Work in Progress: Pilot Study for the Effect of Simulated Laboratories on the Motivation of Biological Engineering Students

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Dr. May is an Assistant Professor in the Engineering Education Transformations Institute and conducts research on online as well as intercultural engineering education. In his work, he focuses on developing broader educational strategies for the design and use of online engineering equipment, putting these into practice and provide the evidence base for further development efforts. Moreover, he is developing instructional concepts to bring students into international study contexts so that they can experience intercultural collaboration and develop respective competences. Dr. May is Vice President of the International Association of Online Engineering (IAOE), which is an international non-profit organization with the objective of encouraging the wider development, distribution and application of Online Engineering (OE) technologies and its influence to the society. Furthermore Dr. May serves as Editor-in-Chief for the 'International Journal of Emerging Technologies in Learning (iJET)' with the aim to promote the interdisciplinary discussion of engineers, educators and engineering education researchers around technology, instruction and research. At his former institution Dr. May was research scientist and project lead of numerous extra-mural funded research projects in the area of Engineering Education Research with focus on distance education as well as remote experimentation and with this he gained extensive experience in developing, integrating, and evaluating innovative learning experiences combining the engineering and didactic perspective. Dr. May has organized several conferences in the Engineering Education Research field and is current program committee member for the annual International Conference on Remote Engineering and Virtual Instrumentation (REV).

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Dr. Cheryl Gomillion is Assistant Professor in the School of Chemical, Materials, and Biomedical Engineering, part of the College of Engineering at the University of Georgia (UGA). She received her B.S. in Biosystems Engineering with an emphasis in Applied Biotechnology from Clemson University, and she completed both her Master's and Ph.D. in Bioengineering also at Clemson University. Dr. Gomillion's long-standing research interests are in tissue engineering and regenerative medicine. Specifically, the work of her research group focuses on three general areas: (1) design and modification of biomaterial scaffolds to study cell-biomaterial interactions and to provide cues for directing cell behavior for tissue regeneration; (2) application of engineered tissues for aesthetic and functional tissue replacements; and (3) advanced application of tissue engineering strategies for developing in vitro tissue models for studying disease systems. Dr. Gomillion is committed to the integration of her biomedical interests with education research endeavors, with a specific focus on evaluating classroom innovations for improving biomedical engineering student learning and exploring factors that facilitate success for diverse graduate students.

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Introduction

Laboratory sections are at the core of undergraduate STEM education as they grant students the ability to observe how the physical world compares to the concepts taught in the classroom. In the context of engineering (as an applied science field), focus on the application of concepts in an educational setting is especially crucial towards proper career development. The data attained from lab assignments can remarkably improve students' understanding of classroom concepts by allowing students to observe the strengths and weakness of various scientific theories.

Compared to traditional engineering disciplines (civil, mechanical, etc.), biological engineering (BE) students have been found to have different motivations for entering the engineering field; therefore, it is paramount that the BE engineering education community capitalizes on this difference to address the systemically lackluster engineering student retention rate.[1] BE students are largely driven to the field for the opportunity to benefit society, which differs compared to traditional engineering majors who cited their love of designing and building.[2, 3] The unique motivational differences of BE students warrants further study, as previous motivational studies in a traditional engineering setting may not be applicable to BE students.

The best way to take advantage of the unique motivation of BE students is to engage them in real-world issues and application in the early years of university study.[4] Applying classroom concepts in a laboratory setting could provide students with exposure to the real-world issues that BE students crave to engage with; however, taking advantage of the unique motivations of BEs majors has proven difficult. This is because BE educators face a variety of logistical challenges towards implementing hands-on BE labs, such as limited campus space and expensive equipment that are not shared with other engineering disciplines (cell culturing hoods, incubators, etc.)[5] Therefore, it is believed that implementation of alternative laboratories could fill this educational gap.

With advances in computer science, simulated labs have been developed by tech companies and educational institutions to address the logistical challenges of hands-on labs.[6] These simulated labs have been found to cost less and require less setup time in an educational setting, which offers a solution to some of the challenges of hands-on labs.[7] Comparison between lab types is difficult as each type has a different educational objective, as hands-on labs are emphasized for design skills whereas simulated labs for conceptual understanding.[8] However, it was found that the attitudes toward the type of lab is highly influenced by the convenience of the lab assignment.[9] Students liked that the simulated lab required less time on setup and tear-down, which aligns with previous literature[7]. In the end, there was little difference in conceptual outcomes between the lab types, which suggests that alternative labs can be as effective as hands-on labs. Therefore, it is our belief that simulated labs are a feasible alternative for BE educators; however, it is of utmost importance to ensure that BE simulated labs are able to properly address BE student motivations before widespread application into BE curricula.

