

Mobile math: math educators and students engage in mobile learning

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Abstract The public and educational communities are aware of the continuing crisis in math education in our middle schools and the convergence of technologies for teaching and learning. This paper presents a case study in which iPod Touch[®] was used to help middle school students learn about algebraic equations and, in particular, the concept of slope, absolute value, and elimination. The development of math movies for use on the iPod Touch provided students with a mobile means of informal math learning beyond the hours of the classroom. While the study explored the use of mobile devices in an eighth grade math classroom, the lessons learned are invaluable to those seeking to implement mobile technologies to support teaching and learning with typical software, such as iMovie, PowerPoint, and iTunes[®].

Keywords iPods · iPod touch · Math education · Video development · Teacher education · Higher education · K-12 education · Math curriculum · Podcasting

Introduction

Today's student live in a digital world. While there are areas of the United States with limited cell phone and Internet access, the majority of students leaving K-12 and entering higher education have been using technology daily—within their school systems, homes, or in their after school employment. These students are called digital natives (Prensky 2005); however, the term may not apply, as the

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digital world is ubiquitous to their very being. Cell phones, laptops, MySpace[®], Facebook[®], Google[®], and a billion plus Web pages are at their fingertips for seeking information, shopping, and social networking, along with opportunities to gain an education.

Mobile devices provide a constant connection to the digital world. Students want to remain mobile while not missing out on educational, social, and employment opportunities. In higher education, these students are asking the question, “Why must I sit in class when I could have the professor’s lecture by podcast, vodcast, videoconferencing, or streaming video on the Web? Is being in this classroom necessary?”

This paper describes a case study based on the experiences of two math educators who implemented iPod Touch technology and math videos in their eighth grade math classroom to support the learning of mathematical concepts. While the sample comes from the eighth grade, implications resulting from the study concern the preparation of current educators and those in teacher preparation programs in colleges of education. Examining the use of mobile technologies provides some interesting insights into math education, student expectations of technology, and the limitations and benefits of mobile learning.

Background

Educational theorists (Dede 2000; Bereister 2002) advocated that classroom experiences must mirror the complexity of society in order to develop collaboration skills, gain proficiency in working with incomplete information and concepts, manage decision making, and create and share new knowledge—part of being a productive member of society. They called for the integration of technology into the teaching of content, as students become more proficient in using the various technologies. Use of technology to investigate problems and design solutions improved their understanding of the process and also the content (Klopfer et al. 2004).

In 1991, Mark Weir began a conversation on ubiquitous computing as a means of allowing the technology to vanish into the background of everyday life while advancing learning. In 2006, researcher Yvonne Rogers took the concept of ubiquitous computing a step further stating, “UbiComp technologies are designed not to do things for people but to engage them more actively in what they currently do (cited in Van t’Hooft et al. 2008, p. 418). Researchers today see the potential for the use of mobile technologies to meet the demand for anywhere, anytime access to educational content through ubiquitous computing.

Such has been the case at Duke University where free iPods given to students provided opportunities to listen to audiobooks, podcasts of faculty lectures, and enabled students to return to review instructional material informally long after the instructor has left the building. Of the freshman class receiving iPods, 60% said they had used their iPod to record and listen to lectures. Professors indicated that the iPod is portable, convenient, and easy for students to use, allowing students to combine text and audio in meaningful ways (Read 2005). Like Duke, Purdue University is

using iPods for RSS feeds that allow students to subscribe and have information sent directly to their devices to be read as needed 24/7 (i.P.O.C. 2006).

In K-12, podcasting is integrated into social studies through: cultural awareness vodcasts, the writing and reading for language arts essays and poems, and foreign language courses by technology skilled educators. The potential for reaching many students led middle school teachers to embrace podcasting. Even though most education-related podcasts are designed for graduate and/or college students, teachers and students with limited equipment and skills are producing essays, music, and photo-journals for their classroom or assignments (Borja 2005). In Irving, Texas, fourth graders read essays and podcast them to others within the school community. Instructional specialist, Darren Wilson, suggests that podcast acts as a motivational tool for the students, as they do not want to be unprepared when recorded. Parents see it as another form of recognition, because it exposes students to reading and speaking out loud. Teachers agree that it is more motivating to write something that the whole world can hear or see in a video or audio format than to just place a grade on their assignment (Warlick 2006).

