Interactive Investigations for Engineering Statics

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Need: Statics is one of the first engineering courses that exposes students to engineering problem solving. It is a required course for 6 of the 8 majors in the College of Engineering with enrollment exceeding 500 students/year. While the fundamental concepts of statics are relatively few and simple to state, many students struggle to apply them to solve engineering problems because of the varied nature and three-dimensional aspects of such problems. Consequently, the overall DFW rate in statics is around 25% and there is a need to address this issue.

Innovation: This project aims to develop interactive investigations using GeoGebra to enhance student learning. A deeper understanding of the principles of statics and their application to varied problems can be facilitated by developing interactive simulations that allow students to:

(a) visualize the building blocks of a concept in a 2D or 3D representation,
(b) investigate the effects of varying parameters by directly interacting with the simulation, and
(c) answer conceptual questions based on these investigations.

GeoGebra is a mathematics software that combines the elements of geometry and algebra. GeoGebra has been chosen for this project because it is simple to learn, open-source and freely available to use for non-commercial applications, and has already been used to create some simulations for an open-source textbook of statics (https://engineeringstatics.org) and for Dr. Benjamin Fahrman's dynamics class at UGA (e.g. https://www.geogebra.org/m/rmwgqwpx).

Impacts: This project is expected to

(a) impact student learning in statics, and provide a better foundation for the many courses in engineering for which statics is a prerequisite (e.g. dynamics, fluid mechanics, strength of materials), and
(b) strengthen the collaboration between instructors in engineering and in physics as one of the investigators of this project is also an instructor of the physics course that is a prerequisite to statics.

The project will also result in a bank of interactive investigations that can be used to study conceptual learning in individual and collaborative settings in the future.

Data collected: We anticipate collecting preliminary data using a representative group of students to measure relative learning between:

(a) Students that use the interactive investigations and those that use an alternative mode (lecture, non-interactive visualizations etc.)

(b) Students that use the interactive investigations individually and those that use them collaboratively in small groups

This project will focus on thoughtful creation of interactive investigations and design of ways to measure student learning in individual and collaborative settings. While we expect to collect some preliminary data as part of this project, further data collection and impact measurement will be reserved for a continuing future project that we anticipate will be funded by some combination of EETI Educational Research Initiation and Development grant, CTL Learning Technologies Grant, and/or USG Affordable Materials Grant (Transformation or Research).

Plan of work: Each of the four instructors of statics involved in this project (Drs. Fahrman, Foutz, Lim, and Savadatti) will:

- develop 4 interactive investigations involving simulations paired with targeted conceptual questions;
- hire and supervise undergraduate students who will code these simulations into GeoGebra; and
- make these investigations available to their statics classes.

Dr. Weliweriya, whose expertise includes conceptual and skills development, will in consultation with the statics instructors develop ways to measure the learning occurring and investigate how an app recently developed by Dr. Johnsen's lab for collaborative problem-solving can be used to investigate the advantages of students attempting these investigations collaboratively.

Dates	**Task(s)**	**Person(s) responsible**
Oct 2023	Develop initial set of 4 interactive investigations (1 investigation/instructor) and hire undergraduate students	BF, TF, EL, SS
Nov 2023	Code initial set of interactive investigations in GeoGebra	Undergraduate students
Dec 2023	Share initial set of interactive investigations, obtain feedback, refine	All investigators
Jan – Feb 2024	Develop full set of 16 interactive investigations (4 investigations/instructor)	BF, TF, EL, SS
Jan – Feb 2024	Code full set of 16 interactive investigations in GeoGebra	Undergraduate students
Feb 2024	Design ways to measure student learning in individual and collaborative settings	NW, KJ in consultation with statics instructors
Mar-April 2024	Deploy interactive investigations, and gather and analyze preliminary data to measure student learning	All investigators

The project funding will predominantly be used to pay undergraduate students hired to code the interactive investigations in GeoGebra and for compensating volunteers used to collect data. Each interactive investigation is expected to take ~6 hours to code resulting in a cost of ~$1140 (4 instructors × 4 investigations/instructor × ~6 hours/investigation × $12/hour). Preliminary data will be obtained from 4 investigations at a cost of $360 (6 volunteers/investigation × 4 investigations × $15/volunteer). Total project expenditure is expected to be $1140+$360=$1500.

Contribution to EETI's mission: This project brings together multiple instructors of statics, a faculty member with expertise in conceptual and skills development who also happens to be the instructor for the pre-requisite physics course, and the director of virtual experiences laboratory that has designed tools to aid and study student learning, to build shared capacity that can more effectively enhance engineering education at UGA.