch for Entrepreneurs

Two of the distinctive features of Villanova's Engineering Entrepreneurship minor program are the spiral curriculum and the active learning pedagogical approach used in the teaching of the classes. The assessment of the engineering entrepreneurship minor program brought these two factors out as being particularly strong elements of the educational program.

### **Methodology of Program Evaluation**

The program evaluation was intended to accomplish three goals:

- 1) Explore the current state of the Engineering Entrepreneurship Minor at Villanova University;
- 2) Determine progress towards accomplishing program goals as defined by the Kern Family Foundation, the main sponsor of the Engineering Entrepreneurship Minor program at Villanova University;
- 3) Evaluate whether modifications should be made in the Minor and provide recommendations for possible programmatic changes.

In order to solicit feedback from various stakeholder groups, the program evaluation used a variety of methods. First, a survey was developed and sent out to all 96 alumni/ae who had

graduated from the engineering entrepreneurship minor program over the period 2011 to 2016. There was about a 30% response rate to the survey. The survey questions were similar to the ones that had been used in a previous survey to assess how well the program was succeeding in instilling the entrepreneurial mindset in engineering students. Details of that research effort including the questions used in the survey instrument were presented in [1]. The questions used in the present survey were updated to reflect the KEEN student outcomes [2].

Survey data revealed that alumni/ae viewed the minor as positively impacting the development of an entrepreneurial mindset, a finding corroborated by focus groups with current students in the program. Alumni rated the quality of courses in the minor very highly with 97% evaluating the courses as “excellent,” “very good,” or “good”. Another significant finding of the survey was that 87% of respondents believed that they use the skills and competencies acquired through the minor in their daily work “sometimes” or “often.” Lastly, based on their experience in the workplace, 91% of respondents would recommend the minor to prospective engineering students.

While survey data revealed the relevance and applicability of the minor to alumni/ae working in the field, focus groups with faculty and students currently enrolled in the minor provided valuable feedback about their experiences with the minor in its current iteration. In addition, a document analysis of course syllabi indicated the degree to which the courses aligned with one another and with the overall goals of the minor as well as the types of pedagogy and assignments used in each course. An outside assessment expert (author 1 of this paper) performed the focus groups and analyzed the data.

The following sections discuss conclusions drawn from the program evaluation of the Engineering Entrepreneurship Minor at Villanova University. These “lessons” may prove useful to other universities who currently offer an engineering entrepreneurship minor or who are considering it.

## **Lessons Learned**

### ***1. The Value of Curricular Alignment***

Curriculum alignment is the process of ensuring consistency and compatibility across the objectives, instructional methods, and assessments used in a curriculum (series of courses). In the case of Villanova University, the KEEN Framework provided the foundation on which the Engineering Entrepreneurship Minor was built. The KEEN Framework identifies the development of the entrepreneurial mindset in undergraduate engineering students as its key goal. Specifically, instilling the entrepreneurial mindset involves nurturing in students the 3 C’s of curiosity, connections, and creating value.

The following student learning outcomes frame the KEEN program:

#### **Curiosity**

1. Demonstrate constant curiosity about our changing world
2. Explore a contrarian view of accepted solutions

### **Connections**

3. Integrate information from many sources to gain insight
4. Assess and manage risk, e.g. interconnected ramifications

### **Creating value**

5. Identify unexpected opportunities to create value
6. Persist through and learn from failure, essential when iterating using stakeholder feedback

In order to determine the degree to which program faculty grounded their courses in these objectives, the evaluator examined course syllabi and assignments. In particular, the objectives for each course were examined to determine whether or not they reinforced the goal of instilling an entrepreneurial mindset. The next step involved determining whether the pedagogical approaches used in the classes and the assessments supported student attainment of those objectives. A curriculum matrix was created which listed the KEEN learning objectives and the courses, teaching methods, and assignments that aligned with them.

