AC 2011-1296: INTEGRATION OF MOBILE TECHNOLOGY INTO UNDERGRADUATE ENGINEERING CURRICULUM

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Legand L. Burge, Jr. is Dean of the College of Engineering and Physical Sciences and Professor of Electrical Engineering at Tuskegee University. He received his BS, MS and PhD in Electrical Engineering from Oklahoma State University in 1972, 1973 and 1979, respectively. He has served on the faculty of George Washington University, Tuskegee, Regis College, Johns Hopkins, Bowie State University and the United States Air Force Academy, and now as dean since 1999 at Tuskegee University. In this position, he is responsible for efficient and effective operations of the College. Dean Burge brings leadership to over 700 students, 66 faculty and 21 staff members, and effective and efficient management of a modest research and development program for the College. The College continues to be a top ten producer of engineering graduates who possess the technical talent to compete in industry, governmental and academia. Dr. Burge has served on the advisory board for the National Science Foundation (NSF) Engineering Directorate, the Advisory Committee on Government Performance Assessment, Northwestern University McCormick School of Engineering, Advancing Minorities' Interests In Engineering (AMIE), Historically Black Colleges and Universities (HBCU) Council of Deans of Engineering, and the National Society of Professional Engineers (NSPE). He served as a member of the American Society of Engineering Education Engineering (ASEE) Deans' Council (EDC) as a member of the Executive Board, Public Policy Committee and the EDC Committee on Diversity; additionally, he has served as a member of the ASEE Engineering Deans Institute (EDI) Colloquium Committee, and as a member of the EDC K-12 Engineering Task Force. He continues to be an active transformational leader using his experience in national defense, academia, and the information technology industry to affect a dynamic program.

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Integration of Mobile Technology into Undergraduate Engineering Curriculum

Background

There is no question that communication has been shifted from PC/Laptop to mobile devices. As stated by ComScore [1], "Adoption rates of mobile internet services are being driven by social networking (growing at 197% each year) and mobile applications (growing at 117% each year)". In addition, the Nielsen Company [2] showed that "In February 2009, social network usage exceeded Web-based e-mail usage for the first time, and the gap is growing." Mobile devices include mobile computers (mobile internet device, personal digital assistant/enterprise digital assistant, calculator, handheld game console, portable media player), digital still cameras, digital camcorders, mobile phones, pagers, and personal navigation devices [3].

The growing rate of mobile device use has led students to expect continuous access to lecture notes, syllabi, homework assignments, library resources, campus announcements, and local and global news. However, available applications on mobile devices designed for education are limited. Kobayashi, *et al.* [4] developed and evaluated a prototype to construct a student ID (identification) system using a cell phone, which significantly reduces the cost of using the conventional student ID card. Richards [5] found that using cell phones as audience response system transmitters provided some benefits without introducing significant distractions in two civil engineering classes. Students enjoyed reporting solutions to group problems by text message and found it helpful to see how other groups responded. The instructor found that having results electronically collected and displayed sometimes facilitated better discussion. Panchul and Akopian [6] used cell phones as a platform for digital signal and image processing (DSP/DIP) education. An educational software toolbox is developed that provided an opportunity for students to use typical cell-phone data for educational purposes at any space, at any time, and in distributed environments. Nakajima and Hori [7] presented how to integrate mobile devices such as cell phones, iPod Touch and iPhone, portable game devices and other peripheral tools with an eLearning system to enhance students' mobile learning at both on and off-campus activities. Huang *et al.* [8] aimed to design a context-awareness synchronous learning system and develop a corresponding pedagogical framework using the Interactive Service Module, which enables interactions between teachers and students via short message delivery. Results indicate that the system can facilitate synchronous learning by enabling students to access lessons conveniently and efficiently from a wide variety of locations, using common mobile communication devices.

