Promoting Engineering Identity through a Pre-Semester Freshman Design Competition

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1. Introduction and Background

The retention of quality engineering students is a matter of concern to all colleges of engineering in the nation and is a concern of the profession of engineering. Of particular concern is the retention of engineering students from the first to second year, as this is when the highest rate of attrition occurs. The traditional engineering student enters his or her freshmen year and is promptly sent to other, non-engineering departments only to return to engineering once they have taken the pre-requisite courses needed to succeed in engineering. While these students often enjoy their time spent in the departments of math, English, chemistry, and physics, they are generally not exposed to much engineering in their first year.

To promote engineering in the first-year, several years ago we joined other universities and modified our engineering curricula to include an introductory course to each specific engineering major. The intent of these courses was to give each student an opportunity to whet their engineering appetites and maintain their interest while they were working on their pre-requisite courses. These courses have proven successful but we have remained interested in finding additional methods to expose students to engineering principles and concepts as soon as possible. We are actively trying to retain our engineering students from their first to their second year.

One theoretical lens that has been applied to the issue of retention is engineering identity. We know that students are more likely to persist in engineering if they can identify with engineering or engineering-related activities. At the same time, we also know that first-year engineering students do not have a strong engineering identity. One reason for weak engineering identity among first-year engineering students is a result of limited exposure to engineering activities in the first-year college courses. In the first year, most engineering curricula include one or fewer engineering courses per semester as students’ schedules are primarily filled with calculus, chemistry, physics and English composition courses. When addressing first to second year retention issues, it is prudent to create ways to promote engineering identity development. A second reason for weak engineering identity among first-year students is limited exposure to engineering during K-12 education periods. Those who have been exposed to engineering during the K-12 years often are exposed through courses that involved “designing” through trial and error rather than a formalized engineering design process. K-12 Engineering experiences are often led by a teacher with an education background, perhaps a science background, but likely not an engineering background. As a result the students have not been exposed to engineering from the perspective of an engineering professional. This design competition is part of a larger program to promote and develop an engineering identity among the freshman students.

Beam and her co-authors suggested an extended summer orientation as one way engineering educators can promote a stronger engineering identity among first-year students. At our university, students move into their residence halls ten days before classes begin. This provided an opportunity for the college of engineering to collaborate with student affairs in organizing an academic activity to promote engineering identity development, and, in August 2014, we offered our version of an extended summer orientation: a pre-semester freshmen engineering design
competition. Our five-day design competition provided an opportunity for first-time freshman engineering students to participate in engineering related activities and learn about the engineering design process. Of the 713 first-time freshman engineering students, 153 registered for the competition. Of the students that registered, 76 actively participated in the competition.

Our design competition was based on the National Engineers Week Future City Competition\(^7\), whereby students were placed in teams and asked to design the city of the future using SimCity\(^{TM}\) software (EA Games). Students were divided into eight teams and each student received a complimentary license of SimCity\(^{TM}\). In addition to the competition, students attended four short seminars that addressed study skills and participated in a “selfie” scavenger hunt.

At the end of the five-day competition, teams presented their final design in a format similar to the Pecha Kucha presentation style\(^8-9\), which limits presenters to 20 slides presented in six minutes 40 seconds total (i.e., 20 seconds per slide). The style results in concise presentations, but for our purposes seven minutes was too long, so we modified the style to six slides and limited the students to three minutes total (i.e., 30 seconds per slide). Consistent with the Pecha Kucha style, slides advanced automatically during teams’ presentations. Students were judged on their ability to use engineering design principles to specifically address transportation and energy requirements for their cities. In order to raise awareness of the competition, competition winners were announced at the engineering professional society organization fair, held the second week of the fall semester.

In this paper, we fully describe the design competition rationale, implementation, and initial evaluation in sufficient detail for others seeking to create a similar event at other universities. We acknowledge a significant limitation of this paper is the lack of evaluation of the competition from the participants’ perspective. Although we have planned to include questions on the end-of-year freshman survey in order to solicit feedback on the competition from participating student, that survey has not yet been distributed. In addition, those questions are more evaluative in nature and likely lack the richness necessary to understand what impact, if any, the competition had on identity development. The absence of student data means that we cannot (and do not) conclude that the competition was successful in promoting engineering identity. Rather, we detail an intervention (i.e., the competition) that was designed to promote engineering identity, and ultimately lead to increased first-to-second year retention. With an eye towards continuous improvement, we evaluated the design competition based on student participation rates, team presentations and design reports, and organizer perceptions. We combine this data into a set of recommendations for others seeking to establish similar programs.

