PROMOTING STEM EDUCATION THROUGH MOBILE TEACHING AND LEARNING

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ABSTRACT

The recruitment and retention of more students, especially women and minority students, into science, technology, engineering and mathematics (STEM) programs is a critical need in technologically advanced countries like the U.S. as there is expected to be shortage of qualified STEM graduates in the future. Educators have to find new ways to interest and engage current generation of students in STEM programs, and the recent advancements in mobile teaching and learning offer promise in this regard. In this paper, the unique needs that STEM courses pose with respect to teaching and learning are identified, and the opportunities that mobile teaching and learning offer to meet those needs are discussed. Mobile teaching and learning is proposed as a solution for recruiting and retaining students in STEM programs and meeting the needs of technologically advanced countries such as the U.S.

1. INTRODUCTION

Stagnating student enrollment in science, technology, engineering and mathematics (STEM) degree programs has been a concern in technologically advanced nations, especially in the U.S. (Hall et al., 2011). The need for scientists and engineers is predicted to be even greater in the coming decades as the number of qualified science and engineering graduates may not be sufficient to fill industry's needs. The lack of increase in enrollment by women and underrepresented groups in STEM programs is also a concern (Burke & Mattis, 2007). As societal factors often contribute to the lack of participation of women and underrepresented groups in STEM programs, especially in the U.S. compared to developing countries, the concern warrants innovative solutions. These concerns could be addressed by exploring teaching strategies and the use of instructional technologies in STEM fields, and finding new ways to meet the needs.

Teaching strategies and technology integration in STEM classrooms continue to follow traditional approaches in the U.S. This is somewhat due to the unique needs of STEM fields and the experience and expertise of faculty teaching in those fields. However, failing to adopt more modern teaching methods and integrate current technology could be contributing to the lack of increase in enrollment and the participation of women and underrepresented groups in STEM programs. The growth in the use of mobile devices among school and college students and the recent innovations in mobile technologies provide opportunities to promote STEM education through mobile teaching and learning.

2. STEM EDUCATION NEEDS

Along with the common educational needs of any field, STEM programs place some additional demands related to course content, delivery, interaction, and assessment on faculty.

a. Delivery strategies – STEM faculty often utilize traditional approaches to teaching, including lectures, due to the need for conveying theory and background information, which students may not generally be inclined to read and learn on their own. The traditional approach to teaching in STEM fields may also be partly due to the way faculty themselves learned when they were students, and as a result, tend to use the same approaches when they teach.

b. Mastering the fundamentals – Courses in STEM fields require mastering theory and fundamentals first before moving onto advanced courses. Therefore, it is critical to engage students in the introductory courses and help them relate to the course topics so that they can be successful in their chosen STEM majors.

c. Experimentation – The ability to conduct experiments in a laboratory or practical setting is one of the critical needs of STEM fields. Such laboratory work often involves setting up and calibrating instruments, following safety procedures, conducting experiments, collecting data, and analyzing data.

d. Team work – Team work is one of the top two needed skills by employers in STEM fields, and students are expected to work in teams in STEM courses to complete course projects and assignments (National Association of Colleges and Employers, 2012).

e. Communication – Communication is the other top needed skill mentioned by employers and communication in STEM fields includes writing and presenting technical information. Students are also expected to work in teams to write and present project reports.

f. Research – In STEM courses, students are expected to explore past work on a particular problem before proposing new or better solutions, research information on equipment and materials necessary for conducting laboratory experiments, and look up standards and data sheets for solving problems.

g. Symbols, drawing and visualization – Students as well as faculty in STEM courses need the tools to type or write mathematical and scientific notations, draw charts and diagrams, and visualize images in multiple dimensions. This ability is needed for developing and delivering content as well as for interactions between faculty and students and among students.

h. Testing and assessment – Assessing student learning in STEM fields requires more than multiple choice or fill-in the blank tests. Such tests may be necessary to demonstrate comprehension of background information but are not sufficient to demonstrate problem-solving skills. It is more important to be able to assess students' ability to conceptualize and solve problems. In some cases, demonstrating the problem-solving process is more critical than reaching the final answer.

The above mentioned teaching and learning needs of STEM disciplines must be addressed in order to make any meaningful impact on student recruitment and retention, and to introduce any new pedagogical techniques or instructional technologies.

3. MOBILE TEACHING AND LEARNING IN STEM PROGRAMS

Mobile teaching and learning provide unique opportunities for addressing many of the STEM education needs (Roshan, 2011). Corporations are also recognizing these opportunities (Verizon, 2012). As mobile devices become prevalent and affordable, more educational innovations are being introduced. Devices for mobile learning are not limited to smart phones but also include personal response systems (clickers), tablets, e-readers, and more.

Mastering the fundamentals is a challenge in STEM fields. Some students find the introductory courses boring and do not recognize their relevance to learning advanced topics. As a result, these students may become discouraged and disconnected. Some may drop out or change majors. What is needed is a way to reach students, make content more engaging, and motivate them to spend time on learning. Mobile technologies are a potential solution. By extending online technologies, students can access course materials easily through their mobile devices. Numerous online tutorials are available for learning foundational concepts in STEM fields. By making sure that those tutorials are mobile-compatible, students can be encouraged to access such educational materials through their mobile devices. More so than desktop workstations, mobile devices can infuse game mechanics into learning which can be more motivating. In addition, students can collaborate with one another using mobile devices.

