Teaching and Learning with Mobile Computing Devices: Case Study in K-12 Classrooms

By Michael M. Grant, University of South Carolina,
Suha Tamim, Dorian B. Brown, The University of Memphis,
Joseph P. Sweeney, The University of Mississippi,
Fatima K. Ferguson, Lakavious B. Jones, The University of Memphis

Abstract

While ownership of mobile computing devices, such as cellphones, smartphones, and tablet computers, has been rapid, the adoption of these devices in K-12 classrooms has been measured. Some schools and individual teachers have integrated mobile devices to support teaching and learning. The purpose of this qualitative research was to describe the early uses of mobile computing devices in these K-12 classrooms. With data from nine purposively selected teachers, participant descriptions were developed and five themes emerged that included (a) ownership and control impacted use of mobile computing devices; (b) administrators champion teachers' uses of mobile computing devices especially for student accountability; (c) teachers use devices to enhance their curricula and as motivation for their students; (d) teachers receive and seek out rele vant professional development; and (e) technical issues were common, but support was available. Implications of these themes are also considered.

Keywords: mobile learning, mobile computing devices, K-12 education, mobile devices in the classroom

Technologies have become synonymous with living and learning. There has been a push to introduce technology into K-12 classrooms since the 1980s. Most recently, this has included the potential of teaching and learning with mobile computing devices (MCDs), such as cellphones, smartphones, and tablet computers. MCDs are becoming increasingly ubiquitous in society, particularly with the current generation of students. Recent survey research indicates growth in student ownership. In 2010, Lenheart reported that 75% of American teens owned cellphones. In 2012, Project Tomorrow, which surveys and tracks student ownership and use of MCDs, reported that 18% to 49% of all school-aged children in kindergarten through 12th grade, respectively, owned cellphones with no Internet access and another 17% to 50% owned smartphones with Internet access. Similarly, 17% to 26% of school-aged children owned a tablet computer.

These devices are becoming more powerful and are being used in a variety of ways. Lenheart, Ling, Campbell, and Purcell (2010) stated, "cell phones are not just about calling or texting — with expanding functionality, phones have become multimedia recording devices and pocket-sized Internet connected computers" (p. 5). Similarly, the 2012 Horizon Report (Johnson, Adams, & Cummins, 2012) describes the increased uses of MCDs, (i.e. cellphones, smartphones, and tablet computers) in school districts across the United States and Canada in all grade levels and across disciplines.

However, this is not the norm. Lenhart et al. (2010) also noted that despite the potential of these devices, "most schools treat the phone as a disruptive force that must be managed and often excluded from the school and the classroom" (p. 4). Fifty-seven percent of middle schoolers and 55% of high schoolers reported

that the greatest obstacle to technology use in their school was that they could not use their own personal devices (Project Tomorrow, 2012). As Kiger, Herro, and Prunty (2012) remarked, there is a need for more empirical research to "guide implementation decisions" (p. 64).

Most recently, there has been interest in bring your own device (BYOD) or bring your own technology (BYOT) policies in K-12 schools (see Johnson, Adams, & Cummins, 2012). In these instances, schools allow students to bring their own MCDs — either as a preferred device specified by the school or any device the student may own. Schools see this as a feasible alternative to providing desktop computers or school-owned MCDs to every students and as a viable vehicle to leveraging the devices students already own and in which they are comfortable.

As a result of the increased uses of MCDs in 2011, we responded by observing how some schools — but mostly individual teachers — were integrating MCDs to support teaching and learning. So, the purpose of this small, qualitative study was to describe the how MCDs were initially being implemented in K-12 classrooms. The research described here was part of an introductory doctoral student course in Fall 2011, guided by the first author and faculty instructor. The research questions for this study were:

1. In what ways are K-12 teachers using MCDs?
2. What supports are teachers receiving when using MCDs?
3. What barriers exist for teachers when using MCDs?

Learning & Teaching with MCDs

Learning with MCDs has been described and defined in a myriad of ways. MCDs have included technologies that are transportable, such as cellphones, smartphones, tablet computers, laptop computers, and netbooks (Valk, Rashid, & Elder, 2010). Keegan (2005), however, recognized that mobile learning should focus on the actual mobility of the device. That is, mobile learning should be "restricted to learning on devices which a lady can carry in her handbag or a gentleman can carry in his pocket" (Keegan, 2005, p. 33). Moreover, Traxler (2007) described devices that learners are accustomed to "carrying everywhere with them" and that they "regard as friendly and personal" (p. 129). Some of the definitions found in the literature focus specifically on the technology; others focus on the learner; still others attempt some combination. Most recently, Crompton (2013) as an extension of Sharples' (Sharples, Taylor, & Vavoula, 2007) definition stated that mobile learning is "learning across multiple contexts, through social and content interactions, using personal electronic devices" ("Defining Mobile Learning", para. 5). In this research, MCDs was defined as portable digital devices, including smartphones and tablet computers that had persistent access to the Internet, such as through a cellular or Wi-Fi network.

