

The Toy Box Project: Connecting First-Year Engineering Students with Entrepreneurship

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Introduction:

The University of Mount Union is a small, private, liberal arts institution located in the Midwestern United States. At the time of this work, The Engineering Department offered ABET-accredited undergraduate degree programs in mechanical and civil engineering, with approximately 130 students majoring in one of these disciplines. Based on alumni surveys, approximately 85% of engineering graduates from Mount Union are hired into industry positions. For this reason, “the development of essential business skills” was established as one of the program’s Four Pillars of Exceptional Engineering Education (Fig. 1). Further, entrepreneurship was identified as an important business skill, because the benefits of integrating the entrepreneurial mindset into the engineering curriculum have been well documented [1-3]. Specifically, the Kern Entrepreneurial Engineering Network (KEEN) identifies the entrepreneurial mindset as helping students understand the bigger picture, recognize opportunities, and learn from mistakes to create value [4].

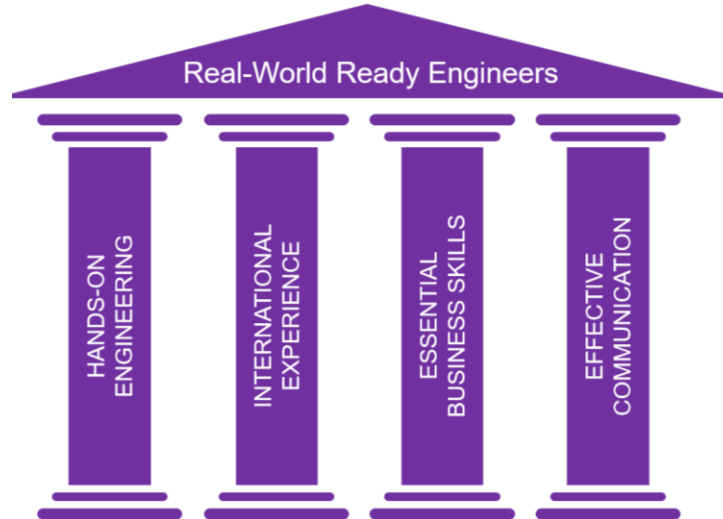


Figure 1: Four Pillars of Exception Engineering Education at Mount Union

In the past, the engineering and entrepreneurship programs at Mount Union operated independently. During the 2017-18 academic year, the two programs began a collaboration to integrate entrepreneurship concepts into the first-year engineering courses. Efforts to incorporate entrepreneurial mindset activities into the Fall ‘17 course were presented by Korach et al. [5]. This paper describes a novel collaboration between the Spring ‘18 first-year engineering course and an upper-level entrepreneurship course.

EGE120, *Introduction to Engineering Design and Analysis*, was offered for first year engineering students during the spring semester. The overarching theme of this 4-credit hour course was engineering communication. Students learned how to organize and write design reports, incorporate appropriate engineering graphics into these documents, and give formal presentations. To provide the background and context for this communication, the content of the course was split evenly between computer-aided design (CAD; 2 hr) and a semester-long design project (2 hr). For

the design project, students followed the engineering design process to develop and build prototypes to solve real-world problems.

In the past, students brainstormed their own project ideas based on activities they enjoyed. While these projects were engaging to the students, it was often difficult to motivate the students to generate appropriate design requirements and to develop design concepts that challenged their personal preferences. One cause of these issues was the absence of market and consumer analysis. In contrast to the first-year engineering students, entrepreneurship students have experience in identifying and evaluating consumer markets [6]. Therefore, the projects could be improved creating interdisciplinary teams of EGE120 and entrepreneurship students.