Schools at all levels are beginning to use iPods and other mobile devices as a means of delivering coursework and content. Amateur podcasters are creating and distributing free programs and content for download to iPods via Apple Computer's iTunes. This greatly expands content available on the Internet for learners of all ages. Dr. Peter Fader, professor of marketing at The Wharton School at the University of Pennsylvania states, "From an educational perspective, podcasting represents distance education taken to the next step. Not only do we "place shift" the learning process to make it more convenient for the student, but we allow the ultimate degree of "time shifting" (i.P.O.C. 2006, p. 46).

With this in mind, educators believe that mobile technologies provide a key to engaging students through the use of video and audio that goes beyond reading a textbook. The use of video and audio provides opportunities for all sensory perceptions—auditory, visual, and kinesthetic—to be engaged during the learning process (Saylor 2004). These new technologies provide opportunities to improve the educational process.

Methods

A case study methodology was used to provide an in-depth description of the two eighth-grade classrooms and the iPod activities occurring in those classrooms. This presented a "bounded system" in which the boundaries include the time and space of the classroom instruction and setting (Miller and Salkind 2002). The case study was used to answer "how" and "why" questions concerning the use of the iPod in math instruction and to gain a rich data set in the normal setting or context of the math classroom in which there was little to no control over the situation or behavior of the individuals' interaction with the iPod and math content (Yin 1994).

This study investigated eighth grade mathematics students' creation of math videos that could be used to study mathematics using a mobile device, iPod Touch, for anywhere, anytime learning. The following question guided the research:

Are mobile devices such as the iPod Touch a useful tool in the mathematics classroom for providing video content to support the learning of mathematics both formally and informally?

The following subquestions (SQ#) were used to support the research question:

- SQ1. What key processes must occur in the classroom in order to use mobile devices to support the learning goals of mathematics?
- SQ2. Do students view the videos created as useful to their learning of mathematics?
- SQ3. Do students actually use the iPod to review math videos in informal (out-of-school, out-of-math class) environments?
- SQ4. Does the math educator view the videos created as useful to the learning of mathematics?
- SQ5. Do other educators within the middle school view the use of iPods as useful tools for learning?
- SQ6. What key processes do educators in the field identify as necessary within the teacher education program to prepare future teachers for use of these devices in K-12?

Setting and participants

Appalachian Ohio is an interesting combination of very rural, socio-economically depressed, small towns that have coal mining as their economic history. Typically, the school districts are small and encompass a large geographic area in which students are bused over an hour each way throughout the school year. The participating school is located in Southeastern Ohio and has been designated as in Continuous Improvement by the Ohio Department of Education. The eighth grade students met 42.5% of the required 75% passing score on the Ohio Achievement Test in mathematics for the 2006–2007 academic year (Ohio Department of Education, Local Report Card 2008).

Each classrooms contained four iMacs with the OS 9.4 operating system. A wireless airport hub allowed Internet access to the larger group of iPods used in the research. However, the school's MacBooks needed to be upgraded to 10.4 so that students could upload or download iTunes materials for use with the newer iPod used in this study. Even though funds were provided for the upgrades to the MacBooks, the task was rejected by the technology coordinator whose lack of support was consistent throughout the study. Consequently, the math educators and researcher installed a PC with Microsoft XP[®] to use for uploading and downloading iTunes materials. The four iMacs in the classroom were used for movies, PowerPoint development, and for locating materials on the Web for use in the projects. Use of the school's MacBooks was abandoned.

The case study examined two eight-grade classrooms at the middle school. A total of 39 eighth graders in a Math8 course participated in the research. MsClass1 group contained 22 students with multiple academic levels from gifted to low achieving students. MrClass2 group of 17 students included special education

students and low achievers. The selection of the two classes was based on past work with Palm technology by the two math educators and the researcher. Their past work with Palms gave them the technological skills necessary for using the iPod. Both educators were classified as highly qualified by the Ohio Department of Teacher Licensure. MsClass1 holds a degree in Mathematics Education and is a contingent math faculty at a nearby university and MrClass2 has a degree in Special Education with additional mathematics coursework to maintain the highly qualified status in mathematics.

