Prospective Use of Web 2.0 Technologies in Promoting Mathematics Education in the United States

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Abstract: Technology has been considered as an important principle in the NCTM Principles and Standards for School Mathematics in the United States. The emergence of Web 2.0 technologies provides another avenue for the effective use of technology in the teaching and learning of mathematics. Additionally, studies have found that American students spend more time with Web 2.0 applications than any other age group. Thus, Web 2.0 technologies that allow Internet users to collaborate and share web information actively (O'Reilly, 2005) have a great potential to promote teaching and learning mathematics. This, paper focuses on the current states of mathematics education in the U.S.; the effect of technology on U.S. mathematics education; and a prospective way to use a Web 2.0 technology in promoting mathematics education in the United States.

Introduction

Technology has been included as an important principle in the National Council of Teachers of Mathematics (NCTM) Principles and Standards for School Mathematics in the United States (NCTM, 2000). Highlighting the importance of technology in teaching-learning mathematics, *Principles and Standards* encourages teachers and students to use technology to broaden and deepen their mathematics understanding. The technology principle states that technology is a tool that can enhance teaching-learning mathematics. NCTM (2000) notes, "When technological tools are available, students can focus on decision making, reflection, reasoning, and problem solving" (p. 24). They recommend, "in mathematics-instruction programs, technology should be used widely and responsibly, with the goal of enriching students' learning of mathematics" (p.25). According to *Principles and Standards*, with appropriate use of technology students can better understand the underlying meaning of mathematics and learn mathematics more easily. Technology can enrich students' range and quality of mathematical investigations by providing a means for viewing mathematical ideas from multiple perspectives (NCTM, 2000).

Meanwhile, the emergence of Web 2.0 technologies is receiving intense and growing interest across many sectors of the education industry for addressing the needs of today's diverse students (Alexander, 2006; Allen, 2008; Lee & Ge, 2010; McLoughlin & Lee, 2008). In the fields of law, business, communication, and politics users have been grappling with advanced features of Web 2.0 tools for at least several years (Lemley & Burnham, 2009). Thus, the possibility exists to motivate today's technologically advanced American students and teachers in using the interactive features of Web 2.0 technologies to create and join in many virtual platforms where they can enrich their mathematical knowledge and understanding by posting mathematical problems and quizzes; providing solutions to problems posted by others; and sharing their thinking in solving and creating mathematics problems. Such activities may change the lackluster attitudes toward learning mathematics held by many American students who are more willing to spend their time on social networking sites than practicing mathematics. This may improve their performance on national and international mathematics assessments. More importantly, this technology might provide a way of learning and understanding mathematics for students enrolled in schools and districts that cannot afford costly mathematical software and updates.

Statement of the Problem

The advancement of Web 2.0 technologies and their access through laptops, netbooks, iPads, iPhones, and handheld cellular devices has made a radical change in the lifestyles of young students in the United States and worldwide. Young students spend more time using computers, the Internet, and mobile phones than any other age group, with most of that time being spent on social network sites (Clark, Logan, Luckin, Mee, & Oliver, 2009; Lenhart & Madden, 2009; Selouani & Hamam, 2007). Text messaging, blogging, online discussion groups, social networking sites, and other Web 2.0 tools and applications have become integral parts of their lives (Baker, Wentz, & Woods, 2010). These young students are arriving in high schools, colleges, and universities having multitasking operation skills in blogging, podcasting, tweeting, and other Web 2.0 applications. Due to their inclination to the Web 2.0 technologies, mathematics instruction in the traditional static mode might not be sufficient to meet their needs (Hossain & Wiest, 2011a, 2011b).

Moreover, due to the rapid growth of the Internet and mobile web usage, the high costs of mathematics teaching-learning software, and the challenges of traditional and Web-based online classes, free and available Web 2.0 applications may provide a means for improving the teaching and learning of mathematics. A blog is a standard example of Web 2.0 applications (Maddux, Liu, & Johnson, 2008) that is free and relatively easy, fast, and requires only basic computing knowledge (Solomon & Schrum, 2007). Due to the rapid growth of the Internet and mobile web usage, it is expected that blogs will be one of the fastest growing Web 2.0 applications for mobile Internet users over the next few years (Kairer, 2009). Thus, a blog could be an appropriate tool to evaluate the possible usage of other Web 2.0 technologies. Therefore, the basic rationale of this paper is to present a Web 2.0-based collaborative model that can be used to promote the teaching and learning of mathematics in the United States.

