WIP: Longitudinal Outcomes of a Requirement for Student-owned Laptop Computers Across a College of Engineering

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***Abstract*—This WIP focusses on one component of our updated first year engineering program (FYEP), a student-owned laptop requirement. Requiring students to bring laptops will enable all students to practice the skills learned during their first-year engineering classes. Other engineering instructors will also be able to require students to bring and use laptops in their courses. Infusing the use of laptops into coursework throughout our engineering curriculums should positively affect computational problem solving and develop a mindset of "ubiquitous computing." In this paper, we outline a longitudinal study in which we plan to assess the impact of the updated first year engineering program and in particular the laptop requirement on computational competencies and attitudes.**

Keywords—laptop; computational problem solving; ubiquitous computing; first-year engineering

I. Introduction

This WIP report focuses on one aspect of a large project to update the first year engineering program (FYEP) at our university. Our current FYEP was institutionalized with the establishment of a department within our college of engineering over 15 years ago; we currently have a yearly enrolled base of approximately 1,000 students; our first year engineering program is a common first year experience across all undergraduate engineering majors. After three planning years, and multiple pilot course offerings, we are now embarked on a roll out at scale scheduled for Fall 2017. Our key student outcome goals in the revamped first year program include: strengthened ability for open-ended problem solving, strengthened facility with computational problem solving applied to engineering problems, and enhanced student growth in traits of self-starting learning and positive attitudes for life-long learning. Our major operational path to reaching these goals are (a) streamlining and integrating our first engineering topics, (b) moving to a near-100% inverted classroom model, (c) establishing a near-peer mentoring program [1], (d) introducing a requirement of student-owned laptop computers, and (e) establishing with strong university and college support a new "scale-up" type instructional space that will serve as the physical home for most of our FYEP courses [2]. In this report we focus on (d), the laptop requirement for all incoming, first-year engineering students.

For our revised program to take root and flourish, the laptop requirement is a key ingredient. Our second-tier student outcome goals that leverage the introduction of student-owned laptops include student development of deeper computational competencies and establishing the mindset of "ubiquitous computing".

II. Background

The use of laptop computers to support and enhance education at all levels became an area of active interest in the late 1990s as technological advances in computing produced affordable and effective computing platforms. The published story of the introduction of laptops into educational settings and the impact on student attitudes and learning outcomes is largely bounded in the literature between 1995-2015, with the greatest number of relevant publications occuring between 2005-2010.

In 2003, Campbell and Pargas reported generally positive student outcomes for the introduction of laptops into several classes at Clemson University [3]. The report however is largely anecdotal.

In 2004, Finn and Inman reported on a longitudinal, Pew-sponsored research project that sought to find the impact on alumni who had participated in an early introduction of laptops in higher education with a major goal being to establish a student mind-set of "ubiquitous computing" [4]. The most strongly supported finding about the reflections of these alumni were described in the Finn and Inman article as:

> *One finding, however, is indisputable. The classes of 1998 and 2000, who fully participated in the laptop computer program, exhibited their highest levels of agreement with two statements in support of digital unity on campus:* ***portable computers were beneficial during their college careers*** *... and* ***the laptop program is important to continue for future students*** *... [3, p. 315; emphasis added].*

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In 2005, Gardner and Eng reported on a study at UCLA regarding student expectations for library use. This study was not about laptops directly in the classroom, but about expectations of Generation Y students in terms of library use. The authors concluded that:

> *Our survey and accompanying research on Generation Y offer support for the four main expectations attributed to this new generation:*
>
> *1. Demand for quality academic facilities and high academic achievement*
>
> *2. The need for customization of technology and research*
>
> *3. The need for integration of technology into learning*
>
> *4. The usage of new communication modes[5].*

The use of available laptops played an enabling role in the remote use of the library on an immediate basis for students in this study.

One of the most comprehensive studies of laptop introduction in higher education was by Fried [6]. Fried reported negative learning outcomes associated with unstructured laptop use in classes. Unstructured laptop use refers largely to students in a largely lecture-style class who are asked to simply "take notes" with the laptop computer. The discussion by Fried indicates that this type of use leads to student "multi-tasking" between listening to the lecture, taking notes, and using the laptop for non-class related activity (reading email and etc).

Laptops cannot be simply handed to students, and the students told to "take notes" if the potential of personal laptop computers is to be achieved. Personal laptops have a place outside the classroom to help establish the mind-set of ubiquitous computing (also called pervasive computing). Personal laptops in the classroom strongly enhance the ubiquitous computing mindset if, and apparently only if, the laptops have a student-perceived, targeted use inside the classroom. This issue of structured versus unstructured use of laptops is made explicitly in a more recent report by Kay and Lauricella [7].

