Work in Progress: Inspiring and Engaging First-Year Engineering Students at a Small Campus Through International Team Design Projects

Abstract

This work-in-progress, innovative practice paper summarizes our first-year Introduction to Engineering Design course at a small campus, and our continuing efforts to improve student engagement, inspiration, and retention in engineering. The paper emphasizes the two major design projects used to teach the engineering design process. For the past thirteen years, one of these long-term design projects has been completed in collaboration with several international universities. The design teams have combined engineering students from diverse cultures and countries, as well as all levels of study, to work together towards a common design goal. The paper includes experiences from different instructors who have taught the course, as well as the experiences learned through collaborating with international schools. Specific examples of student inspiration derived from the experience will be included.

Introduction

First year engineering students take a three credit project-based course, Introduction to Engineering Design, which introduces them to engineering design processes, method, and decision making using team design projects. There are five modules in this course delivered across the Pennsylvania State University system; World Class Engineering, Innovation and Creativity, Professional Communication, Making, and Seeing the Big Picture. Additionally, faculty are encouraged to incorporate elements of making, CAD, and spreadsheet use into their curriculum. There is an emphasis on collaboration and group project work. The seven attributes of a World Class Engineer, as defined by Penn State's School of Engineering Design, Technology, and Professional Programs (SEDTAPP), include being solidly grounded, technically broad, globally engaged, ethical, innovative, an excellent collaborator, and visionary leaders. At Penn State Brandywine, a small campus of about 70 engineering students per year, the ability to help students become globally engaged, as well as to develop international communication skills, has been emphasized by incorporating a design project that includes teams from around the globe [1-5].

Team Design Project I

There are two major group design projects worth 50% of their total grade. The engineering design process in introduced during the first design project. This project is based on reverse engineering a simple device like an electric toothbrush, and then redesigning the device for added functionality. Teams are formed the first week of the semester, so team dynamics are a bit unstable because the students don't know each other very well. Teams are typically formed by who they happen to sit near. During this first project, students learn about reverse engineering, perform market analysis, derive specifications and functional diagrams, generate design

concepts, and apply concept selection techniques. Deliverables include a progress and final reports, as well as a final presentation.

The first design project serves many purposes in addition to introducing the design process. It gives students the opportunity to learn how to find team success on a long term, significantly weighted project. A common outcome is the request to mix up the teams for the second project. By mid-point in the semester, students are familiar enough with their peers to choose teams of like-minded individuals. Significantly better success is achieved during the second project by teaming students with similar study techniques and academic goals.

Team Design Project II

Since 2008, the second design project has involved international clusters with all levels of engineering students collaborating on a single design. Table 1 shows the breakdown of schools participating for the 2018-2019 academic year. Clusters of up to six teams are formed with a mix of teams from each school. Sometimes multiple teams from the same school are paired in a cluster, but they are never from the same section of the course. Each cluster has the responsibility to develop a conceptual design to solve a specified global problem. The schools that have higher level students participating typically have additional design requirements, like completing full CAD drawings and prototypes.

Table 1: Project Demographics for 2018-2019

Location	**Country**	**Class Standing**	**Number**	**Percent (%)**
Penn State Brandywine	USA	1st Year	71	24.8
Western Michigan University	USA	2nd & 3rd Year	52	18.2
Politecnico di Milano	Italy	4th Year	20	7.0
Imoversotate de Samta Catarina,	Brazil	2nd Year	112	39.2
Higher Polytechnic School of the Littoral	Ecuador	2nd Year	31	10.8
		Total:	286	100%

Each cluster is required to meet via an audio/visual conference weekly, with specified goals for each conference. Given the time differences associated with the schools, only one member from each team is required to participate in each conference. Each team submits a pre-conference report summarizing their design work performed that week. The second project typically spans 6 weeks, but has been reduced to four weeks during the spring semester to accommodate the coordination of the various school schedules.

One of the benefits of this collaboration is the exposure to a global mindset. The two most recent projects were designing a personal shopping cart for urban consumers and a manually powered trash compactor. For both of these projects, students performed market analysis by surveying consumers worldwide. Of note for our students was the perspective gained from learning how people around the world might utilize these tools, which varied greatly from their own personal experience.

Inspiration

Students taking their first engineering course don't often realize how their design projects might lead to future applications. There is an opportunity to stress to the students how they might use their CAD knowledge in the future, and how their understanding of the engineering design process can be used to advance creative ideas of their own. The ready availability of 3D printing now allows students to turn their inspiration into prototypes.

In particular, one student from each of the two sections of this course this past year have embarked on advancing personal design ideas. After his experience with designing the personal shopping cart, one student built a fully functional prototype from materials he had in his home. Through presenting their design and prototype at a design showcase for parents and local industry, the pride in his achievement led him to pursue a personal design idea for a new compound bow. He has completely rendered his concept in CAD, prototyped it, and submitted his business plan for an entrepreneurship grant. He did not win this years' entrepreneurship grant, but he reviewed the winner's submissions, and is working hard to flesh out a more complete business plan for his design. Another team of students has taken their CAD experience and are working on a business model for an interactive music-driven LED light display, customizable for any university. It is produced using a combination of 3D printing and laser cut parts.

Conclusion

Students in our first year Introduction to Engineering Design are exposed to the engineering design process via an international collaboration. There are significant challenges associated with this collaboration, including language barriers, time zone differences, and background differences. These challenges are not to be ignored, but are not addressed in detail here. The positive impact of this global perspective far outweighs the challenges. Students gain global engagement and collaboration skills. Most importantly, they gain inspiration and the confidence to pursue personal design ideas of their own. Offering continued support to these inspired students allows them the opportunity for tremendous personal growth and confidence in their engineering design ability.

References

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