Promise of Learning with MCDs

The potential for using MCDs with teaching and learning is substantial. Gikas (2011) emphasized that much of the extant research on using MCDs has been organized around three primary categories: (a) engaging learners with constant connectivity, where learners access content and communicate with classmates and instructors, no matter where they are (Cavus, Bicen, & Akcil, 2008; Shuler, 2009); (b) fostering collaborative learning, where learners are offered opportunities to collaborate, discussing content with classmates and instructors; and (c) enabling authentic learning on the move, where learners can create video/audio, take photographs, geotag, microblog, receive or send text messages, and access social networking sites for communication with classmates and their instructor (Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009). However, Grant and Barbour (2013) have reported that students may not take advantage of learning anytime-anywhere when they dedicate times and places for specific coursework.

Interestingly, Gikas (2011) noted that little research had focused on teaching with MCDs. In fact, she noted that current definitions of learning with MCDs "disregard the instructor as a teacher-partner or collaborator," in a learning environment or classroom (p. 37). Similarly, Swan, Kratcoski, and van't Hooft (2007) posit that few reports had examined strategies for integrating MCDs with the components generally attributed to teaching, such as planning, instruction, assessment, and classroom management.

Barriers to and Supports for Integrating MCDs

Despite efforts to increase the availability of technologies within K-12 classrooms, there are barriers that impede the integration of this technology into the curriculum. Several, external obstacles exist when teachers face integrating technology into their classrooms. Typically, these barriers are described in terms of the types of resources (e.g., equipment, time,

training, support) that are either missing or inadequately provided (Ertmer, 1999). Without adequate hardware and software, there is little opportunity for teachers to integrate technology into the curriculum (Hew & Brush, 2007). In addition to the physical resources required, teachers need hours to preview web sites and applications, to locate the photos they require for a multimedia project, or to scan those photos into the computers. Often, these barriers can be addressed with the appropriate training and administrative support.

Until now, the adoption of mobile devices in K-12 schools has been slow. One of the primary motives for this lack of adoption is that mobile devices are banned in many schools (Katz, 2005; Lenhart, 2010; Project Tomorrow, 2012). As a potentially disruptive, non-educational device, many school and district administrators have seen the potential problems that cellphones and smartphones can cause in a classroom. School administrators reported that 52% of their districts banned student-owned mobile devices in classrooms (Project Tomorrow, 2012). Further, there are reasonable concerns over the costs associated with many of these devices (and their associated data plans), along with the inadequate coverage provided by cellular companies (particularly in rural districts) (Grant & Barbour, 2013). Moreover, some school districts are admittedly reticent to allow students to use their own personal MCDs due to regulations associated with the Internet and the protection of children (Nair, 2006). This is because smartphones and cellphones may use a cellular network—bypassing the school's network altogether—so schools would be unable to monitor, filter, or protect students.

In addition to hardware, software, and networks, successful technology integration requires that teachers be provided with resources and training. Ertmer (1999) considers training, resources, and support as barriers that have to be addressed. Research has shown that teachers need both in-service training and ongoing curriculum support in order to be able to incorporate technology into the curriculum in meaningful ways (Ertmer, 1999). It has been suggested by Roschelle, Pea, Hoadley, Gordin, and Means (2000) that teachers experience intensive and ongoing staff development that provides opportunities for modeling, practice, and reinforcement of technology use with curricula, which should be linked to curriculum goals and objectives from the onset of technology implementation efforts.

In addition to expected barriers to implementations, MCDs may offer unique challenges to integration. Liu, Han, and Li (2010) are explicit in their reminders that adoptions or ownerships of MCDs will not assure that devices meet their potential. For example, Maniar, Bennett, Hand, and Allan (2008) identified small screen size, lack of data input capabilities, limited interoperability, and lack of standardization as constraints to mobile hardware and software. Moreover, Herrington (2009) found that some teachers were unable to design lessons that take advantage of the unique capabilities of mobile devices, and instead, replicated existing tools, such as calculators, in their lessons.

