## Project Year

2015-2016

## Project Title

Virtual Laboratories for *Statics and Mechanics of Materials*

## Project Team

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## Audience

The primary audience for this project will be undergraduate students enrolled in 530.201/560.201 *Statics and Mechanics of Materials* (*Statics/MoM*). *Statics/MoM* is the first engineering class for many students in the Whiting School, and fundamental concepts introduced in the class lay the foundation for much of the students' major coursework. The course is co-listed between the Departments of Civil Engineering and Mechanical Engineering and is required for all students in those departments. In addition, the class is required for students majoring in Environmental Engineering and Materials Science and Engineering. Last year, the total number of students enrolled in *Statics/MoM* was 125.

We expect that the project will primarily benefit the undergraduate students in *Statics/MoM* while enrolled in the course, but the resources developed could also be made available for use in subsequent classes, providing these same students with way to review fundamental concepts.

## Pedagogical Challenge

*Statics/MoM* consists of a three credit lecture and a one credit laboratory. While concepts introduced and practiced during the laboratories are critical to students' understanding of course content, given the size of the class and the desire to keep lab sections small, students end up spending a disproportionately small amount of time performing the labs.

To reinforce concepts outside of lab, students are required to write reports communicating the lab objectives, the equipment used and procedure followed, the results obtained, and the meaning of those results. With only one opportunity to perform the lab, however, students struggle to communicate this information in their reports. Timing the labs to coincide with relevant lecture material is also difficult as the numerous lab sections spread over two weeks result in labs that are performed either before or after the complementary lecture material is presented.

## Solution

We propose the development of a digital resource that would enable students to review the labs as they write their reports and as a result, improve their understanding of laboratory concepts and their ability to communicate those concepts in writing. In essence, we plan to create a suite of virtual laboratory experiments that will model in every way the physical labs performed by the students, including real time plotting of data extracted from the model, similar to the plots required by students in their reports.

These virtual labs would be created using finite element software and linked to Blackboard for students' convenience. The three existing labs that would benefit most from this project include: the Simple

Tension Test, Torsion of a Circular Rod, and Beam Bending, although with the framework established through this project, additional virtual labs could be created and added in the future.

## Assessment Strategy

Three methods of assessment are planned. First, a direct comparison of students' performance before and after the availability of this resource is possible as lab reports and exams from the fall 2014 semester have been saved for the purpose of assessing ABET student outcomes. After the fall 2015 semester, we can quantify the improvement in students' understanding of lab- related topics. Some exam questions are relevant as students were expected to develop a deeper understanding of concepts covered primarily during lab, rather than lecture. A second strategy would aim to assess students' perception of the usefulness of the virtual labs by soliciting their feedback via end-of-term course evaluations. Finally, if housed on Blackboard, the number of times the virtual labs were accessed could be tracked.

## Faculty Proposal

Statics and Mechanics of Materials (*Statics/MoM*) is a fundamental undergraduate class required for students majoring in Civil Engineering, Mechanical Engineering, Environmental Engineering, and Materials Science. The class counts as 4 credits, with 3 credits devoted to lecture and 1 credit to a laboratory.

Lab reports for *Statics/MoM* require students to communicate the objectives, the equipment used and procedure followed, the results obtained, and the meaning of those results. While most students are able to describe the equipment and procedure, they have trouble communicating the objectives and results of the lab. In part this is because the lab time is short and students are only provided with a single opportunity to perform the test, during which time they are focused more on collecting results than thinking about why they are collecting results. Timing the labs to coincide with relevant lecture material is also a problem as the size of the class requires its division into twelve lab sections spread over two weeks, resulting in labs that are performed either before or after the complementary lecture material is presented.

The solution we propose is to develop a suite of virtual laboratory experiments that will replicate the physical labs performed by the students. This resource will be available to students outside of class so they can virtually repeat the labs as many times as necessary to make sense of the results while writing their reports.

Use of this technology is not new. What makes this program different than other virtual labs currently available online is (1) the virtual labs we propose will model the physical labs performed in *Statics/MoM* at Hopkins and (2) finite element analysis (FEA) software will be used to model the tests. The benefits of using FEA software is that it provides the most accurate tool for modeling the experimental tests performed in the lab and it is the tool most often used by practicing engineers to model their designs. Thus an added benefit is that the virtual labs will provide students the opportunity to preview a tool they will be learning later in their undergraduate studies.

The technology fellow is knowledgeable in ABAQUS (FEA software) and he will be able to create the models independently. My role will be to ensure that the final product is easy for students to navigate and natural to associate with the physical laboratory experiments. Weekly meetings during the summer

will help ensure that a majority of the work is completed in time for the fall 2015 semester. I expect that 20 hours/week over 12 weeks will be enough time.

Three methods of assessment are planned: (1) directly compare students' performance before and after the availability of virtual labs; (2) solicit feedback from students regarding the value of virtual labs via end-of-term course evaluations; and (3) track the number of times the virtual labs are accessed by students.

The concepts demonstrated in *Statics/MoM* labs are used repeatedly throughout the undergraduate engineering curriculum; if made available to students in later classes, this resource could help students recall prior concepts and make connections among individual classes.