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Work-in-Progress: Mobile Assisted Gains Through Innovative Curriculum for Students in the Thermal-Fluids Science Course

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Introduction

A learner-centered higher education ecosystem is essential to effective educational outcomes and societal advancement [1]. Mobile devices such as smartphones, tablets, and tablet computers enable learning anytime and from any location [2], blurring the boundaries between formal and informal learning [3]. When paired with effective pedagogy, mobile technologies can positively impact the teaching and learning experience for students in high-demand science, technology, engineering and mathematics (STEM) disciplines, increasing the flexibility and ease with which they are able to pursue their education while developing their professional identities as engineers [1]. Student retention remains a problem in STEM programs [4-7]. In engineering, many students do not even make it past their core courses [8]. This poster reports on initial efforts of a two-year research study to utilize mobile technologies and a technology-enhanced curriculum to improve student engagement and learning in STEM undergraduate courses. This (work in progress) poster describes a quasi-experimental mixed methods study on implementing mobile devices (iPad and Pencil) and a technology-enhanced curriculum in an undergraduate thermal-fluids engineering course, a foundational engineering class. Research has indicated that engineering students' performance in foundational courses is a predictor of future academic success [9].

The technology-enhanced curriculum will be fully integrated in the thermal-fluids course to deliver content and to facilitate student engagement with the content, instructor, and peers. This approach applies the social-constructivist perspective on learning and supports a connected community of learners with classroom peers and co-construction of knowledge where the instructor's role is that of a subject matter expert who facilitates learning. To examine the impact of mobile devices on student learning, in this two-year study (started in fall 2021), the following research questions will be addressed, hypothesizing improvements in the areas of engagement, learning outcomes, and extension of learning goals to real-life problems: (1) Does mobile device use facilitate engagement in thermal-fluid science course content? (Engagement), (2) Does mobile device use increase learning of identified difficult concepts in thermal-fluid science courses as indicated by increased achievement scores? (Enhancement) and (3) What are student perceptions of using mobile devices for solving real-life problems? This poster will provide an overview of the research plan and describe some preliminary research efforts.

Background

Mobile learning in the classroom presents several benefits to students. The rising costs of paper-based textbooks is making access to subject matter content increasingly cost prohibitive for many students [10, 11], especially those coming from low socio-economic backgrounds.

Instructors can help economically marginalized students overcome such barriers by using Open Educational Resources (OER) that students can access via mobile devices; but to be effective, students must have the digital skills to use the devices to learn [12]. Hence, familiarizing students with technology tools, most notably mobile devices, is crucial if students are to access essential resources and to develop important digital literacies needed to succeed not only in college but in the workplace after they graduate. Mobile learning in STEM classes in particular gives students better access to multiple learning platforms, tools, and software packages, all in one place. Particularly, improved access to course management systems, Canvas and applications such as Notability and Google Drive, providing students with increased opportunities for continuous learning that can travel with them wherever they go. Though this study is on mobile integrated learning in thermal-fluid sciences, the findings can transfer to other foundational engineering and STEM courses. The underlying goal of this research is to measure how mobile technology, when purposefully integrated into engineering teaching, impacts student engagement, enhancement, and extension of learning.

To investigate the impact of Mobile Assisted Gains through Innovative Curriculum (MAGIC) on student engagement, learning outcomes, and in building a community of learners, an epistemological perspective through a social constructivist learning framework is appropriate. Some early theorists have stated that what differentiates mobile learning from other forms of learning is the assumption that learners are continually on the move [13]. Learning occurs across space, time, and topic, enabling learners to more readily transfer knowledge and skills across contexts and life transitions than possible with other instructional technologies [14]. The social-constructivist perspective on learning views learning as a process situated within a social context, with complex social interaction [15], and requiring an understanding of the relationship between how people think and the activities in which they engage [16].