Research Design & Plan

The researchers will look at answering two 2 key questions:

1) *Educational Outcome Question*: How does the simulated lab affect student engagement?

2) *Knowledge-Generating Question*: How do bioengineering student experiences in disciplinary-specific simulated labs impact the students' motivation?

To answer these questions, the lab intervention was placed within a senior-level undergraduate Tissue Engineering course that does not currently have any type of lab section. A senior-level class was chosen for this pilot study in order to eliminate any conceptual gaps that students may have with the covered material. Further study will look at the implementation of simulated labs with first-year BE students, as they will be the most likely to gain motivation benefits by experiencing the content at the end their major.

The chosen simulated lab intervention is a Tissue Engineering lab developed by Labster™, which is a fully virtual, desktop-based lab. In the simulated lab, students immersed in a real-world scenario by being prompted to help treat an injured soccer player. To accomplished this, students must develop a scaffold to help regenerate the soccer player's cartilage. Students will accomplish this by relying on their background of chemistry and material science; therefore, the Labster™ Tissue Engineering activity is a perfect fit for the class as it covers material relevant to both BE and biochemical engineering students.

Data Analysis & Preliminary Results

For this study, Jones' MUSIC® Model of Academic Motivation was utilized as a theoretical framework, as it is backed by variety of resources to ensure proper implementation and is made to assess specific elements of a course or activity.[10] The power behind the MUSIC® Model of Academic Motivation is derived from the five separate motivation theories used to create it: 1) Student e**M**powerment 2) Activity **U**sefulness 3) **S**uccess in the course 4) Student **I**nterest towards the content 5) Belief that the academic structure **C**ares for student well-being. By combining separate motivational theories, the MUSIC® Model of Academic Motivation will be able to pinpoint what aspects of motivation can best be improved in future BE simulated lab software. Regarding this project, we hypothesized that sense of empowerment would be the least likely to resonate with students due to the limited control a student has over a guided simulated lab.

Both quantitative and qualitative data will be collected. Post-intervention surveys will utilize Jones' MUSIC® Inventory, which was also developed by Jones to measure the extent to which college students perceive the presence of each of MUSIC model components in a college course.[11] The survey compromises 26 quantitative questions from the MUSIC® Inventory, , which will help us asses how simulated labs affect student engagement, and 6 short answer questions. The short answer questions were added in order to get a more in-depth understanding of the numerical data and to select 5 students to undergo narrative analysis interviews. When combined with the short answer questions, this qualitative data will allow us assess how student experiences with the simulated lab had an affect on their motivation towards the assignment.

Of the 45 students enrolled in the course, 43 participated in the study by completing the activity and survey. The activity was completed outside of the classroom as a distance learning activity, so students had no direct help from the instructors. Additionally, the activity was completed by students in an average of 32 minutes. Considering some of the steps in the simulated experiment required "20-30 minutes" of incubation (which was fast-forwarded), we can assume that the experiment in a hands-on lab would take more time, which aligns with the previous reported expedient/convenience benefit of simulated labs.[7]

	Empowerment	Usefulness	Success	Interest	Caring
Avg:	4.38	4.44	4.89	4.77	5.21
Std:	0.58	0.89	0.46	0.94	0.52

Table 1 - Survey Numerical Data. 1= Strongly Disagree 6= Strongly Agree. n=43.

Discussion:

After completion of the activity, students were directed to fill out the MUSIC® Inventory, which was administered through an online survey. The results of the numerical potion of the survey are presented in **Table 1**. Overall, all 5 pillars of the MUSIC® theory exhibited a positive effect on students as the answers averaged from “Somewhat Agree” to “Strongly Agree”. As hypothesized, the empowerment category was the lowest of the categories; however, students still agreed that they had some power over their learning. This was somewhat of a surprise given that it’s a guided simulated laboratory, which does not offer much space for self-exploration; however, it was revealed in the qualitative short answers that students had multiple options throughout every step of the experiment, which included wrong answers that would derail the experiment. This sense of choice and the need to critically think, rather than just simply clicking through an animation, resonated with students sense of empowerment.

While the narrative analysis interviews are currently being transcribed, it should be noted that a two-sample t-test revealed that the Caring pillar has a statistically significant difference than all 4 other pillars. Additionally, the Success pillar was statistically different from both the Empowerment and Usefulness pillars, which were the two lowest rated pillars. Completion of the narrative analysis interviews is expected to illuminate the reason for these differences beyond what was revealed in the qualitative short answers.

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