Although encouraging results were observed for integrating mobile devices into education, there are still a lot of unknown factors or even potential risks that must be seriously evaluated. For example, viruses may spread through cell phones [9] and the effectiveness of the video-based learning may be inhibited, if the material is displayed on a mobile device with a small screen [10]. The question of whether mobile devices will impact students' learning and instructors' effective teaching remains unanswered.

Objective and approach

The objective of the current study is to investigate the effectiveness of mobile technology in enhancing students' class engagement and learning outcomes, including improving students' understanding of course concepts, improving students' performance, and more efficient communication between students and instructor.

A pilot activity for integrating Blackboard Mobile Learn (BML) into an introductory level Fluid Mechanics course in the Fall semester of 2010 was undertaken. The BML can be used to provide classroom announcements, group discussions, exam solution keys, grades, blogs, class roster, journals, media, and tasks. The BML was used in the classroom when the instructor interacted with the students during the lecture time such as review of homework and exams and use of images and video clips to enhance students' understanding of course concepts. Outside the regular class time, students can use the BML as their portable 24/7 classroom with on-time access to course materials and tools.

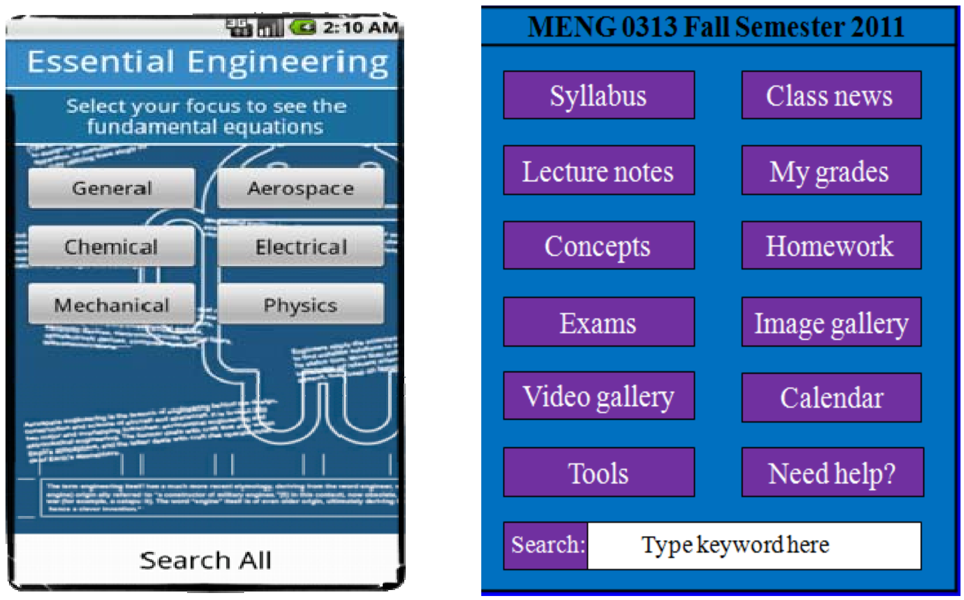
Development and implementation

This study is supported by a project that started 1.5 years ago. On May 14, 2010, "Mobile technology pilot status and reporting" was presented by the leading author in the "College of Engineering, Architecture and Physical Sciences (CEAPS) Workshop: Curriculum Development: Sustainable Development, Concepts for a New Administration, Curriculum and Technology." The presentation reviewed the benefits of using mobile technologies, evaluated advantages and disadvantages of iPhone versus Motorola Droid, developed a preliminary mobile phone application interface for the College (Figure 1a), developed a general interface for a mechanical engineering course (Figure 1b), and discussed the issues and challenges. Table 1 summarizes the main advantages and disadvantages of using iPhone and Android based on evaluations in early 2010. With the fast development of IT technology such as the recent release of CDMA version iPhone 4 by Verizon in 2011, new evaluation needs to be conducted. Overall, both devices have unpredictable potentials to be used for improving higher education.