An analysis of the course descriptions, learning objectives, and assessments contained in these syllabi revealed that the courses in Villanova University's Engineering Entrepreneurship Minor provide numerous opportunities for students to develop the three C's of curiosity, connections, and creating value. Fostering in students an "insatiable curiosity" about the rapidly changing world begins in the first course that students take in the program, "Creativity and Innovation." In this course, students are introduced to the entrepreneurial mindset and learn practices and tools for developing creative solutions to problems. Cultivating curiosity comprises an objective threaded throughout the remaining courses in the program via course assignments, lectures, and group projects and presentations.

The other two elements of the entrepreneurial mindset – connections and creating value – form the backbone of the remaining courses in the curriculum of the minor. Courses in feasibility analysis, product and service prototyping, and market, finance, and venture planning guide students in the steps needed to take a concept from ideation to the market. While document analysis indicated that faculty members incorporate the 3 C's into their courses, focus groups with current students and alumni indicated that the entrepreneurial mindset is truly fostered in the classroom and not just integrated on paper.

## ***2. The Value of a Structured and Spiral Curriculum***

The vision of the faculty surrounding the organization of the program has been a significant point of consistency throughout its implementation. Faculty intended for the minor to align closely with the process used by entrepreneurs, that is, "idea – feasibility – planning – execution." The curriculum for the minor requires students to enroll in a pre-determined sequence of courses, which reflect that process. Faculty believe that these courses have good "flow" and actually parallel the progression embedded in the 3 C's of curiosity, connections, and creating value. In focus groups, students revealed that they found the structure of the curriculum to be one of its strengths.

Students appreciated the way in which the courses in the minor built on one another and mirrored the process used by entrepreneurs in the field. During the program evaluation, one student likened the structure of the minor to “mimicking the process of starting a company,” while another noted that the time devoted to students developing their ideas over subsequent courses was “a really good example of how a business would work.”

A spiral curriculum provides an opportunity for students to encounter course concepts and skills multiple times as they are “circled back” upon one another in subsequent courses. During one focus group, a faculty member explained the purposefulness with which the program faculty “spiraled” topics and activities into the minor:

“We deliberately put [these principles] in the program so that they [the students] see it three times... The first time that they see something like an accounting principle, maybe the definitions and what it means. The next time they would see it, it would be in a case study so they would know how someone else used it. And the third time they would actually be doing it because they are designing their business model.”

Similarly, another instructor described how students build up their skills in prototyping by exercising the competency in three different ways: first as a story board, then as a simple prototype, and then later in the practicum when they build a Rube Goldberg machine.

### ***3. The Distinctiveness of the Minor***

Students often used the adjectives “different” and “unique” as they discussed courses in the minor in comparison to courses in their engineering major. Respondents in focus groups generally favored the style of teaching in the minor courses, calling it “creative,” “fun,” “different from our normal curriculum,” and “a breath of fresh air.” Students cited two ways in which courses in the Engineering Entrepreneurship Minor were distinctive from other courses: they foster a “new way of thinking” and they emphasize application over theory.

Students disclosed that courses in the minor encouraged them to think in ways that they did not encounter in their other engineering courses. For example, one junior said that the minor, “emphasizes creativity which, for engineers, we don’t really have that opportunity in our other classes.” Other elements of this “different way of thinking” included constantly searching for opportunities to create solutions and considering the next step to fix problems. One student explained that “learning how to get your mind to think a certain way – to look for opportunities” was a common theme throughout the courses. Essentially, students’ responses indicated that they had internalized aspects of the entrepreneurial mindset.

In addition to cultivating a different way of thinking, students noted that the minor also introduced them to novel ways of interacting with course material. Students characterized the pedagogical approaches in courses in the minor as more interactive and hands-on than courses in their respective engineering majors. For example, one junior claimed that presentations are not typically required in engineering courses, but in the minor, “We do all this stuff that gets you in front of actual adults.”

Another way in which students differentiated courses in the minor from technical classes in their majors is that the minor courses provided more opportunities for authentic application of concepts. One student described the difference in this way:

*“...you’re never really given the opportunity in these [technical] classes to think about applications you can use them for. You might learn applications in the textbook, but you’re not actually taking the time to think, “What could I make with this? What could I take these skills and use...to improve the existing society?”*

This student implies that textbook problems are inadequate in their ability to connect students’ classroom learning with real-world application, a limitation that this student believes the minor overcomes.