The researcher

The researcher is a tenured faculty member at a midwestern university located in the same region as the middle school. Previously, she was a math and math-science-computer teacher for 20 years in public schools.

The researcher is a familiar face in the middle school math and science classroom, so the issue of trust, which is an important component of case study research, had been established in earlier work at the school. School staff and faculty trusted that the researcher would meet behavioral expectations and would not take advantage of the school and students (Cummings and Bromiley 1996).

Technology used

The materials and technology included the textbook used by the students and math educators, the iMac computers, Microsoft Office version 2003, iMovie on the Macintosh, and Adobe Photoshop. To provide support for uploading the materials to the iPod Touch, a PC with Windows XP and version 7.6 of iTunes was added for use by the students.

Procedure

Contact was made with the school district superintendent and school principal to gain approval for the implementation of the research once it was determined that the math educators would be interested in examining the use of iPods in their classroom. Consent forms were distributed to the students, math educators, and other faculty within the school to collect data on the use of the iPod and the development of the math movies.

The math educators received 12 h of professional development in the form of hands-on use of the iPod Touch and iTunes. It included opportunities to download movies and music to the iPod through the use of iTunes. Some time was spent on learning to use iMovie and PowerPoint by MrClass2. While MsClass1 had used iMovie and Microsoft Moviemaker, neither was familiar with using the iPod to upload and download movies or with the development of materials for use on the iPod Touch.

Next, the math educators began developing lesson plans. They selected math topics for possible video content, designed a plan for how classroom time would be used, and identified the technology to be used. The study was scheduled to take 18 h

of class time for the development and implementation over 3 weeks. However, due to bad weather that closed the school and state testing that was rescheduled during the period allotted for the study, the number of weeks was extended to four. Before the work with the iPods began, the researcher had observed the classroom to better understand how the class typically progressed and later observed four days after the iPod work was complete.

Data collection

Student participants were asked to maintain a daily journal in which they wrote about their experiences in using the iPod. At times, the math educators provided prompts for journal writings; however, this was not required. Classroom observations occurred during the 4 weeks in which the students were specifically working with their iPods in math class (3-days per week) and study hall (6-h per week). The other day's observations were used to determine if students used their iPods when not directly encouraged to develop or implement content. The classroom observations were used to strike up informal conversations with students and the school faculty, during independent work or when students were engaged in the development of video content.

A short survey, with open-ended questions, was administered to the math educators (Math Educator Survey) and students (Student Survey). It elicited their thoughts on the use of technology in math, how the iPod may have contributed to their understanding of math, and when and how they used their iPods outside of the math classroom.

Semi-structured interviews with a sample group of students and the math educators were conducted throughout the 4 weeks of the study. Records of "hall conversations" and comments from faculty who were in other content areas were recorded. Finally, an examination of iPods materials by university faculty and student peer review of the videos were completed.

The objective was to gain insight from faculty not directly involved in the case study of its potential value in teacher preparation programs and for future math educators. All data was transcribed, coded, and examined for emerging themes in an iterative pattern over the research period.

Results and discussion

Flood days, state testing changes, limited electricity, compatibility issues of operating systems, and the technology coordinator's resistance to accommodate the researcher and faculty were problems surrounding the study. The school, located on the Hocking River, was closed 2 days of the study due to roads flooding where the buses needed to travel for student pick up. One day was lost in the research due to an excavation firm cutting the main electric line to the small town. Several laptops from classes were brought into the math classroom to continue the work until the batteries gave out. State achievement tests were rescheduled into the time frame of

the research due to earlier flooding. With all of these challenges, the students and math educators were able to implement the use of the iPod in their classrooms.