2. Welcome to the University

For many years, our university has conducted an acclimation event the week immediately preceding the beginning of classes. This event was initially conceived to help improve retention at the university by giving students an opportunity to learn their way around campus and make friends prior to the start of classes. Activities during this week have consisted of cookouts, paint ball, video games, information on Greek Life, activities on navigating around campus, bookstore shopping activities, and other events exposing students to life as a college student. What has been lacking was a serious exposure to academic events during this time.
This past year, the Office of Student Affairs recognized this absence of academic activities and invited colleges to offer events with an academic flavor. The College of Engineering took advantage of this by developing a weeklong design competition for entering freshmen. This competition would be in addition to, rather than in place of, existing events thereby permitting students to get an academic flavor while maintaining the student life aspect of the week.

3. Academic Content

Student success is dependent on many factors. Students who scored well on standardized admission tests or had high grade point averages in high school – typical of many students admitted into engineering – may be unsuccessful if they do not make the transition from learning in high school to learning in college. Similarly, if they are unable to develop new friendships and create a support group, they can also fail. We also did not want the student to lose sight of their ultimate goal – engineering – while taking math, chemistry, physics, and English classes.

There were four major areas in which we determined academic content could be added to the event. First there were seminars we could present to help students adjust to college. We also wanted to introduce an element of engineering design into the activities to challenge the students’ minds and encourage them to make friends. To improve our students’ knowledge of the facilities and history of the college, we developed a selfie scavenger hunt. This program also presented an opportunity to more fully implement the university’s freshman reading program.

4. Seminars

Although there are many factors that contribute to student success that we could have discussed, time constraints limited us to focusing on a few in our seminars. We opted to focus on learning styles, extracurricular academic opportunities such as earning an entrepreneurship certificate, communication skills, time management, and networking/making friends. Short seminars were developed on these topics, with the exception of networking, and presented to the students during the week. The value of these topics is well documented and it is not our intent to focus on them in this paper.

Students were asked to go on-line and complete the Index of Learning Styles Questionnaire by Richard Feldman\textsuperscript{10}. Through a prior agreement, this questionnaire was hosted locally on our server so that student data could be collected and aggregated. Students were asked to print their results and bring them to the Learning Styles seminar. Their data as a class was aggregated and plotted. The plots clearly showed how they, as a group, compared to previous surveys done of engineering students and to engineering faculty. They were then given some tips to help them adjust and adapt their learning styles to various teaching styles.

Communication skills were stressed to students throughout the week and were highlighted by a presentation from our Director of Technical Communications. This seminar focused on the importance of good communication skills, tailoring a presentation to the specific audience, and preparing both a written report and oral presentation. The primary focus of this seminar was on helping students develop their final design report and presentation.
Students were introduced to the challenges of managing their time, especially in an environment where their classes would be in non-contiguous blocks. They were warned of the many time-wasters they would have in college, as well as how to deal with setting priorities, getting enough rest, and allowing adequate time for studying and preparing for classes. Time management skills were reinforced through the introduction of arbitrary deadline and due dates with deliverables in the design competition. We even limited the times which we would take questions in an effort to get students to meet and think about questions and concerns they had before a session.

We also have a number of certificate programs in which students can participate as undergraduates. One of our largest and most popular certificate programs is the Engineering Entrepreneurship Certificate. We mentioned the other certificates we offer but selected engineering entrepreneurship as the focus of our seminar. In addition to having an overview of the program presented to the students, we had several upperclassmen who had actually developed a product through the program. They discussed both the challenges and thrills of product development and explained how they made design decisions in conjunction with market factors.

5. Design Competition

Engineering educators tell prospective students that engineering is a design profession yet we unintentionally often keep students from being exposed to design until they are in their sophomore years. Arguably students do not possess the needed education to engage in true engineering design until then, but they can still do some design. One successful activity in which design is learned is the National Future City Competition. This competition, developed for 6th, 7th, and 8th graders is conducted annually across the nation culminating in a national competition during National Engineers Week. If middle school aged children can become involved in engineering design, surely freshmen engineering students can as well.

