USING BIOMEDICAL APPLICATIONS IN TOUCH AND INK MOBILE APPS TO ENGAGE AND RETAIN STEM STUDENTS IN CALCULUS

Technology in Practice Strand

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1. ABSTRACT

With support from three Hewlett-Packard Awards and a 4-year NSF-CCLI Grant, the Department of Mathematical Sciences at Clemson partnered with Computer Science to develop and implement pen technology in Engineering Calculus I. Our goals from 2006-2011 included personalizing instruction in large active-learning classrooms, reducing the DFW rate through in-class active-learning and the analysis of errors in inked submissions. Our current focus, via a 2011NSF-TUES grant, is to motivate interest in calculus by immersing students in bioengineering and biomedical applications, and then converting ideas from these experiences, again with the help of Computer Science, into interactive touch and ink "mobile apps" for both Ipad and Android tablets. Beginning in Fall 2011 and continuing into 2013, students with STEM majors can enroll in four (1 credit hour) creative inquiry modules on epidemiology, orthopedics, heat propagation in the human body, or radiology. These modules are taken in parallel with the freshman and sophomore calculus curriculum. Students create presentations on the content in these modules which include a pedagogical component. We ask them how best to convey the information within a touch and ink environment, so as to engage and clearly convey the connection with calculus. We will present brief descriptions of each module's content, student responses and performance, and how we are developing ink and touch mobile apps with the help of students both in mathematics and computer science.

2. PROBLEM STATEMENT AND CONTEXT

The NSF has argued that to build a competitive international workforce in STEM fields, colleges and universities must inspire a greater number of students to learn a greater amount of mathematics and statistics [1]. Much research has focused on the importance of success in the

first college math course and its correlation with success in engineering, and other STEM fields [2]. Calculus is particularly noted to be a stumbling block [3]. Many incoming freshmen declare a STEM major, but know little about their declared field and know less about the applications of Calculus to any STEM field. Students are insufficiently motivated to work consistently in their Calculus courses in pursuit of vague goals and, consequently, they fail and move out of the School of Science and Engineering. Too often, this STEM-attrition scenario disproportionally involves women, under-served minorities, first-generation college students, and community-college transfer students [4]. These students may be less knowledgeable about their career options and less prepared for the rigors and pace of college mathematics. The challenge is to catch the attention of these STEM students early and offer applied learning experiences that engage them with the application of mathematics and statistics in professional practice and applied learning applications.

3. METHOD EMPLOYED

We have initiated, via an 2011 NSF TUES grant, an undergraduate applied learning project where students are impacted by the interplay of mathematical and biomedical concepts in the context of interesting applications that may help them formulate career goals while deepening their understanding of mathematics. One benefit of using medical applications is their appeal to a broad range of students. And it is also true that biomedical science and bioengineering, as well as other medical majors, are among the most popular fields for college graduates today.

3.1 The Modules

We offer four (1 credit hour) creative inquiry modules and students have the opportunity to enroll in one module per semester (up to four semesters) that is coordinated with their current or previous math course (whether pre-calculus, first semester calculus (calculus of one variable), second semester calculus (calculus of one variable II), or third semester calculus (calculus of several variables):

Module 1	Orthopedics
Module 2	Disease Epidemiology
Module 3	Health Hazards from Arc-flash
Module 4	Mammography and Radiology

Students create presentations on the content in these modules which may represent research or an innovative pedagogical approach. In some modules, students are asked to investigate how best to convey the module information within a touch and ink environment, in order to engage users while clearly conveying the calculus connection.

3.2 Interactive Mobile Apps

To disseminate the materials and ideas developed in each of these modules, we are developing "mobile apps" for both Ipad and Android tablets that use touch and ink. Instructors of the modules from Mathematics and Bioengineering work weekly with Computer Science faculty and computer science students.

Below are some images from the Module 2 App on Epidemiology. Touch enables menu selection (Figure 1), graphing sliders (Figure 2), image movement (Figure 3). Ink will allow the student to try to draw graphs that match specific parameters (Figure 4), and these graphs will be evaluated and replaced with the accurate one if necessary.

