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Enhancing Fundamentals of Engineering Program

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16. Abstract

A project was designed to enhance the civil engineering portion of the curriculum in the Fundamentals of Engineering Program to foster workforce development through recruitment, retention, and development of engineering students. This effort supports the educational and technology-transfer-critical missions of the WVU Statler College of Engineering and Mineral Resources and the Center for Integrated Asset Management for Multimodal Transportation Infrastructure Systems (CIAMTIS). Specifically, a teaching module consisting of a team project related to bridge design, analysis, fabrication, and testing was developed for the "Engineering Problem-Solving I" (ENGR 101) course taken by first-year students. The curriculum module was designed during summer 2019 and piloted in both fall 2019 and spring 2020 sections of ENGR 101. Student learning was, and continues to be, assessed and project revisions are recommended for future implementations.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

Introduction

BACKGROUND

While the WVU Fundamentals of Engineering Program hosts a variety of events (including department visits, presentations within the First-year Seminar course, and opportunities to attend research lectures) for students to learn about different engineering majors and careers, the direct teaching of principles of civil engineering, including transportation, within the first year was limited. Much of the first-year curriculum is project-driven, in which students work in teams to solve engineering design problems.

Based on student, researcher, and instructor feedback from the Fall 2019 implementation, changes were made to the project, specifically the order of the design and measurement (and what is being measured in the lab) to clarify the assignment and enable the student to see the broader picture of bridge design.

The Spring 2020 project implementation was completed before the academic interruption caused by the COVID-19 pandemic. Data from the Spring implementation, along with student and faculty feedback, will be evaluated and considered in the assessment process to determine if additional changes need to be made to this educational unit.

OBJECTIVES

The objective of this project was to foster workforce development by embedding a realistic transportation engineering project into the first-year ENGR 101, Engineering Problem Solving I, course. Specifically, the project incorporated bridge design and analysis concepts into the first course project.

DATA AND DATA STRUCTURES

A curriculum module, including a project work statement and grading rubric, was created. The project incorporated bridge design and analysis concepts and required students to (1) research bridge truss designs independently, (2) test various truss designs in teams in a lab setting, (3) use those data to design a bridge using the West Point Bridge Designer software, and (4) calculate the factor of safety at points under stress and compression for the designed bridge.

CHAPTER 2

Methodology

INTRODUCTION

This section of the report describes the methodology used to create the instructional module and assessment tools.

CURRICULUM MODULE

A curriculum module, including a project work statement and grading rubric, was created. The project incorporated bridge design and analysis concepts and required students to (1) research bridge truss designs independently, (2) test various truss designs in teams in a lab setting, (3) use those data to design a bridge using the West Point Bridge Designer software, and (4) calculate the factor of safety at points under stress and compression for the designed bridge.

ASSESSMENT TOOLS

Student learning was assessed through performance on their submitted technical report, team presentation, individual performance on test questions, as well as student comments and feedback to instructors.

Team Project Technical Report & Presentation

Team project technical reports and team presentations were assessed using a standard FEP grading rubric. Students were provided the grading rubric at the beginning of the project so they knew how they would be graded.

Project Grading Rubric

The technical portion of the project was graded using a spreadsheet comparing factor of safety numbers and project costs. Specific information was collected, including: costs, material types, size of cross section (solid bar), length of model, compression force, compression strength, tension force, tension strength, plus a minimum and maximum factor of safety calculation. Factor of safety was compared to the target factor of safety (2.0) and student teams were awarded points relative to their peers. Those with factor of safety calculations closest to the target earned the highest points.

Student Feedback

Student feedback was collected via Student Evaluation of Instruction comments as well as direct comments made to the instructor, course coordinator, or assistant dean related to the course content, clarity of assignment, and grading.

CHAPTER 3

Findings

INTRODUCTION

As shown in Table 1, the model bridge project was piloted in 10 sections of ENGR 101 with 551 students in the Fall 2019 semester and in 5 sections with 249 students in Spring 2020. A total of 800 students participated in this project.

Table 1. Student participation.

Semester	# Sections	# Students
Fall 2019	10	551
Spring 2020	5	249
TOTAL	15	800

Student learning was assessed through performance on their submitted technical report, team presentation, individual performance on test questions, as well as student comments and feedback to instructors.

CURRICULUM MODULE

The curriculum unit was effective in leading students through an engineering design project related to transportation engineering, and specifically, bridge design. Students researched types of trusses and applied their knowledge to creating and testing model truss designs in a lab setting (Fall) and in creating and testing loads on a model bridge (Spring). They gained experience taking measurements and then using their knowledge to design a bridge using the West Point Bridge Designer 2019 software. They also used that software to estimate loads within the truss bridge and estimated total project costs.

In the Fall term, the project required students to research truss types, build and test trusses, then use that information to design a model bridge using the software. Based on instructor, researcher, and student feedback, the project was modified to have students research truss types, design their bridge using the West Point Bridge Designer software, move to the lab where they built a physical model of their bridge design, and then measure the force on at least three beams/locations for the model bridge.

