

## **A Mini-Project Approach Toward Learning the Engineering Design Process**

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### **Abstract**

First-year students in an introductory engineering graphics and design course often lack the problem solving background necessary to engage in learning the engineering design process and its importance. This paper presents series of mini-projects (completed within the first 2 weeks of a three-credit course at Georgia State University) that is easy to implement to actively engage all students in an open-ended and meaningful introduction to the engineering design process. Students define problems, brainstorm, research and constrain their problems, explore possibilities, and select a solution approach through a set of individual and group assignments requiring structured thinking.

### **Keywords**

engineering design process group project

### **Introduction**

A core competency of first-year engineering courses is often a strong understanding of the engineering design process, yet many students lack the background to fully understand how critical the design process can be towards turning an idea into a reality. In this work, a set of mini-projects that seeks to create a lasting impact on student comprehension of the engineering design process is presented. Students are tasked with active-learning independent and group assignments that are open-ended and allow students to take ownership and responsibility for their ideas.

### **Mini-Projects Format**

In the first iteration of the engineering design process mini-projects, students were required to work independently outside of class but in assigned groups during class. The mini-projects were completed within one week through two individual homework projects and two group in-class projects. This series was designed to occur within the first two weeks of the semester to allow students to make early connections between engineering design and their personal lives.

Following an in-class introduction to the engineering design process of the first day of the course, students were assigned their first homework mini-project: to “define 2-5 problems in your world for which you might be able to design/engineering one or more solutions.” Students were given a short video on how to observe problems and an example problem statement that stems from the problem discovered in the video. They were also told that they will be sharing their problem statements in groups during the next class period.

When the next class period met, students were divided into groups of 3-4 and given an ice-breaker activity (a free-standing paper tower competition) before being asked to each share their favorite two problem statements with their group. Groups discussed the problems and worked to clarify any misunderstandings about each other's problem statements. Each group was tasked with selecting their collective "best" problem using the criteria: a) most in need of a solution; b) most accessible (the entire group clearly understands the problem); and c) most solvable (potential solutions were to be crafted as homework). After choosing the group's "best" problem, groups were tasked with writing a detailed, but clear and concise problem statement before the end of the class period.

As homework, the next individual mini-project required students to brainstorm potential solutions to their group's problem statement. Students were given a video example of the brainstorming process and asked to write descriptions and create ideation sketches of three unique solutions to their group problem.

The following (3<sup>rd</sup>) class period, groups re-assembled to establish criteria specific to solving their problem and shared their potential solutions to their shared problem. Each group created a decision matrix using their established criteria to objectively narrow their potential solutions and rank the overall best solutions.

## **Outcomes**

In the initial homework assignment, students individually defined engineering problems that were personally meaningful or exciting before discussing and refining their problem statements in groups. While this was a challenging assignment with a short turn-around period, many students were excited by the opportunity to try to think as an engineer on their first day of their first engineering course (enrollment in this course requires completion of College Algebra, while all other engineering courses offered by Georgia State University have higher math prerequisites). Several students shared their excitement for being able to start designing solutions for problems they see in their homes and communities. Others were motivated by the reality that they would be required to discuss their ideas with classmates.

Individual student problem statements ranged widely from those which fully met the assignment criteria to those which were poorly formulated or already solved, or those which exceeded current scientific knowledge or were too challenging for their group fully comprehend. Within the group discussions of problem statements, all groups were able to quickly narrow their problem statements to the best three, with most able to refine their problem statements down to one within twenty minutes. Students with weaker problem solving backgrounds were aided by teammates to understand the challenge that had been posed.

Upon completing the solution brainstorming homework, groups reconvened in class. Many groups discussed potential solutions during the previous class session and thus had similar solutions presented in their homework. Each group was able to determine a small set of criteria and develop a decision matrix to assist in selecting the best solutions.

## **Conclusion**

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Students seemed highly engaged and excited by their group's ideas and results, suggesting active learning occurred. Groups completed the activities with minimal conflict, and several groups chose to continue work refining their solution approach even after having satisfied all class requirements. Without significant prompting, student groups were able to later apply their understanding of the engineering design process to a larger midterm group engineering design project. Further refinement of these mini-projects is planned.

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