During the Spring '18 semester, a collaboration was developed between EGE120 with ENT350, *The Entrepreneurial Experience*. ENT350, a 4-credit hour course, was the culminating experience for the entrepreneurship studies minor. The course was structured to give students a simulated experience of starting and participating in an entrepreneurial venture. One recurring challenge for ENT350 instructors was motivating the students to develop working prototypes of their ideas since the program lacked resources and a maker-space was not present on campus. Additionally, most of the students' venture ideas were service-industry based projects. As goals, the entrepreneurship faculty wanted their students to experience the startup of a new-product venture and to then use the students' prototypes to promote the entrepreneurship studies minor. By connecting the two courses, the ENT350 students could provide market data and direction to EGE120 students as they developed working prototypes using the engineering fabrication labs. Overall the goals of this collaboration were to 1) implement a mutually beneficial, cross-disciplinary project, 2) generate quality, market-driven prototypes, and 3) promote the entrepreneurship minor to the engineering program and greater campus community.

Collaboration Details

The ideas for each design and new-venture project were inspired by ABC's *The Toy Box* [7], a show similar to *Shark Tank* with a twist: the panel of wealthy judges is replaced by children who solely evaluate pitches for new toys. At the start the semester, both EGE120 and ENT350 students generated ideas for novel toys or yard games, and then narrowed the list to four projects. Three engineering groups (one from each EGE120 section) were assigned to work with each ENT350 group (Figure 2). This accounted for the enrollment disparity between EGE120 (3 sections, 51 total students) and ENT350 (1 section, 14 students). Therefore, three different prototypes were developed for each project idea. The experience was structured so each EGE120 team was competing with analogous groups from different sections to win a bid from their ENT350 clients.

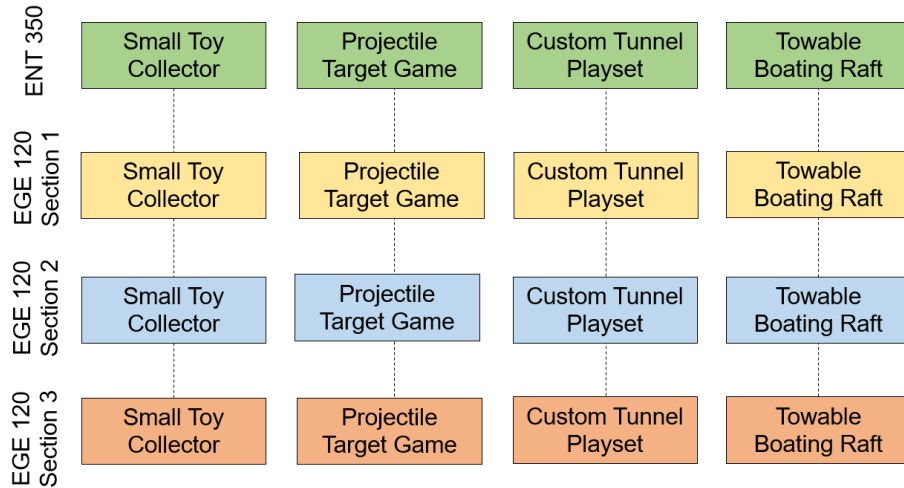


Figure 2: Project Team Organization

The course content associated with the design project was structured to guide the students through the steps of the engineering design process (Fig. 3) [8]. Recognizing that communication between engineering and entrepreneurship students was of great importance, a universal meeting time was scheduled during the ENT350 course lecture. This was possible since ENT350 lecture was scheduled for 3.5 hours on Monday evening, which was not a common time for courses taken by first-year engineering students. In this timeslot, the ENT350 clients would hold office hours, during which the EGE120 groups could come to communicate details about their designs and ask questions as needed. While students were strongly encouraged to meet face-to-face regularly, only four meetings were required: 1) an introductory meeting after the teams are assigned, 2) a progress update meeting where EGE120 students describe designs concepts for the final prototypes, 3) a formal design presentation by EGE120 students describing final design details to their ENT350 clients, and 4) an engineering-entrepreneurship design expo (Fig. 3).