The project incorporated bridge design and analysis concepts and required students to (1) research bridge truss designs independently, (2) test various truss designs in teams in a lab setting, (3) use the West Point Bridge Designer software to design a bridge to meet specific criteria, and (4) calculate the factor of safety at points under stress and compression for the designed bridge.

ASSESSMENT TOOLS

Student learning was assessed through performance on their submitted project deliverables, primarily the team technical report and PowerPoint presentation, the project design score, and student feedback on the project. Each of these assessment elements is presented in more detail here, following a brief description of all the project deliverables and how the ones use for assessment fit into the overall grading for the project.

Two project deliverables were submitted by students as an assignment, contributing to their overall assignment grade for the course. Many assignments are submitted each term, contributing toward the assignment grade. The assignment grade represents 20% of the overall ENGR 101 course grade.

Project 1 contributes 10% of the overall course grade. The elements that comprise the overall grade for Project 1, listed in Table 2, include: (1) an individually written background research summary (requiring the use of at least five independent sources of information); (2) a mid-project update, including the Introduction, Background (created by combining each of the individual background research elements), and Phase I Results sections of the Technical Report; (3) a calculated Design Score, computed by imputing each team's results into the instructor's spreadsheet, which compares each team's overall Factor of Safety scores and project cost; (4) the team presentation and PowerPoint slides; and (5) an individual Peer Review of each of their team members' participation, cooperation, and contribution to the final products.

Table 2. Student project deliverables.

Project Deliverable	Type of Product	Grade Category	Percent of Project Grade
Team Charter	Team	Assignment	N/A
Background Research Summary (5 sources, minimum)	Individual	Project 1	15%
Mid-Project Update (Introduction, combined Background, Phase 1 Results)	Team	Assignment	N/A
Design Score (calculated by Instructor based on FoS and Cost)	Team	Project 1	20%
Project Presentation and PowerPoint Slides	Team	Project 1	20%
Project Final Technical Report	Team	Project 1	35%
Peer Review of Team Member Contributions	Individual	Project 1	10%
Total Project			100%

While the Spring results have not yet been assessed by the researchers, the Fall implementation yielded deliverables (team charter, Gantt chart, lab notes, technical report, and a presentation with PowerPoint slides) of equivalent quality to those items generated by previous projects, not related to transportation engineering. Spring documents need to be reviewed to determine if the revised project was more clear to students.

Team Project Technical Report & Presentation

Team project technical reports and team presentations were assessed, using a grading rubric, on content, written and oral delivery, and ability to follow the instructions and guidelines provided. Students were provided a template for the technical report, guidelines for creating appropriate PowerPoint presentations, and the grading rubric at the beginning of the project so they would know how they would be graded. These materials are standard for all projects in the Fundamentals of Engineering Program.

Project Grading

The technical portion of the project was graded using a spreadsheet comparing factor of safety numbers and project costs. Specific information was collected, including: costs, material types, size of cross section (solid bar), length of model, compression force, compression strength, tension force, tension strength, plus a minimum and maximum factor of safety calculation. Factor of safety was compared to the target factor of safety (2) and student teams were awarded points relative to their peers. Those with factor of safety calculations closest to the target earned the highest points.

In the Fall semester, students complained about their bridge design factor of safety and cost elements being graded relative to their peers. The idea of competition within a grading structure in a class was foreign to them, and several students stated they believed it was an unfair system of grading. In the Spring, faculty spent more time explaining the competitive nature of this project and emphasized that competition is part of the engineering profession. Faculty explained that engineering firms frequently compete for contracts to perform a job and then must work within the time and cost specifications in their bid. There were no complaints that made it to the Assistant Dean's office in the Spring term; however, concerns and changes to the course because of the COVID-19 pandemic may have superceded student concerns on this one element of their course grade.

Student Feedback

Student feedback from the Fall term indicated that improvements were needed in project instructional materials, as there was confusion about what needed to be done and how the technical aspect of the project was to be assessed. Specifically, first-year students are not used to being graded relevant to the performance of their peers and had many questions about their grades based on a comparison of price and factor of safety of their bridge and those of other teams (competitors) in their class. Student comments focused on clarity of assignment and perceived fairness of the grading structure. These concerns were addressed in the second implementation of the course as described previously in the Project Grading section.

CHAPTER 4

Recommendations

INTRODUCTION

Recommendations for future implementation of this project are presented here.

Project Design

Based on student, researcher, and instructor feedback from the Fall implementation, changes were made to the project, specifically the order of the design and measurement (and what is being measured in the lab) to clarify the assignment and enable the student to see the broader picture of bridge design.

The Spring 2020 project implementation was completed before the academic interruption caused by the COVID-19 pandemic. Data from the Spring implementation, along with student and faculty feedback, will be evaluated and considered in the assessment process to determine if additional changes need to be made to this educational unit.