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Enhancing Fundamentals of Engineering Program under the COVID-19 Situation

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Prepared by:
R. Hensel and F. Dai
West Virginia University

r3utc.psu.edu

PennState College of Engineering

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Fei Dai https://orcid.org/0000-0002-8868-2821 Robin A. M. Hensel	

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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 criticial missions of the WVU Statler College of Engineering and Mineral Resources and the Center for Integrated Asset Management for Multimodal Transportation Infrastructure Systems. 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 piloted in both fall 2019 and spring 2020 sections of ENGR 101. Rerunning of the curriculum module was conducted in both fall 2020 and spring 2021 sections of ENGR 101 under the situation of covid-19. Student learning was, and continues to be, assessed and project revisions are recommended for future implementations.

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CHAPTER 1

Introduction

BACKGROUND

While the WVU Fundamentals of Engineering Program (FEP) hosts a variety of events (including department visits, panels of practicing engineers, engineering student organization fairs, and opportunities to attend research lectures) for students to learn about different engineering majors and careers, the direct teaching of civil engineering, including transportation principles 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.

A project was developed to introduce principles of bridge design into the ENGR 101, Engineering Problem Solving 1 course. That team project requires students to use the West Point Bridge Designer software and PASCO structural kits to design, build, and test a truss bridge model and calculate total bridge project cost.

Based on student, researcher, and instructor feedback from the fall 2019 and spring 2020 implementations, changes were made to the project, specifically the order of the design, format, 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.

Both fall 2020 and spring 2021 project implementations were completed under the situation of the COVID-19 pandemic. Therefore, relevant changes were made to enable continous learning and maximally protect the participants. Data from the fall and spring implementations, along with student and faculty feedback, will be evaluated and considered in the assessment process to determine if additional changes are to be made to this educational unit.

OBJECTIVES

The objective of the proposed project is to continuously enhance the introduction of basic civil engineering principles within the Fundamentals of Engineering program under the COVID-19 situation for fostering workforce development through promotion, recruitment, retention, and development of engineering students based on outcomes from year 2.

DATA AND DATA STRUCTURES

A curriculum module, including a project work statement and grading rubric, was created and continously improved. 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 2019 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 and improved. The project incorporated bridge design and analysis concepts and required students to (1) research bridge truss designs independently, (2) study given data instead of testing various truss designs in teams in a lab setting due to the COVID-19 pandemic, (3) use those data to design a bridge using the West Point Bridge design software, and (4) calculate the factor of safety at points under stress and compression for the designed bridge. Two explanatory videos were produced to help students understand the expectations of the project and how to use the tools provided, including (1) the PASCO structures kits (in the lab) and how to take the measurements and (2) the West Point Bridge Designer 2019 software. Links to these instructional videos are:

- PASCO Video: https://youtu.be/V1OJ5qyLy6s
- Bridge Designer Video: https://youtu.be/EH0bZ5Wi2Cg

ASSESSMENT TOOLS

Student learning was asssessed through performance on their project results, 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 (Fall 2020, not Spring 2021) 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 saftety 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

Course and student data for the first 2 years of this project are presented in Table 1. In AY 2019-2020, 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, totaling 800 students who participated in this project in year 1. In AY 2020-2021, COVID-19 protocols required smaller class sizes. The bridge project was piloted in 31 sections of ENGR 101 with 510 students in fall 2020 and in 10 sections with 238 students in spring 2021, totaling 748 students participating in year 2. In the first two years, a total of 1,548 students participated in this project.

Table 1. Student participation.

Semester	# Sections	# Students
Fall 2019	10	551
Spring 2020	5	249
Yr 1 Total	**15**	**800**
Fall 2020	21	510
Spring 2021	10	238
Yr 2 Total	**31**	**748**
Project Total	***46***	***1,548***

Student learning was asssessed through performance on their submitted reports, 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. Because of the restrictions due to the COVID-19 pandemic, modifications were made to this project to protect students from physically interacting at close quarters. Sample data relating to force load were provided from a simple Warren truss bridge built using a PASCO structures kit. Using the West Point Bridge Designer 2019 software, students (individually) researched types of trusses and applied their knowledge to create and test model truss bridges to meet assigned specifications. In teams, students presented their best design and the team selected or created a final bridge design, which was tested and modified to optimize the strength and cost of the bridge. Students used the West Point Bridge Designer 2019 software to estimate loads within the truss bridge and to estimate total project costs.