The National Future City competition is a months long event for the middle school students. There was clearly no way the full competition could be condensed to be conducted in one week, however we could take and use elements of the competition. One of the unwritten results of the Future City competition is networking with other students and forming friendships. This was one of the goals of the activities.

For our competition, students were given an overview of the design criteria and instructed that they were to specifically address transportation and energy issues in their city. Cities were designed using the popular SimCity™ software that was provided to each participant at no cost due to the generosity of EA™. Students were also provided with guidelines concerning the expectations of their final presentation. Although the national Future City competition includes the production of a physical model of the city, there was not adequate time to design, simulate, and construct a physical model in our competition so we instead relied on SimCity™ screenshots and a narrative in a final written report.

The design competition culminated with a presentation by each team in the Pecha Kucha style (Figure 1). Presentations were exactly six slides presented in a 3-minute period (30 seconds per
slide). Since teams were large, only a subset of team members presented. Teams were given only an outline of what was expected from the presentation and some instruction on making presentations, but they were free to present any material they thought important. Presentations were required to be submitted beforehand and loaded onto a computer in random order. As a slide listing the team name was projected, each team had to assemble on the stage and begin their three-minute presentation. Each slide automatically transitioned to the next slide at a given time interval and presentations ended when the next team’s name was projected. This forced the students to prepare in advance and focus on those aspects of their design they thought were most vital. A panel of judges used a rubric in judging the presentations.

![Figure 1. Pecha Kucha final presentation](image)

In addition to making a final oral presentation before the judges, each design team also had to submit a one to two page narrative. This narrative was required to discuss the design developed by the team, explain how they used the engineering design process, how engineering contributed to the various aspects of their future city, and how they address the two design challenges of transportation and energy.

Students were provided some general information on the city they were to design. Given the compressed timeline, students were only asked to design a city taking into consideration transportation and energy. For transportation, they were told to identify a problem of moving people in their future city and to design a mode of transportation to solve that problem. To power their future city they were instructed to select one alternative energy source and then design a method of generating electric power that would not deplete natural resources and had a minimal impact on the environment.

6. Design Teams

Students were divided into large teams of mixed majors. Consistent with the recommendations of Michaelsen, Knight, and Fink\textsuperscript{11}, teams were formed in the presence of all students through a series of questions focused on factors relevant to student success. Immediately following team formation, we conducted an icebreaker activity to help students meet all members of their large team. By the end of the week, it was evident that teams had formed bonds (e.g., Figure 2). Each team was tasked with selecting a project manager. They were told the project manager would not
necessarily tell everyone what to do but he or she would be the only ones the competition coordinators would receive questions from. To further improve their networking, they were instructed to determine what specific tasks needed to be performed and then to assign people to those tasks.

![Figure 2. One design team on final presentation day](image)

One of our initial concerns was that we might end up with design teams split along specific majors and we wanted to have interdisciplinary teams. In forcing students to design for both energy and transportation we anticipated this would not favor one major over another. What we found was that this was indeed not an issue and students did tend to have interdisciplinary teams.

The cities designed by the students were wide and varied. In listening to their presentations and reading their documents detailing how they arrived at their designs, we were impressed with their thought processes. Some put significant thought into their design before doing any modeling with SimCity™. Others put more effort into brainstorming ideas for designs and then modeling them quickly before selecting the optimal solution. Although these students lacked any formal training in engineering design and had little to no experience in mathematical modeling, they were able to explore design options, evaluate trade-offs among the design options, and do some modeling of their designs.

7. Selfie Scavenger Hunt

We wanted to expose our entering freshmen to the history of the college of engineering, some of the faculty and administration of the college, as well as help them learn their way around our facilities. We also thought this would let them see some facilities they might not find until the sophomore year or later. To accomplish this we developed a list of clues that were given to the students via Blackboard. They were instructed to decipher as many of the clues as they could and then to take a selfie of themselves with the person, building, or room that clearly indicated they had figured out the clue. The pictures were then submitted via Blackboard and verified for accuracy.
To ensure the maximum impact of this event, it was developed as an individual competition. Winners would be determined by who submitted the most correct selfies. In theory and practice, this significantly reduced the likelihood of one person deciphering a clue and sharing it with friends. Prizes were awarded to the top three winners.

