Use of the Engineering Design Process and the Concept of Stress to in a First-Year Engineering Course

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Abstract –
In the first course of a freshman engineering sequence, civil, electrical, mechanical, and engineering management students are introduced to professional and technical concepts from the various disciplines of engineering. These concepts are presented through a number of tutorials, laboratory experiences, and projects. In seeking to unify the sometimes diffuse course content, the authors developed a culminating project that incorporated key aspects of the engineering workflow with technical concepts from among the various disciplines. Throughout the semester, the students frequently questioned whether (and how) engineering is distinguished from mathematics and the sciences. Through the creative composition of the project requirements, the students had the opportunity to see how, from among the Science, Technology, Engineering, and Mathematics (STEM) disciplines, engineers are somewhat unique in the charge to apply their understanding of mathematics and scientific principles to create new technologies and tools for further scientific discovery and advancement.

The project brought together a collection of technical concepts from mechanical, electrical, and civil engineering in the design of a load cell. In civil engineering, structural members are subjected to various forces requiring the materials used in the structure to undergo testing and characterization. A common instrument used to measure the forces in structural members under test is a mechanical load cell. The load cell device is subjected to stresses from a load that ultimately result in strain on the cell’s surface. The load cell can be instrumented with a strain gauge—a device whose electrical resistance changes as the mechanical strain varies. The students were given a reference load cell and tasked with instrumenting it to verify that load on the cell could be determined from the strain measured. Upon functional verification, the students were required to capture the design in a solid modeling package to complete further simulation and analysis of the underlying scientific and material principles. Starting with a functional prototype, the students were required to iterate through the engineering design process (EDP), redesigning multiple load sensing devices, and verifying that the new designs met the instructor-specified design requirements. A depiction of an instrumented load cell along with a solid device model is shown in Figure 1.

This presentation will provide background information on the course environment, define the project parameters, detail how the concepts of mechanical stress and strain were made accessible to the students, and provide anecdotal feedback on the successes and shortcomings of the project from the point-of-view of the instructors and the students.

Keywords: First-year engineering, freshman engineering, engineering design process, stress, and load cell.

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