Activity

5

Open-Ended Design Problems

Educator: Kathleen Issen, Associate Professor, Mechanical & Aeronautical Engineering
Context: Out of class; Statics, Mechanics of Materials
Keywords: group activity, teams, design teams
Student Activity Time: 2-4 hours outside of class

In their design teams, groups of students explored and reflected upon other groups' design solutions.

Introducing the Reflection Activity

In groups of three, students engaged in solving open-ended design problems—context rich problems that have fewer boundaries than homework assignment problems, but are similar in calculation-scope once students finalize their design specifications. In working on these problems, students reflected in at least two ways: (1) by discussing and proposing alternative designs solutions within their group, and (2) by peer reviewing another group's design process and solution. The purpose of these reflection activities was for students to discuss the design problems and solutions, identify mistakes, discuss what they learned, and brainstorm alternative design solutions.

In a mechanics-based course, such as Statics or Mechanics Materials, engineering students can be engaged in group design problems. In these groups, students collectively grappled with and reflected upon alternative design solutions and possible mistakes. Throughout these design problems, there were different types of reflection—process and team reflection; technical reflection; and evaluative reflection. When the groups submitted their final design reports, they were asked to list and/or discuss useful things the team learned—a process and team reflection. Second, in the final design report, students were asked to provide an alternate design and discuss it—a technical reflection. Third, after each group submitted their final design reports, they were given another group's final design report to engage in peer review reflection—an evaluative reflection.

At the end of the design process, each group of students was asked to peer review, essentially grade, another group's design report, looking for errors or omissions. In this review, the groups were required to use a red pen to circle the errors or omissions and to provide a correction for each mistake. The goal of the peer review process was for each group of students to determine if the other group of students: (A) provided sufficient information to build and analyze the proposed design(s), (B) performed the analyses correctly, and (C) confirmed that the design satisfies the design constraints or requirements. In these peer reviews, the reflection occurred when students discussed and evaluated the other group's design report and solution. These peer reviews were guided by a rubric that the educator provided. When students finished the peer review, they submitted the completed rubric with the marked-up design report. Then the educator graded each design report using an expanded version of the

rubric. Groups received bonus points for actively participating in the peer review process or a deduction for non-participation. There was also a strong grade incentive (additional bonus points) for students to find all the errors and omissions in their own report (i.e. their own report was mistake-free) and in the report they reviewed. If during or after the reflection activity there were common misconceptions, the educator addresses these topics.

In terms of outcomes, there was opportunity for students to reflect on the course content, in addition to their own process for engaging in design. For example, as students peer reviewed other designs, they needed to discuss what they learned throughout their own design process.

DIGITAL LIBRARY CONTENT

- 5.1 Design Problem Overview
- 5.2 Design Problem Assignment
- 5.3 Design Problem Rubric
- 5.4 Peer Review

Recreating the Reflection Activity

	Description
1	Identify and assign a group design project.
2	Introduce the team evaluation when assigning the project.
3	Provide students with a timeline to complete the design project (approx. 5 weeks).
4	Conduct design project testing in class.
5	Administer team evaluation form at the end of project testing.

In the words of the Educator: Tips and Inspiration

Balance the number and timing of open-ended design problems. From several years of experience using open-ended design problems, two per semester is a good balance; these are best placed at the front of the semester. Students apply what they learned during the first design and review process toward the second problem; this is reflected in higher grades for the second problem. With each design/review cycle requiring four weeks elapsed time, a third problem would fall late in the semester when students have projects due in other classes; thus, the third design problem receives less effort and less reflective learning occurs, so I eliminated the third problem. Because learning from and reflecting on the open-ended problem solving/review process do not require advanced content knowledge, design problems can be placed near the front of the semester.

What was the inspiration for the reflection activity? I was inspired by a National Academy of Engineering (NAE) workshop that emphasized the need to engage students in more open-ended design problems, throughout the curriculum, to better prepare them for engineering careers. Additionally, from my own industry and research experience, peer review is a fundamentally important engineering skill to which undergraduates are rarely exposed. I created relatively small open-ended design problems that are accessible to sophomores, but simulate a real-world engineering design, report and review process.