Given the long history of technology integration, we were interested in how MCDs may or may not be different in their implementations. We had an opportunity in our research to describe the early progress of the promise of learning with MCDs. As primarily novice researchers, we were interested to see if teachers were integrating increased connectivity, collaborations, and authentic learning on the move as described in the literature by Gikas (2011), Keegan (2005), and Traxler (2007). In addition, we felt it was essential to describe teacher professional development opportunities and supports teachers were receiving. Our research questions (and subsequent interview protocols) broadly considered consistent barriers to and supports for technology integration, such as those described by Ertmer (1999) and Hew and Brush (2007), as well as mobile device-specific challenges as detailed by Lui et al. (2010).

Method

Since the research questions were grounded in description and the research team was interested in learning teachers' direct experiences, a qualitative approach was appropriate. This descriptive study followed a case study design (Merriam, 1998). The research methods described here were conducted as part of an introductory doctoral research course in Fall 2011, where novice student researchers collaboratively designed, carried out, analyzed, and reported the research guided by the primary researcher and course instructor. So, iterations, revisions, and collective consensus were critical to understanding the processes of research, as well as interpreting the findings.

Participants & Contexts

The participants in this study were K-12 teachers who either taught using MCDs or who had students using MCDs. The participants were selected using criterion sampling (Miles & Huberman, 1994), where the primary criterion

was teachers or students who were using MCDs, such as cellphones, smartphones, or tablet computers for teaching or learning. Because the use of MCDs was a recent trend in K-12 schools, we purposefully chose to delimit our research from the previous research on laptop computers and netbooks (see Fleischer, 2012; Hew & Brush, 2007). Secondly, we employed a maximum variation strategy (Miles & Huberman, 1994) in order to have diversity of gender, geographic regions, public and private schools, subject areas, and who primarily was using the devices (i.e., teachers or students). Using the participant identification methods described below, we sought out teachers and contexts that were varied.

Participants were located through a variety of methods, including a Google search for teachers who use MCDs, a social network (i.e., Twitter) invitation, professional contacts, and published magazine articles (e.g., USAToday). All of the participants were contacted via email and invited to participate in the research. Potential participants were asked to complete a brief form, and each student researcher followed up with two teachers to make sure they matched our criteria and were willing to participate.

Nine teachers agreed to participate. The characteristics of each of the participants for this study are presented in Table 1 and they are summarized as follows: (a) five were female, (b) ages ranged from 27 to 53, (c) five were White Caucasian, (d) eight were from public schools, (e) grades ranged from Pre-K through 12th with four teaching Grades 9-12, (f) states included Kentucky, Michigan, Mississippi, New York, and Tennessee, and (g) eight participants were using Apple iPads while one used an Apple iPhone.

Data Collection

Because this study sought to understand how teachers were integrating MCDs into their classrooms, these data could only have been obtained through the participants' knowledge. Therefore, interviews were the primary method for data collection. A semi-structured interview (see Appendix A for protocol) was used to allow the interviewers the flexibility to add additional questions. The open-ended nature of this type of interview structure gave participants an open forum for response. The interview protocol was tested within our student research team to help ensure alignment with the research questions, as well as to test the general communicative flow of the protocol.

In order to reach between eight and twelve participants, each student researcher was responsible for conducting at least two teacher interviews, hoping this would allow us to reach data saturation, appropriately describe uses, and meaningfully answer the research questions. Individual interviews were conducted by face-to-face, telephone, and Skype, depending on the participant's preference. All interviews were audio or video recorded then transcribed.

Data Analysis

The student researcher who conducted the interview was responsible for developing a participant description. Participant descriptions were developed first in order to describe the context and participants, using researchers' interview notes. This gave the research team an understanding of all of the participants prior to the abstraction of data and helped to (a)

Table 1. Overview of participants

Name	Age	Gender	Ethnicity	Grade(s)	Subject Area(s)	Public/ Private School	Location
1. Ashleigh	46	Female	Caucasian	BK-4th	Computers	Public	Michigan
2. Garrett	27	Male	Black	9-12	Algebra I	Public	Tennessee
3. Isabella	29	Female	South American	3rd	All/Dual Language	Public	Tennessee
4.Laura	29	Female	Caucasian	6-8	Math	Public	Tennessee
5. Michelle	43	Female	Caucasian	9-12	Spanish	Public	Tennessee
6. Mike	39	Male	Caucasian	12	English	Public	New York
7. Pam	53	Female	Black	8th	Inclusion	Public	Tennessee
8 Steven	25	Male	Caucasian	9th-12th	Math	Private	Kentucky
9. Tony	29	Male	African American	6-8	Input Technology	Public	Mississippi

describe the uses of MCDs and later (b) discuss developing themes. The descriptions were sent back to the participants, where each participant was invited to edit and add to the descriptions in order to best represent the participants, his or her context, and his or her students.