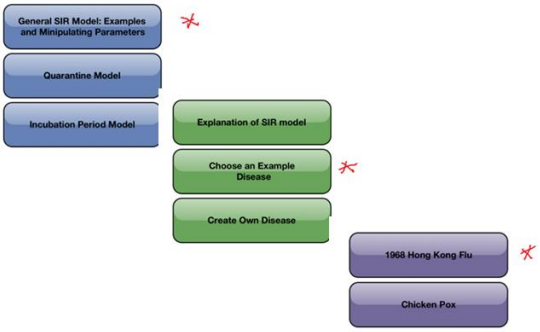

Figure 1: Epidemiology Menus

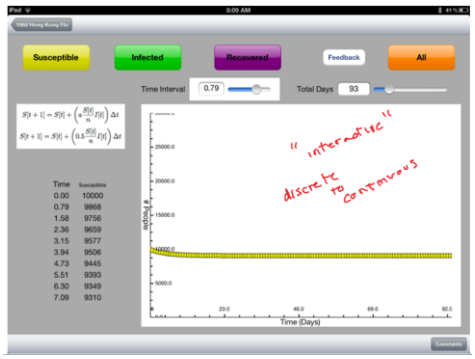

Figure 2: Graphing: Discrete to Continuous

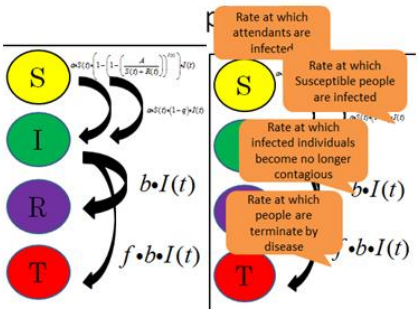

Figure 3: Model Explanation

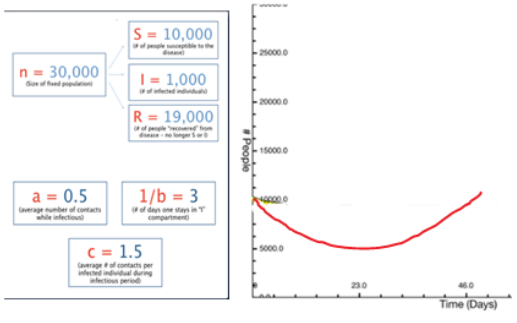

Figure 4: Parameters & Graph

3.3 Creative Inquiry Course

At Clemson University, certain courses are distinguished as "Creative Inquiry" (CI) courses. These differ from regular courses in that in CI courses students typically work on projects that impact teaching and learning, university life, the environment, cultural activities, international relations, or society in general. The development of this app is the result of such a CI course

In this course, computer science students who have successfully completed the data structures course work on development of apps. We focus on the iOS platform in fall semesters and on the Android platform in spring semesters.

The structure of the course is identical in both semesters. The first half is spent developing the students' app development skills (Objective-C, the iOS SDK and XCode in the fall semester, Java, the Android SDK, and Eclipse in the spring semester). Students work on four assignments of increasing difficulty, culminating with an app that works with an internal database using SQLite and an eternal database using MySQL. The apps access the external database using web service scripts written in PHP.

In the second half of the semester, the students work on individual projects many of which are taken from ideas proposed by faculty and staff at the university. In this manner, a small but growing cadre of Clemson students with app development skills become available for continuing the applications started in the class. Or as in the case of the epidemiology app described in this paper, student programmers are available to work on projects that emerge from funded grants.

A growing number of apps have been uploaded to the Apple App Store, five to date, and more scheduled in spring 2013. In addition two apps are scheduled to be uploaded to the Android Marketplace. All of these apps are the result of activities related to this CI course.

4. RESULTS AND EVALUATION

Over the last three semesters, the four modules have been fully enrolled. The pre- and post-module assessments verify positive changes in student perception of mathematics' importance and in their conceptual understanding of the math skills involved in these applications. We are also tracking student success in the four semester calculus sequence.

We will continue to involve students from mathematics, bioengineering, and computer science in the continued development of our first mobile app, on Epidemiology. We have used the app from this module to inspire ideas in other modules and the second app on Mammography

and Radiology is now under development. An outside evaluator in his external review of the project praised our "smooth implementation of the modules into the curriculum," commented that our multi-departmental team has "very positive dynamics," that the students are "having fun," and that "the hands-on activities used in the modules should be widely distributed via the apps."

5. FUTURE WORK

Apps will be continually updated with new touch and inking features. Other universities in the area have been motivated by our project and some may join us in the second phase of the NSF grant (e.g., Emory University; Georgia State University). We expect that the wider dissemination of these Apps will be helpful to calculus students in both high school and college.

6. REFERENCES

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[3] Ohland, M.W. & Sill, B. Identifying and removing a Calculus pre-requisite as a bottleneck in Clemson's general engineering curriculum. *Journal of Engineering Education*, Vol. 93, No. 3.

[4] Schwartz, M. Hazari, Z., & Sadler, P. (2008). Divergent Voices: Views from teachers and professors on pre-college factors that influence college science success. *Science Educator*, 17 (10, 18-35.