### ***3. The Value of Real-World Pedagogy***

In addition to providing a curricular basis for course content and student learning objectives, the KEEN Framework also emphasizes a particular instructional approach called “entrepreneurial minded learning.” [3] Rae and Melton (2016) define “entrepreneurially minded learning (EML)” as “an emergent pedagogy which resembles problem-based learning (PBL) and Design Thinking, but emphasizes opportunity recognition and value creation for stakeholders” (p. 12).

As part of the curriculum alignment review, a separate curriculum matrix was created to map the instructional approaches and types of assessments used in each of the courses in the minor. The matrix indicated that “entrepreneurial-minded learning” was infused across the curriculum for the minor. Active, student-centered approaches such as team projects comprised a recurring theme in the matrix and could be found in all of the courses in the minor.

According to students, one of the principal strengths of the Engineering Entrepreneurship Minor is the way in which it mirrors the “real world.” Students saw a clear connection between their experiences in the minor and the actual work of entrepreneurs. Specific aspects of the minor that conveyed “real-world” relevance for the students were the use of projects and presentations and exposure to guest speakers from the field.

One aspect of the minor that students particularly enjoyed was the prevalence of practical assignments and exercises, such as group projects and oral presentations, in their courses. Students identified these instructional approaches as directly relevant to their future careers. For example, when asked to identify the most important strengths of the minor, a senior explained, “I would say it’s how interconnected it is with the real world ... there is nothing that you do towards your final project that’s just for the sake of the class. ...so that’s one of its biggest strengths, that sort of real-world feel.” Similarly, one junior asserted that “a lot of us may want to work in a [start-up] atmosphere like that,” so the hands-on work of prototyping “gives you a taste for what it can be like.” These students viewed the minor as laying a foundation for their future work. Students cited working on team projects and making presentations as opportunities to practice the types of skills that they would need in the workplace. For instance, one student shared, “It was good to see feedback for your own product and just in general, how presenting goes in the real world, too. It was different than in the classroom. It was real, like they actually wanted to see your idea come to life.”

The participation of guest speakers, particularly Villanova University alumni, in courses or at competitions greatly contributed to the “real-world” quality of the minor as well as its appeal. Significantly, students noted the impact of guest speakers in helping them to develop the entrepreneurial mindset. As one junior explained, “...these people have lived through it and it is inspiring to hear what they’ve done and that, I think, is one of the best ways to get students in the mindset - to see and hear people that have actually done it.” Guest speakers offered tangible evidence of theories put into practice and held great credibility as individuals who had successfully applied the entrepreneurial mindset in action.

Another important aspect of including guest speakers in classes and at competitions is that they represent the “real world” – the environment into which students will graduate and work. One alumnus, whose team had won the Innovation Chase and traveled to Chicago, described the impact of being able to present his idea to a panel of Ford executives: “Having people at Ford talking to me as a college student and me pitching my idea to them and talking to a panel on a conference call...I thought it was really cool, being able to explain my idea to people who might have actually implemented it.”

#### ***4. The Challenge of the Practicum***

Since its inception, the required courses in the Engineering Entrepreneurship Minor have not changed; however, program directors had altered the nature of the practicum. The practicum was originally intended to provide students with work experience in a start-up business environment. Its purpose was to provide an opportunity for students to see and experience how theories and concepts from their coursework manifested themselves in a real-life work setting. When the minor was first offered, students scheduled their field experiences individually and completed the practicum at a site off-campus where they worked on the ideas of local entrepreneurs.

For a variety of logistical reasons, after a few semesters the practicum transitioned from an internship experience in a start-up environment off-campus to a series of extra-curricular activities conducted on-campus. Currently, the practicum is comprised of three, one-credit courses. For one of the courses, students are provided with a list of professional development opportunities, such as attending the lecture of a guest speaker on campus or joining one of several campus-wide competitions. Each of these activities corresponds to a certain number of points. Students choose which activities to attend in order to accumulate the required number of points for each practicum. The other two practicum experiences have been restructured into semester-long team projects under the direction of an instructor.