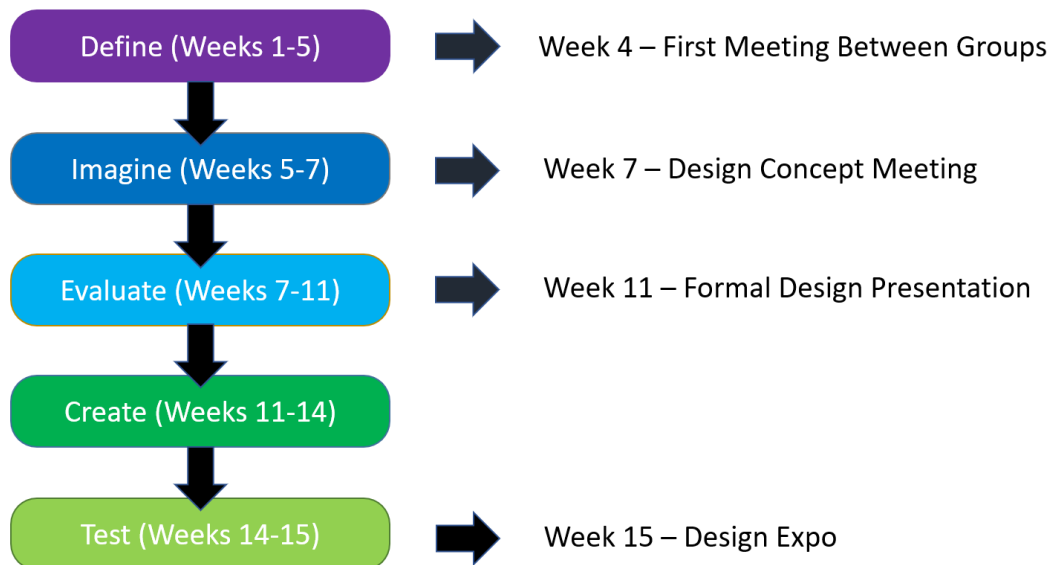


Figure 3: Engineering Design Process Timeline

Instead of presenting the final projects to a panel of children *Shark Tank*-style, each team was required to attend an Engineering-Entrepreneurship Design Expo during the last week of the semester. The Design Expo was an existing event previously showcasing the upperclassmen's engineering projects to the greater campus community. The event was marketed in advance and visitors received one ticket to vote for their favorite toy project. During the expo, teams were required to demonstrate their prototypes (Fig. 4-5) and convince visitors to vote for their project. The team with the most votes was awarded a cash prize.



Figure 4: The Engineering-Entrepreneurship Design Expo



Figure 5: EGE120 students demonstrate their prototypes at the Engineering-Entrepreneurship Design Expo.

Evaluation:

All twelve EGE120 teams were able to design and fabricate a working prototype. As typical with first-year engineering projects, the quality of the prototypes varied depending on the team. Each of the projects was directly affected by its ENT350 clients. For example, less guidance from the

clients resulted in a greater diversity in the prototype design (Fig. 6). In contrast, some clients allowed for less design freedom, and the prototypes were more similar (Fig. 7).



Figure 6: Divergent Projects: Small Toy Collector Prototypes



Figure 7: Convergent Projects: Towable Boating Raft

At the conclusion of the semester, the EGE120 students were surveyed to evaluate if the course learning goals were achieved (Fig. 8). Each statement shown in Figure 8 was evaluated on a 5-point Likert scale. Overwhelmingly, students indicated that they had learned how to effectively communicate (94%; Eval 1) and could use CAD appropriately to describe design information to non-engineers (96%; Eval 5). The students also enjoyed the design expo at the end of the semester (88%; Eval 7). The design expo was also successful in attracting the greater campus community. More than 270 guests registered at the event (more than 10% of the campus population). While most of the students also enjoyed working on the collaborative project (67%; Eval 8) and recommended continuing the collaboration (67%; Eval 9), these outcomes were rated lower than others. Only one student (2%) disagreed with the collaboration being continued next year. Evaluation 4, *Our prototypes exceeded our expectations*, was the lowest rated with only 63% of EGE120 students agreeing with this statement, although only 10% disagreed. Ten engineering students (19%) indicated that they were more interested in pursuing the entrepreneurship minor after the course (Eval 10), which would account for a 71% increase in the enrollment of ENT350 if the minor was pursued.