Delivering content through mobile technologies can be accomplished in many ways that engage students and increase learning. For example, faculty can deliver lectures using synchronous methods using learning management systems such as Blackboard Collaborate™, and students can participate on their mobile devices. Faculty can also embed videos and problem solving steps in their mobile lectures. Figure 1 shows a sample of a mobile lecture through Blackboard Collaborate. Lectures can also be recorded and delivered asynchronously, which allows students to watch them repeatedly, until they feel comfortable with the content. This is an obvious advantage over face-to-face STEM classrooms. In some developing countries, course lectures are even delivered as audio files through smart phones on a weekly-basis.

There are many opportunities to use mobile technologies to enhance or replace STEM experiments and laboratory work. While not all experiments and laboratory work could be accomplished through mobile technologies, some could be conducted with smartphones or tablets. There are portable lab kits available for some disciplines to conduct all the laboratory experiments at students' homes (Jaanus et al., 2007). Some universities have also designed experiments that students can conduct by interfacing with the experimental setup online or through mobile devices. For example, see: http://www.vlab.co.in/. The possibility of conducting laboratory experiments through mobile technologies diminishes the need for students to be present in a particular location to complete laboratory exercises. This can make STEM courses accessible to more students.

Many of today's students prefer texting and chatting compared to email or asynchronous discussion boards. Therefore, mobile technologies are ideal for communication and teamwork. Students can interact with each other using text, chat, and video conferencing through Skype™ and other similar apps. They can also record and share their individual work with each other, post their work on a course site, or collaborate on course wikis through their mobile devices.

In STEM courses, students need to be able to search for information on equipment and materials, look up safety data sheets, and search library databases for past work on a particular topic. All of these tasks can be accomplished through mobile technologies. Many STEM publishers, such as EBSCO (http://www.ebscohost.com/academic/mobile-access), have made their journal databases mobile-friendly. The voice-command features available on some smartphones make it easy for students to look up information while working on experiments.

Typing mathematical symbols and scientific notations is time consuming on a desktop computer. However, there are numerous mobile apps that make the process easier. There are also apps for drawing charts, graphs, and diagrams. Other apps, like ShowMe™ (see Figure 2), allow users to handwrite content while simultaneously recording narration. These tutorials can be shared with students for multimedia lectures. The photo and video capabilities of mobile devices also offers unique opportunities for visualization, augmented reality, and constructing new knowledge

Figure 1. Screen capture of Blackboard Collaborate™ mobile lecture

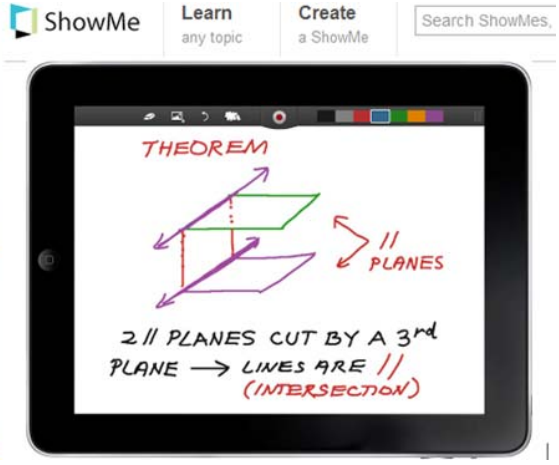

Figure 2. Screen capture of a ShowMe™ mobile app lecture

It is already challenging to test problem-solving skills in STEM courses because of the need to have students demonstrate the problem-solving process rather than just state the final answer. Students can respond to online tests and quizzes with multiple choice questions or brief answers. However, on a tablet or smartphone, students can demonstrate the problem-solving process by handwriting step-by-step answers with scientific notations, mathematical symbols, charts, and graphs, and then submit electronically. Another advantage of using mobile technologies for testing is that students can record audio explanations of their problem-solving process and submit them with the solutions..

Mobile technologies also bring additional advantages to STEM education with respect to diversity and students with disabilities. Women and underrepresented students are often in the minority in mathematics, technology and engineering courses, especially in the U.S. As a result, many are hesitant to speak in class or

interact with their professors. Students with disabilities may also feel marginalized and are reluctant to engage in face-to-face classrooms. However, the same students may feel empowered to communicate freely using mobile technologies as their identities are masked by the communication technologies.

Finally, the key to successfully implementing mobile teaching and learning in STEM courses is faculty members' willingness to explore new ways of teaching and learning. They must experiment with technology and methods to transform their courses in incremental steps. This requires that academic institutions promote mobile teaching and learning by training faculty and establishing the necessary infrastructure (Krishnamurthi & Richter, 2012).

4. CONCLUSIONS

Mobile teaching and learning offers new possibilities for enhancing STEM education, retaining students, and recruiting students from underrepresented groups, especially in the U.S. There are numerous inexpensive or even free mobile teaching and learning resources available that can make teaching and learning science, mathematics, technology and engineering courses more interesting and engaging than traditional face-to-face approaches. Mobile technologies may empower women and students from other underrepresented groups to interact more and engage in STEM courses.

Faculty should rethink their traditional approach to teaching STEM courses and explore more online and mobile technologies to meet the learning needs of the current generation of students. Faculty can experiment with adding mobile learning components incrementally to their STEM courses. As faculty feel comfortable to explore mobile teaching and learning techniques in their courses, students' attitude towards STEM fields may also change. As a result, more students may choose or continue with STEM majors, which will help meet society's needs for qualified STEM graduates in the future.

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