Examining the question, “Are mobile devices such as the iPod Touch a useful tool in the mathematics classroom for providing video content to support the learning of eighth grade mathematics both formally and informally?”, the following results and discussions are presented.

The comments, observations, interviews, and surveys all indicate that the iPod was useful in supporting math content developed by students in the learning of mathematics. The math educators in the study overwhelmingly supported the use of the iPod Touch in formal and informal settings.

MsClass1 made the following comment,

The iPod was so much fun for the students and provided ownership to the math concepts being developed into movies. All of the students talked about how hard it is to explain math to someone. I think it made them really think about how math is taught.

MrClass2 agreed stating,

I am glad we were a part of this study and used the iPods. I was skeptical, but the students love to work with them, and the movies actually helped me to understand what I need to teach better.

Some students indicated that while they loved the iPod and building the movies, they would rather work alone with their iPod rather than in teams. Others enjoyed working in teams. In the survey and again in interviews, a large number of students (27 out of 39) responded to the item “how much fun” using the iPod made math. Most mentioned the need to “think” about the math, how to organize math content in the video, and how difficult it was to explain math to others.

Results from the subquestion 1 is given below.

SQ1: What key processes must occur in the classroom in order to use mobile devices to support the learning goals of mathematics?

Technology support

Throughout the classroom observations, the need for adequate technical support was apparent. It was a major stumbling block in the use of the iPods and other technology. Many sites were censured and requests had to be sent to the principal for approval so that the technology coordinator would be forced to open up sites for use by the students. Wireless technology was provided but without assistance in set-up. While the principal was very supportive of the use of the iPods, the constant need to go to the principal for every technology request and upgrade of the software wasted valuable instructional time and at times discouraged students.

Student15 was very adept with technology and constantly complained about the lack of access to Web sites. His statements followed this path most days, “It is stupid to block sites. We all get on these at home. My friends and I use so many sites that are really good that we can’t use at school.”

The need for quality and accessible technology support is critical. Web sites for use by students need to be quickly reviewed and allowed through the censoring software as appropriate.

Recharging stations

Electrical outlets are a major need when implementing mobile devices. While these devices do have a long battery life, use throughout the day to play video is a major drain on the battery life, and 39 students seeking electrical outlets to recharge is a challenge. In this setting, recharging stations were wired around the math classroom so that students could recharge their iPod throughout the day. Chargers were also taken home with instructions to recharge the iPod each night.

Technology skills

Educators need to develop the technology skills necessary to use mobile devices. The math educators were fairly technologically adept but still had difficulty in uploading video or downloading the iTunes to add to the video. At times, connecting and synchronizing the device to the computer was difficult and cut into instructional time.

The major concern voiced by the math educators at the beginning of the study was unfounded. Both math educators expected that the students would have difficulty using the devices and developing video. However, the students had a good command of PowerPoint and only needed instruction on adding voice-overs and music. iMovie was seen as very easy to learn and use, and student peer mentoring in the use of the software proved invaluable.

Rethink curriculum

The presentation of mathematics in a video format requires careful planning. The use of a storyboard helped students organize thoughts, pictures, content, and order of presentation. In the realm of the mathematics classroom, this was unusual work. Students needed coaching on changing the world of numbers into visual representational models. After viewing several videos MrClass2 noted,

I had not thought of that equation being represented in that manner with those pictures. It makes sense, and I see how kids get it, but I would not have thought of that. I am going to have to think about how I might use that idea next year to change my instructional delivery.

Math, as a visual, is a new concept for most math educators in K-12 and often for future teachers in teacher education. Queried about the use of video to represent math concepts, a university educator commented:

I think you can use video to teach math concepts, but I have not tried it myself or seen it before now [a reviewer of the iPod math videos]. I probably need to think about how this can be incorporated into my courses since our students are video oriented—you know—digital natives.

SQ2: Do students view the videos created as useful to their learning of mathematics?

Most students indicated that they felt the project was as much about learning how to use the iPod as it was about learning math. Student11 said, “We made a math movie and then put it on the iPod. It was about elimination math.”

Another stated, “I am good at math, and I already knew about the math we were making movies to explain, but it did give me a review.”