Then, inductive analysis was used to develop patterns, categories, and themes. Individual interviews were open coded individually by the researcher who conducted the interview. The unit of analysis was a single sentence, following Meyer and Avery's (2009) process for analyzing qualitative data in a spreadsheet; however, a Google Docs spreadsheet was used in order to facilitate collaboration among the researchers. In addition to open coding, methodological coding (Bogdan & Biklen, 2003) was applied in order to help answer the research questions.

All of the open codes from the spreadsheet were then printed out for review. In dyads, the student researchers determined patterns from all of the codes. The patterns were then combined as abstractions of the data (Merriam, 1998). Patterns from each dyad were listed and compared as a whole group on a whiteboard, then negotiated for specific meanings, clarifications, and similarities. For example, one dyad created a pattern called "training and [professional development] received" while another group created patterns called "[professional development] outside of school" and "[professional development] inside of school." Both of these described the training and professional development teachers used to learn about integrating MCDs.

Each student researcher open-coded independently and each dyad created patterns independently. So, we felt a face-to-face negotiation process with all of the dyads offered the strongest verification and credibility of the findings across the novice researchers, which included multiple common patterns such as teacher benefits, student benefits, and training. Many pattern-codes overlapped in terms or meanings. So, patterns were discussed and combined (or eliminated) to create categories as needed. Finally, categories were revised to create themes. With the lead researcher acting as a peer de-briefer, the novice researchers described and defined the themes, and revisions were made in order to move beyond descriptive categories (Bazely, 2009).

Rigor & Trustworthiness

The case study used a number of typical strategies to ensure trustworthiness of the data and findings. Triangulation among multiple researchers was used to reduce bias from individual researchers (Thurmond, 2001). An audit trail documented shared decision-making in combination with a shared Google Docs file for initial coding. Moreover, we took photographs of the collaborative analysis process. Member checks were conducted with the participants, and the primary faculty member (first author) acted as a peer de-briefer throughout the analysis process by asking the student researchers to articulate and clarify their decision-making for collapsing codes and categories, as well as defining themes.

Findings & Interpretations

Our findings are organized into two sections. First, we present the participant descriptions and then five themes that were abstracted from the interview data. Pseudonyms are used for all participants and their schools. Quotations are verbatim comments and they are uncorrected to represent most accurately the voice of the participants.

Participant Descriptions

Ashleigh was a teacher in charge of a computer lab classroom that had 32 iPads available for instruction. The school was located on the east side of Michigan about 45 miles from the Canadian border. Students BK-4th grade (BK stands for Beginning Kindergartner) came to her once a week during an activity period. She had been teaching for 25 years and had been at this school for 13 years. This is the first year she has had access to iPads for instruction, she began teaching computers in 1998, and has taught various subjects, including P.E. and 5th grade curricula.

Garrett was a 27-year-old African American and had only been teaching for three years. His enthusiasm for his profession was apparent. Garrett taught Algebra I to 9th–12th grade students at a Tennessee high school. Garrett indicated that although the iPads are available for use by his department, his colleagues rarely used them in their instruction. As for his own use of the iPads, Garrett indicated that he only used them with his students for supplemental purposes because they were new to his school. Garrett did not plan lessons around using the iPads; however, he utilized a math application for review or to "lighten" the students' workload. Garrett considered himself a bit of "a Lone Ranger" in regards to using the iPads with his classes, because as he puts it, most of his colleagues "don't really utilize the technology." Despite having had professional development

on how to use the iPads, Garrett indicated that because of the school's emphasis on generating data for student performance, he did not rely on them as much as he would like.

Isabella was a first year, public school, dual language immersion, 3rd grade teacher. She had been teaching two years total; but the organization and evidence of student learning in her room reflected an experienced teacher. She was from Paraguay and fluent in Spanish and English. Isabella used her class set of iPads for discovery activities, research, problem solving, writing, drill and practice, and reading, and she used them across all content areas.

Laura was a young Caucasian teacher who taught 8th grade math in a large inner city public school district in Tennessee. Laura recently entered into the field of education through a Teach for America grant funded by the Bill and Melinda Gates Foundation. Laura's class size was between 28 and 30 students, and the majority of the African American students entered her class approximately two grades levels behind. Laura received a refurbished iPad as part of her Teach for America program and she used it to check attendance, document behavior, and display "PowerPoint." Laura was a highly motivated teacher; and she was the only teacher in her school using a mobile device with teaching.