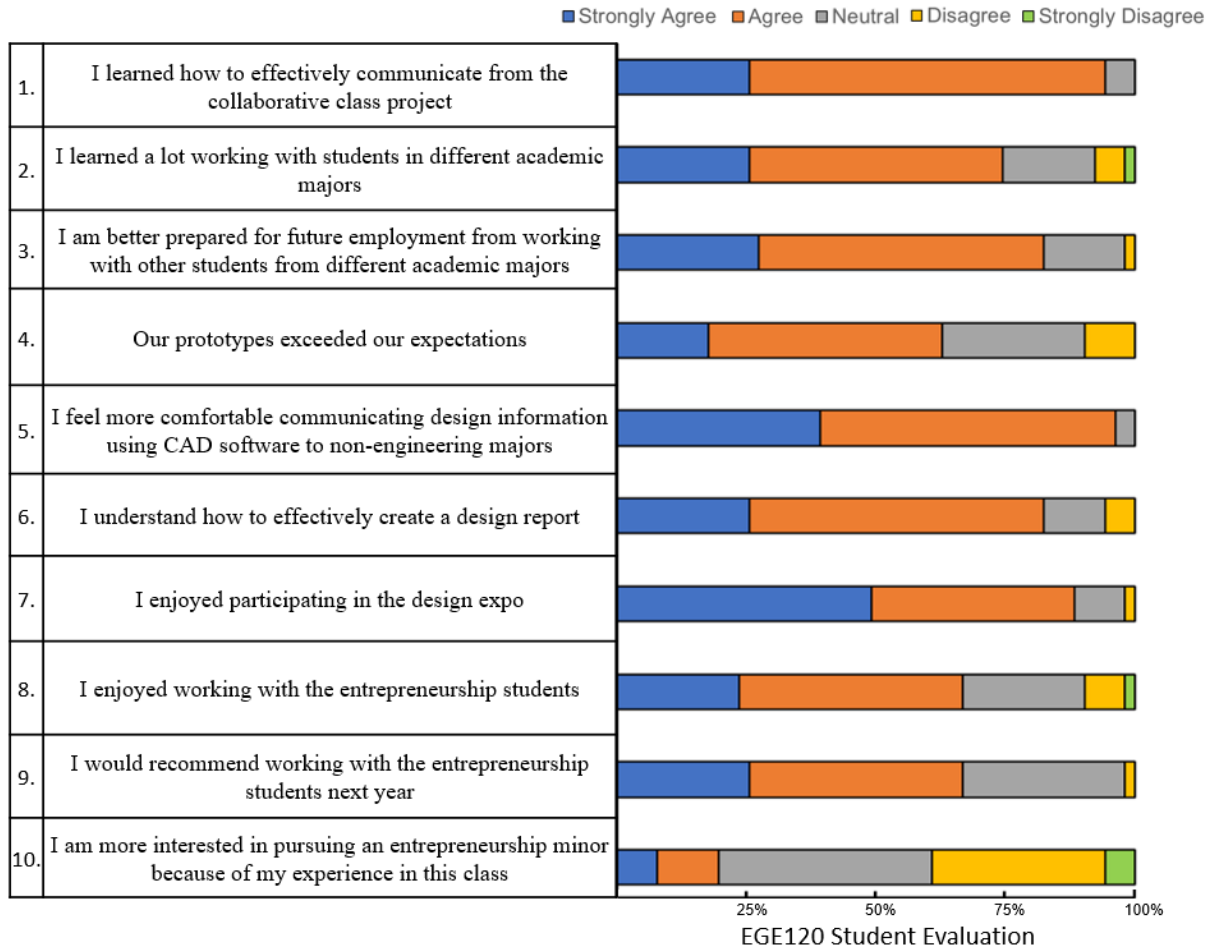


Figure 8: EGE120 course evaluation responses

The EGE120 students were also provided an open-ended question, “How could the collaboration between EGE120 and ENT350 be improved?” Similar student responses were grouped and are shown in Table 1. Overwhelming, students commented on the need for more meetings and better overall communication with the ENT350 clients. Approximately 20% of the students responded with the need to address a conflict between the teams. Of these, about 1/3 indicated a complete lack of guidance from the ENT350 clients, 1/3 suggested that the ENT350 students had unreasonable expectations for the project, and the final 1/3 argued that the engineering groups should have more control of the direction of the project. In the end, the best ENT350 groups were able to incorporate the ideas of the EGE120 and allow for a degree of design freedoms, while also providing direction through design requirements and data gathered from customer surveys.

