Scholarship of Teaching and Learning: Design and Development of Project-Based Instructional Materials for ETEC3375 Statics

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STEM courses involved in the proposal:

This proposal is to support the ETEC3375 Statics section 01 (only one section is offered) with an expected enrollment of 20 students in Spring 2020.

Executive Summary

This project is to design and develop project-based instructional materials for the ETEC3375 Statics, which is a required core course for the Engineering Design Technology program and the Mechanical Engineering Technology program to be offered in Fall 2020. These instructional materials will supplement the classroom lectures and emphasizes practical applications of theoretical knowledge and the development of skills that are essential for engineering designers. The primary task of the proposed project is the development of PowerPoint slides, lab manuals, and customized lab equipment and tools for the instruction of methods and procedures used to construct and test various structures such as truss and bridge. With the support of the Fred Pirkle Endowment Foundation, a collection of PASCO structural models and sensors have been acquired to support this project. The PI will exam the capabilities of these models and sensors, design lab activities to enhance theoretical knowledge, and design projects for inquiry-based learning experience based on previous success[1]. A survey will be administered to assess students' progress and the effectiveness of the developed instructional materials at the end of the Spring 2020 semester.

This course prepares students for advanced topics covered in courses such as the existing ETEC4367 Strength of Materials as well as the new ETME 4385 Mechanical Design for the future Mechanical Engineering Technology degree program.

Project Narrative

Project Objectives: This project aims at designing and developing a collection of lab activities and associated course materials to supplement the instruction of theoretical knowledge of the STEM course: ETEC 3375 Statics. PASCO products, including the truss, bridge, building, large structure, and advanced structures sets, will be used to design various engineering structures for illustration of fundamental concepts and analysis of common static structures. Load cells, displacement sensors, amplifiers, and the Capstone software will be used to experimentally measure loads and displacements of structural elements in these structures. A term project requiring knowledge discussed throughout the semester and teamwork will be designed and incorporated in the instruction. Fig. 1 shows a small bridge constructed using the PASCO truss kit, four load cells, a weight representing a static load, and an amplifier (courtesy of PASCO.com) for data acquisition. This project will serve the ETEC3375 Statics in spring 2020 and could be used for instruction of ETEC4367 Strength of Materials to be offered in Fall 2020 with minor adjustments and additions. These activities can also be used for instruction of ETME 3376 Engineering Dynamics and ETME 4385 Mechanical Design in the future.

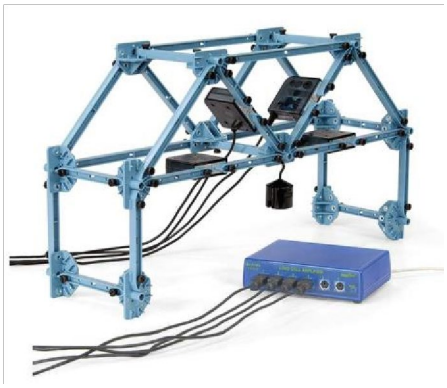

Fig. 1 Truss with load cells and an amplifier

[1] Ma, J., Coogler, K., & Suh, M. (2019). Inquiry-based learning: Development of an introductory manufacturing processes course based on a mobile inverted pendulum robot. *International Journal of Mechanical Engineering Education*, 0306419019844257.

Proposed Study: The proposed design and development of the instructional materials is to provide students with hands-on experience to help them visualize and better understand fundamental concepts, engineering structures, experimental measurement of force and displacement, and methods used to analyze these structures when they are subjected to static loads. For this project, the PI will exam lecture materials for the following topics that are previously determined by the curriculum committee of the Department of Engineering Technology and develop lab activities to enhance the instruction. Emphasis will be placed on the learning-by-doing practice and inquiry-based learning pedagogical approach.

1. Fundamental concepts including Newton's laws, vector and vector operations, forces and projections of a force, the moment of a force, moment of inertia, the radius of gyration, work, and virtual work;
2. Vector representation of a force and 2D/3D force system with application to the analysis of equilibrium of a particle;
3. Scalar and vector representation of the moment of a force;
4. Equilibrium of a rigid body when it is subjected to a system of static forces in the planer and 3D spaces;
5. Method of joints and zero-force members for analysis of frames and trusses when they are subjected to static forces in the planer and 3D spaces;
6. Experimental measurement of internal forces and deformations using a force transducer and displacement sensor;
7. Design and construction of a large-scale structure as a team term project. ***Expected Results and Dissemination Plan***: The PI will develop the instructional materials discussed above as the semester proceeds when related topics are being introduced. The newly developed instructional materials will be incorporated into the instruction of the ETEC 3375 Statics course in spring 2020 to solicit feedback from the cohort of students. Based on the inputs and feedback from the students, the PI will make the necessary adjustments and changes to finalize the developed instructional materials. At the end of spring 2020, it is expected that the planned instructional materials will be developed, and hard copies of the lab manuals will be created for future use. The PI will design and build customized tools and fixtures using 3D printing, laser cutting, and CNC machining, etc. manufacturing methods so that the PASCO equipment can be customized for the designed activities. The PI will also work with the instructional design specialist of the College of Science and Engineering Technology to create instructional videos for illustration and demonstration where it is applicable. Digital copies of all the newly developed instruction materials will be deployed on the Blackboard learning management system. The PI will explore the possibility of publishing the manuals after two more experimental runs with refinements.

Assessment Plan: On top of the IDEA evaluation, the PI will develop a customized survey to assess the effectiveness of the newly developed instructional materials at the end of spring 2020. The survey consists of students' progress self-assessment to include the understanding of knowledge, applying knowledge to solve practical problems, and working in a team environment, as well as evaluation of course materials and instruction to include problemsolving skills development, appropriateness of the equipment, and effectiveness of the instructional

method. The PI plans to submit the assessment results for publication at the American Association of Engineering Education (ASEE) 2021 annual conference.