Student23 commented, “I learned how to solve absolute value equations and how to explain math problems to people.”

Student15 stated,

I learned about absolute value, elimination, and solving different kinds of math problems from the movies I watched—but sometimes it was hard to get some of the movies—some of the movies needed better stories to make them easier to understand.

This would suggest that students could benefit from more help storyboarding ideas as part of the process.

Student34, a special needs student, acknowledged, “I learned that you need to be detailed. You can never explain too much.”

SQ3: Do students use the iPod to review math videos in informal (out-of-school, out-of-math class) environments?

In interviews with social studies and science faculty, observations and “hallway” discussions, it was noted that students were listening and viewing the movies outside of the math class. While some faculty indicated that using iPods was distracting to others in the classes without iPods, most agreed that any avenue to improving math was worth the experimentation. Faculty suggested that sharing videos with other students provided an opportunity to discuss math and improve their understanding of concepts. One faculty member was amazed at how students would share ear plugs so that two people could view and hear the video at a time.

Student 6 declared,

The only thing that would make this a better project is if I got to keep the iPod. I use it everywhere for music, Internet, and movies. I figured out absolute value by looking at one of the movies at lunch.

SQ4: Does the math educators view the videos created as useful to the learning of mathematics?

Both MsClass1 and MrClass2 felt the experience of using the iPods was worthwhile not just for the learning of math but in learning to use technology and working in teams. MsClass1 said:

It was amazing how they just jumped in and helped their classmates when they were having technology difficulties. It was neat to watch students demo their

creative shows in math class.... These students do not have these technologies at home. Some will have a computer, but it may or may not be connected to the Internet. The students have told me that they go to places that have wireless access and use the iPod to surf the Web. I am really glad they can do this as it gives them an opportunity to read!. I think we have to use every way possible to get kids to think about math.

MrClass2 was very supportive of the learning with iPods and stated,

My special education students better understand the math concepts due to the technology. They loved the iPods and focused more on the math work than usual. It was a great practical application of the technology and an iPod that is typically thought of as for music only.

SQ5: Do other educators within the middle school view the use of iPods as useful tools for learning?

Observations, comments, and interviews supported use of the iPod. Faculty from the middle school visited the math classroom when students presented their videos. All commented on the use of the technology to teach difficult concepts, such as slope, solving equations, and functions. At the conclusion of the presentations, several faculty suggested the use of the iPods across the curriculum in a possible thematic unit.

SQ6: What key processes do teachers in the field identify as necessary within the teacher education program to prepare future teachers for use of these devices in K-12 for our digital natives?

A common theme that occurred in the study was the need for teacher education to adequately prepare teachers to work with mobile devices. Most educators in the study from the university and middle school acknowledged that mobile technologies would soon permeate the schools and society. While it was often noted that low socio-economic schools and students may not have as much access to these tools, it was concluded that nearly every student in the school had an XBox[®] or Playstation[®].

When asked to identify specific processes, one educator suggested,

Teachers coming out of Colleges of Education need to learn to take risks and be creative. So many of my student teachers are doing some of the same things I learned in college. Even I know that these strategies no longer work with today's students.

A university faculty noted,

The same issues of technology support—electricity in the walls for plugging in devices, curriculum change, and technology skills—apply to university faculty. I need access to these devices and time to explore their use. I have never made a video, and the students know all about it. I am really behind!

Another educator stated, "I hope this problem of teachers using technology will take care of itself, because new teachers [coming into the system] have grown up

with technology. But they will need to be willing to change often, since the technology changes so rapidly. Learn and relearn is the name of the game.”

Conclusions

This study showed that the use of the iPod Touch[®] to build math videos was viable in the middle school studied. The math educators, the students, school administrator, and university faculty were impressed by the ability of students to present difficult concepts in a visual format and then discuss them with friends. While this research did not “test” the achievement of the students, the math educators and university faculty suggested that a clearer understanding of some of the math concepts had been achieved and could be identified in the building of the video. Nevertheless, further research on learning outcomes may lead to a series math videos developed as an aid in teaching complex concepts.

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