Table 1. Evaluation of iPhone (AT&T) and Android (Verizon)*

Mobile device	iPhone on AT&T	Android on Verizon
Advantages	1. Operating system is developed 2. Accurate touch screen 3. Quality of Apple Application store is higher	1. Far superior network 2. Very responsive QWERTY keyboard 3. Application development is open with sufficient online support provided by Google
Disadvantages	1. Less robust network 2. Application development is not open	1. Operating system is developing 2. Not very accurate touch screen 3. Applications are not as diversified as Apple Store

* evaluated early 2010



(a) (b)

Figure 1. Design of the interface for new Mobile technology application: (a) interface for the whole College of Engineering and Physical Sciences, (b) interface for individual courses.

To expose students to mobile technologies at the beginning of their study, each of the 27 freshman students were given a Motorola Droid On June 9, 2010. Seven application classes enabled students to experience latest mobile device functions, try selected educational applications, and learn how to develop those applications following simple tutorials on their own laptops.

In the Fall semester of 2010, BML was implemented in an introductory level fluid mechanics course in the College. The IT department of Tuskegee University set up a mobile Blackboard environment for this course so that students can access both web-based Blackboard and BML to facilitate comparisons. A representative from Blackboard Inc. helped the instructor to set up usernames and passwords for all students and resolved some technical problems on downloading and running BML on different platforms since students' personal mobile devices differ significantly from each other. Before the instructor gave each lecture, he informed students on any updates on the BML and help students to resolve any problems they may have. Students went through the BML materials with the instructor together in class briefly. Students can access the electronic lecture notes, announcements, syllabus, and assignments with due dates. Due to the difficulties of setting up the mobile technology environment, other functions in the BML were not used but planned for the Spring semester of 2011.

Evaluation and assessment

The objectives and relevant course concepts are listed in Table 2. Evaluation and assessment were conducted based on instructor perceptions, two surveys, and ABET learning outcomes. The instructor observed increased student interest in using the BML and they were eager to experience more.

Table 2. Objectives and relevant course concepts[Φ]

Objectives (Students will)	Concepts
1. be familiar with the properties and behavior of liquids and gases, classification of various types of flows, and understand the basic concepts of boundary layer and its importance in fluid mechanics	1. Properties and behavior of fluids, boundary layer
2. be familiar with the hydrostatic equation and its application to engineering problems	2. Fluid statics
3. be familiar with the Bernoulli equation and its application to flow measuring devices such as Pitot tube and Venturi meter, and to solve engineering problems	3. Elementary fluid dynamics – The Bernoulli equation
4. be familiar with the velocity field, acceleration field, control volume and system representations, and the Reynolds Transport Theorem	4. Fluid kinematics
5. understand the four basic principles of fluid mechanics: continuity equation, momentum equation, and energy equations, and their application to engineering problems	5. Finite control volume analysis
	6. Differential analysis of fluid flow
6. understand dimensional analysis and be able to use non-dimensional parameters in solving fluid flow problems, and do similitude and modeling in fluid mechanics	7. Similitude, dimensional analysis, and modeling
7. be familiar with the laminar and turbulent pipe flows and used Moody chart to compute head loss.	8. Viscous flow in pipes

[Φ] All objectives and concepts are closely related to ABET learning outcomes "a" and "e."

The 1st survey asked students to evaluate their own learning outcomes on how well they thought that they had understood the course concepts listed in Table 2 using a scale including "1" for "Definitely do not understand," "2" for "Generally do not understand," "3" for "Somewhat understand," "4" for "Moderately understand," and "5" for "Highly understand." The average of students' grading for each concept indicates their confidence understanding the concept and is shown in Figure 2. A separated evaluation for those concepts were conducted by the instructor using students' grades on homework and exams. The teacher's grading for each concept is also shown in Figure 2. Comparison between the two grades shows that: (1) overall the instructor's grades agree reasonably with students' own grading with relative difference less than 11% for all concepts except for Concepts 4, 6 and 7; (2) the largest difference is for Concept 4 where instructor grading is 24.4% higher than the student grading. This is due to the abstractness of this concept. Students can solve the problems correctly but they didn't feel that they really understand the concept very well; (3) the second largest difference is for Concept 7 with students' grading 19.2% higher. This is partly due to the limited time the instructor spent on this concept. It is also possible due to the insufficient explanation on laminar vs. turbulent and inviscid vs. viscous flows; (4) Students' grading for Concept 6 is 12.3% higher than the instructors' grading. It suggests that students felt that you can do the dimensional analysis and similitude but they could easily make mistakes during their derivations and calculations.