There are some caveats to the use of laptops in classrooms, however, as cited in the following studies. Earlier work in a K-12 environment by Gulek and Demirtas reported substantial positive impact for students in middle school after an initial year (Gulek and Demirtas 2005). The one year delay of a positive impact was attributed to students being unfamiliar with use of computing and requiring a time of acclimation. The positive impact observed in the second year was described as "… participation in the laptop immersion program had a significant impact on student achievement." [8, p. 30]. In the work reported by Gulek and Demirtas, it is important to note that the laptop use as described would fall into the "structured laptop use" category as described above.

A different and negative outcome for student attitudes and learning outcomes was reported by Wurst, Smarkola, and Gaffney in 2008 [9]. The context of this work was in the Temple University School of Business, for honors students who used a laptop. A likely reason for the outcome of this study is that the study process, although apparently quite rigorous, simply handed out laptops to identified faculty and staff, and recorded both outcomes (with an instrument designed to measure constructivist activity) and attitudes with minimal curricular integration of laptops-for-purpose attempted.

The "to what purpose laptops" issue raised above helps to put the results of the study by Wurst, Smarkola, and Gaffney into perspective. Laptop classroom use needs to have a purpose within the classroom and through the curricular design if the laptops are to be perceived as beneficial by students, and if they are to enhance student learning outcomes.

III. Why a Laptop Environment; Priliminary Data

In our FYEP courses, students have had access to two desktop computers for each team of four students (1-to-2 ratio). While some students bring their laptops with them to class, not all students have access to a computer for their individual use during class. While many students are actively working together on a shared computer, some students do not fully engage in the activities or rely on their teammates to complete the in-class activities. Opening of the Active Learning Center (ALC) in fall 2014 allowed some sections of our courses (12% of our first-year students) to have one desktop computer for every student (1-to-1 ratio). Instructors of courses held in the ALC have noticed that their students are more engaged when all students have access to a computer for their individual use.

Most of our students do have access to computers, so the laptop requirement should minimally impact our students. A survey to determine computer access and familiarity was given to students at the beginning of the school year in their first-year engineering course in fall 2015. The survey response rate was high, with 764 of the 887 students (86%) completing the survey. Results from this survey indicate that student access to computers is high, with less than 1% of the respondents reporting that they live in a home without a computer or laptop and 92.5% reporting that they have a laptop or desktop computer in their home for their personal use [10].

Beginning Fall 2017, all first-year engineering and engineering management (School of Business) students will be required to have a laptop that meets a set of minimum specifications. This will enable us to require students to bring laptops with them to their first-year engineering courses. The laptops will be used for problem solving, analysis, and design activities both in and out of class. Requiring students to bring their laptops with them to class will give every student the opportunity to learn how to use his or her laptop as an effective engineering tool. As these students progress through their engineering programs, other engineering classes will also be able to require students to bring laptops to their classes. As students are increasingly required to use laptops in their courses, it is expected that a mindset of ubiquitous computing will be developed.

IV. Future Research Goals

Incorporating student owned laptops into our engineering curriculum provides an opportunity to study student

computational outcomes longitudinally. To determine the impact of requiring laptops on student computational competencies we will need to first characterize the computational competencies of students prior to the requirement and then monitor those competencies to see if any changes are observed. We can use historical data that has been collected in our first-year engineering course as a baseline in the first year. The measures that we have been collecting include 1) performance on lab practicals where students are expected to solve problems using Excel and MATLAB, and create parts and assemblies in NX; and 2) performance on exam questions related to the use of Excel and MATLAB. Additionally, we will establish a baseline of computational competencies in the senior year by collaborating with several capstone design teams and departmental curriculum committees. One assessment measure will involve characterizing the computational problem solving demonstrated in capstone project reports and/or presentations. A second measure will be based on a competency check where graduating seniors will be given a problem and asked to outline their computation solution using a flowchart or pseudocode. As students required to bring laptops reach their senior year, we will be looking to see if there are any changes in their use of (or documentation of) computational problem solving. Since we have approximately 130 students who went through a pilot version of our updated FYEP in 2016/2017, the year prior to the laptop requirement, we hope to be able to separate the impact of the laptop requirement from the updated curriculum.

To more fully understand the impact of the laptop requirement and an updated FYEP curriculum on developing a computational mindset, we will survey students as they progress through their curriculum on their use of laptops in and out of class and their attitudes on their usefulness. We will use tools such as the expanded Student Laptop Use Survey [11] or the Computer Use and Familiarity Survey [12] to determine how often students use their computers for a variety of activities. Additionally, it will be important to document the courses students are taking at the time they complete the survey as well as how active use of laptops have been incorporated into those classes.

V. Conclusion

Through the use of student surveys and evaluation of demonstrated use of computational problem solving, we will be able to determine the impact of the updated FYEP and its components, including the requirement of student owned laptops, on students' computational competencies and the degree to which they develop a ubiquitous computing mindset.

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