Effect of Technology on U.S. Mathematics Education

In the United States, technology has been a powerful tool in the mathematics classroom for several decades. Technology is one of the six principles stated in the NCTM (2000) Principles and Standards for School Mathematics (Garofalo, Drier, Harper, Timmerman, & Shockey, 2000). The NCTM (2000) recommends the appropriate and integrated use of technology in every aspect of mathematics education from what is taught in mathematics; how mathematics is taught and learned; and how mathematics is assessed (Powers & Blubaugh, 2005). Technology is playing an increasingly important role in teaching-learning mathematics at all levels in the U.S. U.S. schools and mathematics classrooms are equipped with advanced technological tools including sufficient number of computers, projectors, smart-boards, graphical calculators, etc. (Garofalo et al., 2000). Standalone software, Computer-Based Instruction (CBI), and web-based interactive applets have served to enrich the mathematics classroom.. Mathematical programs or tools that are widely used in U.S. mathematics classrooms include Terrapin Logo, Geometer's Sketchpad, Fathom, My Mathematical Life, Math Arena Advanced, Data Explorer, TI-84 Graphing, and Explorer Calculators (Garofalo et al., 2000).

These technological tools assist teachers and students in the collection, recording, organization, and analysis of paper-based data into electronic form, aiding the teaching and learning of mathematics (Kimmins, 1995). Technological tools also provide convenient, accurate and dynamic graphing, drawing, and enhanced computational power. Use of these tools is expected to extend the range and quality of student investigations and allow them to encounter mathematical ideas in more realistic settings. More categorically, it is expected that the above mathematical programs will aid in teaching-learning mathematics in the following four ways: (1) mathematical concept and skill development, (2) mathematical problem solving, (3) mathematical reasoning and proof, and (4) mathematical communication (Kimmins, 1995; Kimmins & Bouldin, 2009).

The Standards for Mathematical Practice of the Common Core State Standards Initiative [CCSSI] stress the importance of helping students persevere in the problem solving process (CCSSI, 2010). The use of web-based forums on the Internet is expected to enable mathematics students and teachers to discuss mathematical problems and to work collaboratively (Kimmins & Bouldin, 2009). In this way, the interest generated by online interaction could provide the motivation necessary to increase the level of perseverance of students engaged in the problem solving process. Additionally, the CCSSI emphasize the importance of constructing arguments and critiquing arguments developed by others (CCSSI, 2010). Clearly, online interaction among students on blogging sites can provide a forum for these types of activities. Thus, in a variety of ways, web-based activities may play an important role as educators across the country attempt to implement the Common Core State Standards.

Unfortunately, technology has not reached its full potential in many mathematics education programs in the United States (Gunter, 2001; Kurz & Middleton, 2006). Many prospective mathematics teachers' views on the role of technology in mathematics education is not satisfactory (Habre & Grunmeier, 2007). Habre and Grunmeier (2007), found that prospective mathematics teachers believe that mathematics teachers should use technology to help teach students mathematics in mathematics classrooms; and that mathematics and not technology should remain the focus of instruction in mathematics classrooms. However, many of these preservice teachers believe that in many mathematics classrooms technology is used improperly in ways that focus more on the technology than on mathematical understanding or calculation (Habre & Grunmeier, 2007). For instance, in an experiment if students are shown tessellations of a plane using a web-based Java applet many participants may skip the mathematical knowledge behind the tessellation, as a Java applet may not show the mathematical calculation behind it (Habre & Grunmeier, 2007).