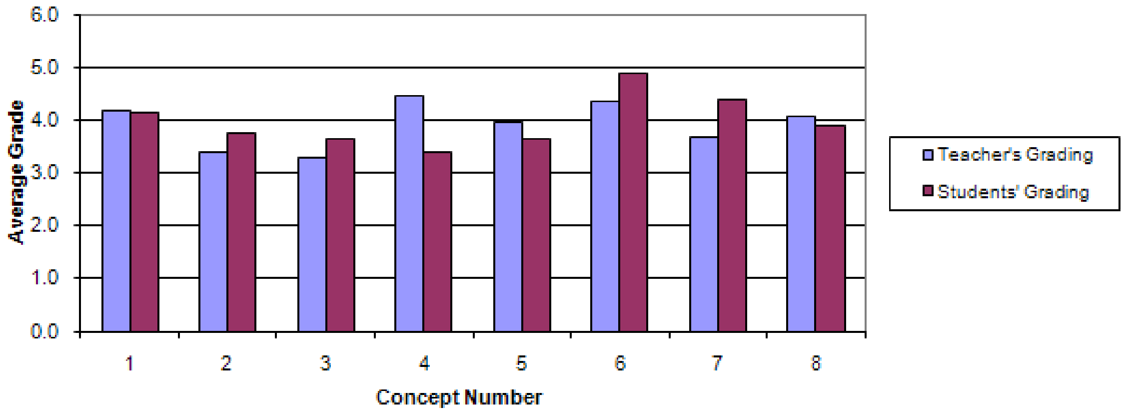


Figure 2. Evaluation of learning outcomes for MENG 0313 for Fall 2010

The 2nd survey has 9 evaluation questions on students experience of using BML. The survey was given to the 8 students enrolled in the course who are all living on-campus. Students were asked to evaluate each statement from Strongly agree (10) to Neutral (5) and Strongly disagree (0). The survey questions are listed below with averages for the survey questions shown in Figure 3.

1. BML has enhanced my engagement and learning
2. I like the BML interface
3. I prefer to use BML than use web-based Blackboard
4. I would like to use BML for all my courses
5. I like the handy grades
6. I like the electronic lecture notes
7. I liked handy assignments with due dates
8. I like announcements and class news are helpful
9. I like the handy syllabus