8. Common Freshman Reading Program

For the last several years all of the freshmen entering our university have been required to read a common book. There are several events focused on the book throughout the first semester including a presentation by the book’s author. Our college of engineering has been supportive of this program from its conception and decided to integrate it into the overall design competition.

A copy of the selected book, *The Invisible Girls* by Sarah Thebarge was given to all freshmen at their orientation session at the beginning of the summer. They were told repeatedly that they needed to read it over the summer and be prepared for the design competition. During the seminar sessions of the design competition, several questions were presented to students via Blackboard. The students had a few minutes to log into Blackboard and complete the quiz. There were several questions presented that were very detailed with the intent of providing a tiebreaker. Several of these questions focused on the technology in the book (medical diagnostic equipment, public transportation, etc.) but the primary purpose of this was to ensure the students read the book so that they would be better prepared for freshman classes where the book would be discussed in further detail. Given the difficulty of the questions, we expected a good student to perhaps answer fifty percent correctly, however many students answered nearly ninety percent correctly. Although we did have a single winner, there were several who were within one or two questions of tying the winner.

One additional aspect of the reading program competition was to impress upon the students the value of life-long learning. This was discussed some during the seminars. We also wanted students to understand that they would be responsible for their learning while in college and that not everything they needed to learn would be covered in lectures. Although we talked about the value of the book in the seminars, we never actually lectured on or discussed the details of the book until the end of the week when we revealed the winners. Students had to prepare for the quizzes on their own.

9. Outcomes and Lessons Learned

We were pleased with the outcomes of our first design competition. We had hoped to have more students participate in the competition but were pleased that roughly twenty percent of our entering engineering freshmen registered for the event. Half of those who registered actively participated in the design competition. Students were not required to be on campus the week prior to classes beginning so we do not have data on the actual percentage of students who did participate who were present.

The goal of the design competition was to improve student retention and engagement through promoting an engineering identity. It is too early to determine if this had the desired impact but
we do plan to look at students who completed the design competition at the end of the 2014-2015 school year and determine if they remained in engineering and see how their GPAs compare to those who did not participate.

We also had some students begin the competition but then quit attending the sessions. Anecdotal evidence indicates that some of them thought this was too much work for what they believed was supposed to be a fun week. Some design teams also lost individual team members along the way. We used those cases as teachable moments and stressed that when a study partner fails to live up to his or her commitment, you must still complete the task and prepare by yourself. Interestingly, those who completed the competition did indicate that it was fun.

There were also several attractive nuisances present during the design competition that negatively impacted participation. Although there was a central calendar of events for the week, there was no formal deconflicting of events done overall. As a result we found that one day, after our sessions had long been scheduled and the room reserved, another group scheduled a meet your mentor session that involved playing paint ball.

Several substantial prizes were awarded to entice student participation. The Grand Prize was a gift card equivalent to an Apple iPad Mini. Bookstore gift cards were also awarded to all members of the first, second, and third place design competition teams. We also gave a first place prize of a Kindle Fire, a second place prize of a bookstore gift card, and a third place prize of a cowbell (a traditional symbol of our university) to winners of the Freshman Reading program and Selfie Scavenger Hunt winners.

The authors are currently developing an assessment plan for the entire Engineering First-year Experience program in order to quantify the impact on retention. This design competition was designed and implemented in three months and there was not adequate time to develop and complete desired assessments. This design competition, created to improve engineering identity development, is only one component of a larger program. We do not believe that any single component will be solely responsible for developing engineering identity. Rather, we think it will be the continuum of activities and courses that yield the desired results. In future years, we plan a survey of attitudes and engineering identity both before the design competition and after the first and second years in engineering. The authors are also planning to conduct focus groups to tease out which components of the Engineering First-year Experience have the most impact on identity development.

References


10. [https://www.engr.ncsu.edu/learningstyles/ilsweb.html](https://www.engr.ncsu.edu/learningstyles/ilsweb.html)