The use of computers for instructional purposes still lags behind the integration of technology in the corporate world and is not used as frequently or effectively as is needed (Powers & Blubaugh, 2005). Many newly graduated preservice mathematics teachers do not have sufficient experience in the use of computers in teaching-learning processes (Kurz & Middleton, 2006). In a study conducted by K. B. Smith & Shotsberger (2001), most preservice mathematics teachers identify technology as important in education; however, due to lack of knowledge, some of them are uncomfortable discussing the specific use of technology for instruction. Many preservice mathematics teachers feel that after graduation they might not be well prepared to teach with technology in their classrooms (Carlson & Gooden, 1999; Terri, 2011).

How to Use Web 2.0 Technologies in Promoting U.S. Mathematics Education

Over the past decades, many mathematicians, mathematics educators, and researchers have practiced and developed web-based and web-assisted mathematics and mathematics education courses (Thomas & Li, 2008). Web-based Virtual Learning Environments (VLEs) such as Web CT, Blackboard, and eCollege are well-known programs that have been developed to provide online mathematics courses (Engelbrecht & Harding, 2004). Although, using full functionalities of Web 1.0 technology, WebCT allows faculty members to manage and control online courses easier than others (Lu, Yu, & Liu, 2003; Wernet, Olliges, & Delicath, 2000). Several important problems have been identified that highlighted the limitations of using Web 1.0 technologies in mathematics courses. While the WebCT discussion forum provides the means to decrease many of these limitations of traditional online systems and increase students' critical thinking for such discourse, students still lack the intellectual maturity and experience necessary for true collaboration (Thomas & Li, 2008). Many students and even teachers face problems retrieving and uploading course content from home and/or school computers simultaneously in the WebCT environment (Respondus Inc, 2003).

Other notable limitations of WebCT classes are that WebCT courses are provided only through the use of supporting tools and technologies that require additional cost, installation, and support in both school and home computers that may have different configurations, operating systems, and security setups (Thomas & Li, 2008). Moreover, students' and instructors' access to a WebCT class is limited to the semester or class offering time only. Once the class or semester is over students no longer have access to the WebCT system. Thus, they cannot go back to the discussions, emails, or any course content unless they have previously saved them. WebCT programs need technology savvy instructors that are sometimes unavailable or unaffordable to the schools in the rural school districts or in developing or underdeveloped countries.

The problems and challenges of traditional and WebCT-based online classes, associated with the limitations of Web 1.0 technologies, call for the use of Web 2.0 technologies in the teaching and learning of mathematics. According to Baker, Wentz, and Woods (2010), one technology that has the potential to engage students in online interaction is the use of virtual worlds, or multiuser virtual environments. As Web 2.0 tools allow end users to create Web content from text based web pages and online journals to visual format, Web 2.0 could provide appropriate technologies to create such multiuser virtual environments. As Web 2.0 facilitates a relatively quick communicative exchange between individuals who are geographically or temporally distant (Hodson, 2008) it could lead to new dimensions that could enhance mathematics education.

A blog is one of the simplest tools Web 2.0 technologies can offer, but it is capable of providing unlimited possibilities for building collaborative teaching-learning environments in mathematics education. According to IDC's expectation, over the next few years, creating blogs will be one of the fastest growing applications for mobile

Internet users (Kairer, 2009). Blogs promote reflective practice as well as collaboration and social interaction among users (B. B. Ray & Hocutt, 2006). As a collaboration and communication tool, educators can use blogs to post announcements for students and parents; students can build their portfolios and digital diaries; and students can share their reflections with others and plan for new projects (J. Ray, 2006). This may benefit students by allowing them to become "engaged as subject matter experts, motivated as owners of their own learning, involved in a community of practice, and exposed to diverse perspectives" (Norton & Hathaway, 2008). Blogs can be used as the means of obtaining or outsourcing solutions of quizzes, fallacies, and various mathematical problems students need to know to be prepared for competitive tests.

To initiate a new blog on a topic, teachers first need to form small groups of students to work together on specific topics. For instance, a middle or high school geometry teacher might form several study groups for discussing important or sophisticated topics that he or she wants to explore more extensively so that students can clarify and deepen their understanding. Hossain and Aydin (2011) call these *iGroups* to reflect the interactive and dynamic nature of working together using Web 2.0 technologies such as blogs, wikis, and podcasts. An iGroup may continue to discuss a topic long after the topic or semester is finished. Students may be more motivated to join and study in such an iGroup if they are using a blog or other new technology instead of simply writing on paper (Solomon & Schrum, 2007). If someone outside the class requests to be a member of an iGroup, teachers can add or reject the request based on the nature of the activity.