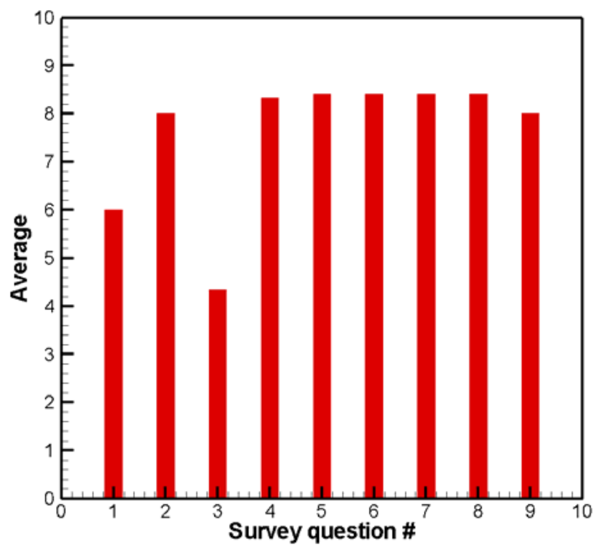


Figure 3. Results for survey questions

Overall, student feedback on using BML for their learning is quite positive, especially the handy and electronic lecture notes, handy assignments and grades, and real-time class announcements, etc. However, due to the difficulties on setting up the BML for the course, students did not have enough time to use the BML in their learning such that they were not sure if the use BML enhanced their engagement and learning (Survey statement 1). The lowest evaluation is for Survey statement 3 for which students don't agree that BML can replace the web-based Blackboard that has been used in this class for the whole semester. Additionally, student suggested to have a new function that will enable the real-time communication between students and instructor using text messages. They also did not like using a single interface of BML for all courses. They prefer to use customized interfaces for different disciplines so the use of the mobile device application can be more efficient and straightforward. It should be noted that the sample population for students was small. A much larger student size and a full-semester experience of BML are needed to draw any general conclusions.

New evaluation and assessment is undertaken for Spring 2011, especially for statements 1 and 3 of the 2nd survey. The number of students in this class is doubled (16). In addition to the survey statements presented above, a more comprehensive evaluations will be conducted on evaluating different course concepts, students' performance on homework and exams. The evaluation results will be compared with the results without using the BML.

Development of new mobile phone applications

In order to use more user-friendly and disciplinary-based interfaces for different courses, the new application shown in Figure 1b will be developed. The new application will be implemented in the same course in Fall 2011 or Spring 2012 as an alternative for students. Students' feedback and suggestions will be used to improve the application before it is extended to other courses/laboratories in the College of Engineering and Physical Sciences. The interface was designed to be as general as possible such that it will mitigate the steep learning curve and in the mean time provide faculty enough flexibility to add course–specific materials. Students will be strongly encouraged to participate in the development of mobile phone applications, especially in the design of the interface. Their involvement in this process will be fostered through competition between different student groups.

Challenges and issues

There are some challenges and unresolved issues on integration of mobile technology into undergraduate curriculum. The authors of this paper are faculty specializing in mechanical or electrical engineering. Development of a robust and bug-free mobile phone application needs collaboration with people specialized in computer science. Staff and support infrastructure, including information technology capacity and support systems are enhanced through supporting environments. As the project moves forward, faculty are suggesting the following inquiry: Should we prepare students to be only users or both users and developers? How to handle appropriately the copyright related issues for the video clips and pictures in the gallery? How to capture intellectual property related to innovative developments?

Conclusions and future work

A preliminary study on incorporating mobile phone into undergraduate engineering curriculum is conducted using a commercial software Blackboard Mobile Learn (BML). The application may be used in the classroom when the instructors interact with their students during the lecture time such as review of homework and exams and use of images and video clips to enhance students' understanding of course concepts. Outside the regular class time, students will use the applications as their portable 24/7 classroom with on-time access to course materials and tools. The effectiveness of using BML was evaluated and assessed by instructor perceptions, two surveys, and ABET learning outcomes. Overall students like handy lecture notes, grades, assignments, and announcements. But students didn't have enough exposure to BML such that they are not sure if the use of BML has enhanced their engagement and learning. They seem to disagree with the statement that BML will replace the web-based Blackboard in the future.

Future work includes: (1) more BML functions will be used and evaluated for 16 students for the whole 2011 Spring semester, (2) a new application with customized interface will be developed, implemented, and evaluated for the same course in Fall 2011 or Spring 2012, and (3) evaluation and assessment will be conducted by comparing students' learning outcomes with and without using BML and the new application.

The integration of mobile technology is to enhance NOT replace the current traditional teaching. The successful use of user-friendly applications is expected to increase students' engagement, enhance students' understanding of course concepts, improve students' performance, and provide real-time interactions between students and instructors.

Acknowledgement

The contents of this poster were developed under a Congressionally-directed grant from the U.S. Department of Education. However, those contents do not necessarily represent the policy of the U.S. Department of Education, and you should not assume endorsement by the Federal Government. The authors are grateful to Mr. Chris Guzek from Blackboard Inc. on enabling this pilot study. The support from the IT department of Tuskegee University is also appreciated.

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