The practicum presents a unique challenge and opportunity within the minor curriculum in engineering entrepreneurship at Villanova University. The faculty are currently revisiting the practicum requirement and discussing the following questions/options, which have applicability beyond this institution:

- What are the end goals of the practicum? Does it complement the other courses in the minor? If so, how? If not, how could it do so more effectively? Does the practicum align with the learning goals of the minor?
- If the faculty committee determines that the original intent of the practicum to immerse students in a start-up environment is worthy of reconsideration, then a field placement or internship coordinator (designated staff member or graduate assistant) would be needed to serve as a community liaison and coordinate efforts with local entrepreneurs.
- In focus groups and interviews, students stated that they really valued the extracurricular competitions in which they participated as part of the practicum. As the faculty discuss the next iteration of the minor, they might consider maintaining the menu of professional development options offered in the practicum, but evaluating the choices and possibly making changes. A matrix could be created to determine if the options included in the practicum align with program goals. Options that do not provide diverse and robust challenges for students to develop the entrepreneurial mindset and rehearse engineering skills should be eliminated from the list. New opportunities could be added.
- How is student learning in the practicum assessed? The faculty committee might consider adding a portfolio component to provide a direct form of assessment. An electronic portfolio would list the characteristics of the entrepreneurial mindset and the related engineering skillset and require students to upload two forms of assessment evidence for each disposition and skill: an artifact and a reflection. Students would upload artifacts from their participation in various practicum experiences coupled with a narrative that explains how participation in that event developed a given disposition or skill. The use of portfolios in engineering education has been documented since at least the late 1990s (e.g. Sharp, 1997 [4]; Christy & Lima, 1998 [5]; Knott et al., 2004 [6]). Christy and Lima (1998) [5] noted that at that time student portfolios were listed as “a possible means of assessment under the basic level accreditation criteria for ABET ‘Engineering Criteria 2000’ (p. 1).

## Conclusion

In this paper, we have described some of the results of a recent program evaluation conducted on the Engineering Entrepreneurship Minor at Villanova University. The results of this program evaluation offer insights into how to effectively structure and implement a minor in engineering entrepreneurship. Data drawn from surveys with alumni/ae and focus groups with students and faculty point to the elements that these stakeholders viewed as strengths of the program.

Curriculum alignment is perhaps the most important consideration in organizing a minor in any course of study. For this university, the notion of an “entrepreneurial mindset” offered by the KEEN foundation provided the theoretical framing for the minor. The creation of a curriculum matrix helped to determine the alignment of course objectives, instructional methods, and assessments with the KEEN goals. The curriculum matrix also highlighted locations in the curriculum where student exposure to key concepts and skills was revisited over the course of the program. A related aspect of the curriculum, which proved to be beneficial for students, was the way in which the course sequence was purposefully structured to mirror the process used by entrepreneurs (i.e. idea > feasibility > planning > execution).

Students have a number of choices when it comes to selecting a minor to accompany their major area of study. At Villanova University, the entrepreneurship minor enjoys great interest among students due to several distinctive features. First, courses in this minor push students' thinking in qualitatively different ways than their other engineering courses. Students value the opportunity to develop creativity and look for ways to place innovation in the service of society. The minor also stands out among program offerings because of its unique pedagogical method, an approach that blends theory and practice in an experiential format. Students favor teaching approaches that allow them to do hands-on projects and apply conceptual knowledge in real-world scenarios. The real-world relevance of course projects and presentations in addition to engagement with guest speakers from the field help students see the clear connection between coursework and their chosen profession. Villanova University also offers a variety of campus-wide entrepreneurship competitions that provide interactive and enjoyable ways in which students can nurture the entrepreneurial mindset and skills.

The real-world applicability of the minor can be further extended through the inclusion of a high quality practicum experience. An off-campus internship in a start-up environment provides an ideal situation for students to apply what they have learned; however, organizing such a network of internship locations requires significant human and financial resources. In addition, the practicum experience must include an assessment that allows instructors to determine whether or not the practicum has met its goals. At the conclusion of the program evaluation at Villanova University, it was determined that the practicum course was the aspect of the minor in need of the most reconsideration and revision.

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