Web 2.0-Based Collaborative Models for Mathematics Classrooms

There are several ways of using Web 2.0 tools and technologies to foster mathematics education in k-12 schools, colleges, and universities. Hossain and Wiest (2011a) describe a model to use a blogging activity for building a collaborative teaching-learning environment for a high school geometry class in which the teacher wants to give more focus on geometric shapes and their measurement. Hossain and Wiest (2011b) also discuss another model for using a blogging activity for a middle school geometry class in which the teacher wants to explore common and unique characteristics of different types of quadrilaterals. In their models they suggest dividing the class into several iGroups, and running the activities under the supervision of the class teacher. Hossain and Wiest (2011a, 2011b) claim their models require several phases; and each phase might take several days to weeks.

Based on Hossain and Wiest's (2011a, 2011b) models, the following adaptation of a Web 2.0-based model for building a collaborative environment in teaching-learning mathematics should be considered. This model might be appropriate for any mathematics class from middle school or high school to any higher level. This model could provide an excellent way to help students discuss and explore various topics of algebra, geometry, and calculus or any area of mathematics. This activity also runs under the supervision of a class teacher who will initiate the process and supervise the entire activity. Before starting, the teacher will select some topics that s/he wants to cover in the activity; and divide the class into several iGroups and assign a name to each of the iGroups. An individual topic is assigned to each of the iGroups. Then the teacher will create a blog on a free blog-publishing service such as on Edmodo or WordPress and invite the iGroup members to participate in the activity. Then the teacher will post a discussion and an assignment with a problem set relevant to the topic on the blog. The designated iGroup members will be asked to post complete solutions of the problems by the assigned due date. Other group members will also be asked to read and substantiate the posted solutions by the same or next due date.

Based on the nature and depth of the topic, the teacher will allocate two or three weeks to complete each phase. For instance, the teacher might post a problem set on the blog. Students of the relevant group might be given ten days to post complete solutions to two problems each. Then the entire class might have five days to substantiate and comment on the solutions. Now the assigned group has the chance to revise, correct, or update their previous responses. By this time, every student in the class will have had the opportunity to read and comment on their own and other classmates' responses. The teacher might further discuss particularly efficient or creative solutions in class. Thus, in a two- to three-week period the teacher can orchestrate discussion of a topic with active participation of the entire class.

Similarly, at some point during another topic or chapter, the teacher can start another phase of the blogging activity for a different group by posting a discussion and a problem set in the same fashion discussed above. During this blogging activity, students are expected to verify their conjectures about various mathematics topics, and to share, justify, and critique problem solutions. They might develop broader, class-inclusive thinking, as well as enhanced collaboration skills. For example, upon reading and comparing the findings, students might notice that rectangles have congruent diagonals that bisect each other and rhombuses have diagonals that bisect each other perpendicularly. Once a student learns something new or important and posts that information on the blog, other

members can investigate the idea further in order to substantiate it. Students are likely to learn new ways of looking at concepts and solving problems. Thus, once group members explore an idea or strategy and publish it on the blog, it is anticipated that all or most participants will personally acquire and retain the concepts discussed.

Conclusions

Blogs, podcasts, wikis, facebook, and similar interactive Web 2.0 tools are already being adopted in the fields of technology, engineering, business, language, journalism, and the medical sciences. These tools have open and free access to all. As many sectors in education settings increasingly use Web 2.0 tools, the time has come to think about providing preservice K-12 mathematics teachers with ways in which these tools might support classroom teaching and learning. There is a potential that Web 2.0 tools can be implemented alone or in conjunction with one another to create collaborative teaching-learning of middle and high school mathematics classes. The interactive and emerging features of the blog and other Web 2.0 technologies can enable middle and high school students and mathematics teachers to build collaborative learning environments inside and outside of the classroom and in so doing improve the quality of mathematics instruction being provided.

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