The project incorporated bridge design and analysis concepts and required students to (1) research bridge truss designs independently, (2) use the West Point Bridge design software to design a bridge to meet specific criteria, and (3) calculate the factor of safety at points under stress and compression for the designed bridge. In AY 2019-2020 and fall 2020, the project also included having student teams prepare Power Point presentations and written formal technical reports. These reports took a lot of student time and effort, which reduced their focus on the scientific and engineering principles involved, as student questions seemed to focus more on the technical reporting aspects than on the engineering principles involved. Based on student and faculty feedback, this assignment was modified for spring 2021 to focus solely on the application of engineering principles involved in bridge design, and the communication requirements (Power Point presentation and technical report) were removed. A larger percent of time in spring 2021 was spent on the engineering principles involved in the bridge designs. This change is expected to be continued into AY 2021-2022 implementations of this team project with individual components. As COVID-19 restrictions are removed, teams will be able to use the lab space and PASCO structures kits to make their own force measurements.

ASSESSMENT TOOLS

Student learning was asssessed through performance on their submitted project deliverables, primarily the team technical report and Power Point presentation in Fall 2020 (not in Spring 2021), the project design score, and student feedback on the project. Each of these assessment elements is presented in more detail below after a brief description of all the project deliverables and how the ones used 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 listed in Table 2 that comprise the overall grade for Project 1 include: (1) an individually written backgroud research summary (requiring the use of at least 5 independent sources of information); (2) a mid-project update, including the Introduction, Background (created by combining each of the individual background research 5léments), 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 individidual Peer Review of each of their team members' participation, cooperation, and contribution to the final products. It should be noted that elements (2) and (4) were not implemented in Spring 2021, but in Fall 2020.

Table 2. Student project deliverables (AY 2019-2020 & Fall 2020).

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) (Only Fall 2020)	Team	Assignment	N/A
Design Score (calculated by Instructor based on FoS and Cost)	Team	Project 1	20%
Project Presentation and Power Point Slides (Only Fall 2020)	Team	Project 1	20%
Project Final Technical Report (Only Fall 2020)	Team	Project 1	35%
Peer Review of Team Members Contributions	Individual	Project 1	10%
Total Project:			100%

The primiary difference between Fall 2020 and Spring 2021 is that in Fall 2020 students did technical reports and video presentations online via zoom meetings, whereas in Spring 2021 students focused more on technical aspects of the project, not on presentation and report writing. The updated list of deliverables for spring 2021 includes:

1. Experimental Summary, including a table and graph presenting descriptive statistics for each of the three sensor locations plus written evaluation of the analysis performed.
2. Computer Analysis (using the West Point Bridge Designer 2019 software) including data tables for the first and second truss design plus a written analysis of those designs.

Team Project Technical Report & Presentation (Fall 2020, not Spring 2021)

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 guidlines 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 (Fall 2020 and Spring 2021)

The technical portion of the project was graded using a spreadsheet comparing factors 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.

Student Feedback

While grading rubrics were more clearly defined than in previous semesters, student feedback continued to indicate that first-year students are not used to being graded relevant to the performance of the standard

factor of safety and to their peers. Some students questioned 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 perceived fairness of the grading structure. These concerns were addressed by explaining the nature of competitive contracts within the engineering industry in class and in an updated assignement description.

CHAPTER 4

Recommendations

INTRODUCTION

Recommendations for future implementaton of this project are presented below.

PROJECT DESIGN

Both Fall and Spring project implemenations were impacted by the COVID 19 pandemic, leading to change of the delivery mode to be online via zoom meetings. Based on student, researcher, and instructor feedback from the fall implementation, changes were made to the project, specifically the format of evaluation that excluded technical reporting and PowerPoint presentation for feasibility of implementing the bridge design module in this course for the spring implementation.

While faculty provided data to students for their project during the pandemic, it is recommended that students collect their own data as soon as conditions are safe for them to return to the lab environment. Necessary improvements will be made continuously regarding 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. Data from the spring implementaton, along with student and faculty feedback, will be evaluated and considered in the assessment process to determine if additional changes are to be made to this educational unit.