Table 1: EGE120 Student Response to “How could the collaboration between EGE120 and ENT350 be improved?”

Response	Percentage*
Require more face-to-face meetings	35.3%
Better communication is needed between ENT350 and EGE120 groups	23.5%
Don't make any changes/No response	23.5%
Conflicts between ENT350 and EGE120	19.6%
Improve Course Scheduling	9.8%

*Some students represented in multiple categories.

Discussion:

Overall, the collaboration between the entrepreneurial studies program and the department of engineering was mutually beneficial. Transferring prototype development to engineering students allowed the ENT350 students to focus on venture planning and consumer surveying. EGE120 students were then guided by their clients toward market-based designs. Moreover, the competing engineering teams from different course sections were able to develop unique products from the initial design scope, leading to a diverse collection of final prototypes. Students from both courses enjoyed competing at the design expo at the end of the semester, which was also a seemingly popular event with its visitors.

Other documented collaborations between entrepreneurship and engineering students have demonstrated that working with entrepreneurs fosters entrepreneurial thinking and behavior among engineering students [9-11]. The collaboration presented in this paper is unique in that it connects first-year engineering students with upperclassmen entrepreneurship students. EGE120 students could observe how entrepreneurship works from their ENT350 client teams, and then be self-motivated to learn more about entrepreneurship. As such, 19% of the students indicated a greater interest in pursuing the entrepreneurship minor. Additionally, this experience could motivate student investment in future entrepreneurial experiences in the engineering curriculum. Some of the conflicts between the ENT350 and EGE120 groups may have been avoided by collaborating with upperclassmen instead of first-year engineering students. However, it is believed that there would still be the potential for conflict because the entrepreneurship students were also learning how to best communicate to the engineering students.

The projects were inspired by the show *The Toy Box*, but the collaboration was not modeled off the show. Many first-year engineering programs have incorporated *Shark Tank*-like pitch competitions to incorporate entrepreneurial experiences and develop entrepreneurial thinking [12-14]. In this collaboration, the engineering students were not required to participate in a formal pitch competition, but The ENT350 course did include a mandatory pitch competition. To properly prepare, the ENT350 teams solicited detailed design information from the EGE120 teams well before the completion of the prototypes. This process introduced the engineering students to pitch competitions, and as such, the students would be familiar when required to participate later in the curriculum.

EGE120 is a course focused on communication, so one auxiliary goal of the toy project was to stress the importance of communication when working on an interdisciplinary team. Student comments revealed that communication between the two courses could be improved; therefore, providing more group work time during class could improve a team's synergy and overall performance. The EGE120 students were given time each week to work with their engineering teammates, but it wasn't feasible to have the ENT350 groups attend three different sections EGE120. Instead, a universal group work time called *Office Hours* was established during the ENT350 lecture. Requiring more face-to-face meetings between the EGE120 and ENT350 students during these office hours may improve the quality of collaboration.

While some conflicts within groups inevitably will occur [15], developing strategies to overcome adversity is a valuable learning opportunity and can improve future project work. To motivate such learning, the course instructors could adapt practical teaching methods to handle conflict, such as providing "crisis clinic" sessions to brainstorm solutions to actual or potential group difficulties [15]. Additionally, a self-reflection activity could be added at the conclusion of the project. For this activity, students could address the need for consistent communication, identify weaknesses in their team's communication, and create a plan for how they would fix those issues if they were working on a similar project in the future.

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