Technology integration frameworks like the Triple E Framework [17] emphasize how instructors need to move away from arbitrary use of technology to more thoughtful ways of adding value to student learning. Developed primarily for K–12 application, this framework measures the degree to which a lesson integrates technology and helps students reach the learning goal(s). The framework is based on three main components: (1) Engagement in learning goals (2) Enhancement of learning goals, and (3) Extension of learning goals. The key concept of this framework which is relevant to this study is its emphasis on the importance of the instructional strategy, which goes hand-in-hand with the use of any technology for learning.

In this project, the Triple E Evaluation framework will be utilized as a lens to assess whether the technology choices made for teaching and learning leads to student engagement in learning goals, enhancement of learning goals, and whether technology use helps the learners extend their academic learning to authentic, real life tasks.

Method

Study Setting and Participants

This research project will utilize a mixed methods design. The research team will collect both qualitative data (i.e., classroom observations, student end-of semester interviews) and quantitative data (i.e., course achievement data, course grades of D, F, and Withdrawal rates, Triple E Rubrics, surveys) to investigate the impact of MAGIC. Based on past enrollment, it is estimated that class enrollments will be about 40 students. An IRB approval is in place to invite students to participate in the study. All those who wish to participate in the study will sign a consent form which describes the study and informs them that participation or otherwise, will have no impact on course grades.

Data Collection

Data will be collected over two years, from two separate student groups in the 300-level Thermal-Fluids I course—one supported by mobile device, i.e., iPad with Pencil (spring 22 and 23) and the other not supported by mobile devices (fall 21 and 22). As this study will be conducted over two years, there will be, in total, two spring sections and two fall sections. The spring sections will be loaned the device for the semester, free of charge. Each student will use the iPad and Pencil to learn through engagement with abstract and difficult concepts, the instructor, and with peers. The software vObjects (NSF IUSE#1712210), an application specifically created to help engineering students visualize and better understand abstract concepts such as thermodynamics, will be utilized in this curriculum. The vObjects application will be used in a project that engages student teams in proposing a new energy system at a prospective site in Jamaica, Panama, or Rwanda. Students in the fall sections will not be provided with an iPad and Pencil, however they will engage with the same abstract and difficult course concepts in traditional course delivery formats and engage with the same active learning methods that are deployed in the spring. Both sections will receive the similar course content, homework, and assessment.

Analysis

At the end of the Thermal-Fluids I course, all students will take an end-of-course survey/student learning satisfaction questionnaire to gauge their perceptions of the extent to which various aspects of the course were helpful for developing their understanding of the course content. The survey includes Likert-scale questions on a scale from 1 (very unsatisfied) to 5 (very satisfied) and elicits feedback from students on the perceived value of various aspects of the course, including instructional strategies, note taking, self-evaluating their engagement. The survey will be administered in week 15 using an online survey platform (i.e., Qualtrics) to facilitate data

processing. At the end of the survey, students will be invited to participate in a semi-structured interview after the completion of the course. The Triple E Framework rubric will be used to do classroom observations to address research questions 1 and 3. To account for pre-knowledge and misconceptions of thermodynamics among the participants of both sections, students will complete a Thermodynamics Concept Inventory [18] in the beginning and end of the course, consisting of about 25 questions. In order to identify the overall impact of MAGIC, the interview process, end-of-course survey, and Thermodynamics Concept Inventory will be analyzed using thematic coding and other analysis techniques. In particular, statistical methods such as t-tests, analysis of variance, and hierarchical regression will be used to evaluate the Thermodynamics Concept Inventory to confirm at pre-test which concepts are most difficult for students to grasp.

Conclusion

The findings from this research are potentially transformative, being one of the first to offer full integration of mobile devices in the teaching and learning of the thermal-fluid science curriculum. Using a thermal-fluid science course as a model course, the primary contribution of this research is to directly improve and transform engineering students' learning in one of the most difficult and abstract content in engineering curricula. By studying student learning that can result from using mobile devices, findings from this project can not only contribute to thermal-fluid science education but also to other foundational engineering courses. Specifically, this work will demonstrate the approachability and utility of social science research for technical faculty looking to improve engineering formation processes. While the proposed study will engage engineering students who are learning thermal-fluids science concepts, study findings may be applicable to other STEM-related disciplines.

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