Problem Solving Skills in Mechanical Engineering Labs

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ABSTRACT

The *Strength of Material* is one of the key courses for the students in the Mechanical Engineering and Environmental Sciences. In this course students learn some of the fundamental concepts regarding the mechanics of deformable bodies such as stress and strain. More importantly, they learn a mathematical framework to apply these concepts for design of the beams that are one of the most common and basic components of many mechanical systems. Therefore, the *problem solving skills* are crucial for the success of the students in this course.This work presents the pedagogical practices that are developed and implemented to promote students problem solving skills in the engineering lab sessions. Students found to benefit from active learning strategies such as roundtable activity and group presentations.

LEARNING OUTCOMES

1. Understand the basic concepts of stress, strain, deformation and material behavior under different types of loading: axial, torsion, bending.
2. Perform stress analysis and design of beams using several methods.
3. Perform stress analysis of thin-walled members.
4. Understand and analyze elastic stability of columns.

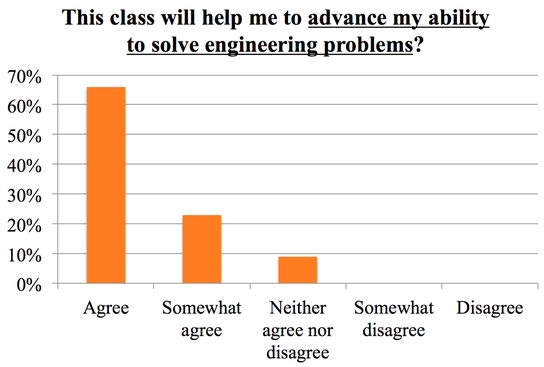

Figure 1: In the early-smelter survey the students' perception and expectations found to be aligned with the learning goals.

WHAT IS PROBLEM SOLVING?

"Problem solving may be the quintessential expression of human thinking. It is required whenever there is a goal to reach and attainment of that goal is not possible either by direct action or by retrieving a sequence of previously learned steps from memory." [1]
The following is a list of some instructional practices that are shown to be effective in problem solving education.

- Using a **specific framework** for problem solving [2],
- **Differentiate** different problem types [3],
- Providing **model examples** for students [4],
- Modifying the classroom format to **promote interaction and guidance** [5].

INSTRUCTIONAL DESIGN AND ASSEMSNET

Student-Centered Environment

Based on the observed trends in literature regarding the effective teaching practices for problem solving, the following assignments are designed for the Lab sessions.

1. **Roundtable**

   Students in groups of four to five sit in a circle and respond in turn to a problem by stating their ideas aloud as they write them on paper.

2. **Presentation**

   After the roundtable, students discuss and summarize the ideas generated and report back to the class. Other groups ask questions to understand the process of the problem solving.

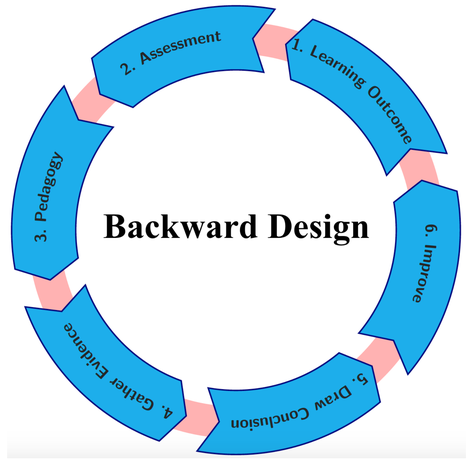

Figure 2: Backward design is used to ensure the pedagogy and assessments are aligned with the course learning outcomes.

Analytic Rubric

	4	3	2	1	0
Collaboration	All members discussing	Partial participation	Sporadic interaction	Low interaction	None
Representation (Graphics and Math)	Necessary details and principles	Missing some details	Missing some fundamental information	Formulation not understandable	None
Execution	Components, Step by step approach	Minor flaws	Trial & error	Not solved	None
Presentation & Explanation	Context, Concepts, Communication	Partial understanding	Incorrect context and concepts	Lacking of understanding	None

LEARNING TRAJECTORY

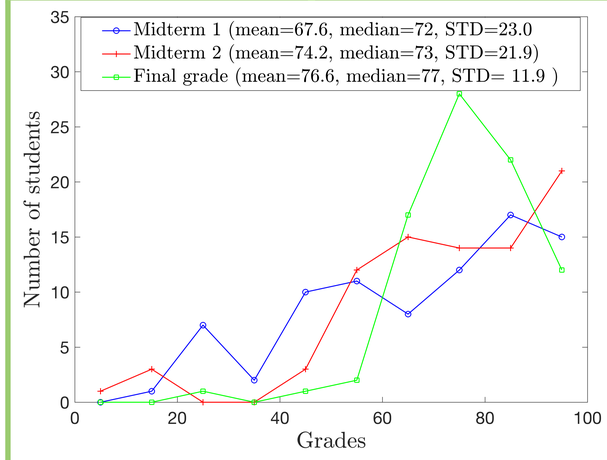

Figure 3: Performance of the students improved continuously. The final exam was accumulative, hence the results show that students achieved intended outcomes of the course by the end of semester.

ACT ON RESULTS

This project intended to leverage assessment as a mean for research and pedagogy. Assessment is an opportunity to evaluate both the student's and the instructor's performance. The backward design provides a framework to iterate the design process and rethink the strategies based the evidence of the student learning.

ACKNOWLEDGMENT

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