Michelle was a high school Spanish teacher employed in North Carolina's largest school district with 17 years of teaching experience. She taught Spanish to students in Grades 9 through 12 at Middle Creek High School, which held a strong Science, Technology, Engineering, and Math focus. In her instruction, Michelle had been implementing iPads as she aimed to increase her students' knowledge of the Spanish language. As a part of a school-wide initiative to implement technology, Michelle indicated that the use of the iPads was being encouraged among all teachers at her school. Michelle shared student work samples of how students were using iPads and applications to create commercials in Spanish.

Mike was a middle-aged Caucasian teacher who taught 12th grade English in a New York public school. He had been teaching for a total of eight years and had been using iPads as an instructional tool for two years. Mike was a very energetic and enthusiastic teacher that was passionate about the implementation of new technology into his teaching. As an Apple Distinguished Educator, Mike utilized a variety of teaching strategies into everyday lessons using the iPad. He believed that although there was a lot of work involved with planning on the front end when creating technology integrated lessons, it was much easier in future uses. Mike uploaded all of his lessons, including course materials to his website for students. Because each of the 23 students in his class was issued an iPad by the school district, they were able to easily access the material. Even when students were absent, they were still able to stay abreast of coursework. Some examples of lessons in which Mike engaged his students included using plays such as *Romeo and Juliet* to create "iMovies," as well as comic books. Mike believed the iPad allowed him to extend the classroom "beyond the four walls."

Pam was a Black, public school teacher of 25 years, teaching 8th grade inclusion students. Having been in her current school and grade level for eight years, Pam was a well-respected and well-known figure in her school. This was Pam's first year using iPads, but she was no stranger to technology as she pulled out portable projectors, hover-cams, iPads, an iPod, a sound dock, an e-Beam, and cameras in the interview. Her excitement over how technology creates eagerness in her students was evident. Pam used a class set of 30 iPads for instruction, mainly for math and language arts. The students use them for peer tutoring, teaching the class, manipulatives, problem solving, writing practice, and vocabulary building.

Steven was a high school teacher in a private school located in Kentucky. He primarily taught math to 9th and 10th graders. He was a 25-year-old Caucasian in his fourth year of teaching. He primarily used his own iPhone as a way to rigorously document student work and behavior. He uploaded scanned tests, quizzes, assignments, and photographs into a web-based software application called Evernote. Each of his students had a file in this program and he could bring up any uploaded document or photo for any particular student. This was helpful to Steven when conducting formal and informal parent-teacher conferences and also when discussing with other teachers and administration.

Tony was a young African-American who taught Grades 6 through 8 in a Mississippi public school. He had been teaching for seven years and had been using iPads in his classroom for one and a half years. Tony taught computer applications, as well as input technologies. Tony's class consisted of 23 students, of which about half of his students possessed their own personal iPads. Students without an iPad used desktop computers furnished by the school. One of the main uses for his iPad was to upload weekly notes for students. Students in turn were

able to retrieve class notes before or during class. Tony believed the use of iPads had enabled him to become more mobile in his classroom. He thought that being mobile was especially helpful in maintaining discipline, such as when he was streaming videos from the Internet as an introduction for an objective.

Themes

Given the intimate nature of findings and interpretations in qualitative research, these are presented together below. From this study, five themes emerged: (a) ownership and control impacted use of MCDs; (b) administrators champion teachers' uses of MCDs especially for student accountability; (c) teachers use devices to enhance their curricula and as motivation for their students; (d) teachers receive and seek out relevant professional development; and (e) technical issues were common, but support was available. Each of these is discussed below.

Theme 1: Ownership and control impacted use of MCDs. The teacher participants used mobile devices in three main ways: (1) six teachers provided students with devices, such as classroom sets; (2) two of the teachers owned their own devices; (3) one teacher allowed her students to use mobile devices at their discretion. Who owned or controlled the devices directly impacted how and when they were used.

Six of the teachers determined how and when students used MCDs. The schools owned these devices and the teachers chose when students used them. There were a variety of ways in which these teachers allowed the students to use mobile devices, including (a) creating learning artifacts, (b) communicating, (c) augmenting lessons, and (d) differentiation and alternative assessments.

Michelle, for example, described how she had students create and collaborate on projects using mobile devices:

I have them do a newscast, and they can tape it and they can send that to me…. We did, like a fashion show, where they had to make a commercial using iMovies and use sound and everything they can do with iMovies.

Mike, for example, described how he used mobile devices as a form of communication to exchange voice mails, send reminders, or submit assignments and provide quick annotated feedback. He said,

Students are able to electronically submit responses to me and I am able to provide feedback quickly…. I am then able to use the iAnnotate app to insert comments and suggestions and electronically send the paper back to my students.

Teachers also used mobile devices to introduce, reinforce and supplement lessons. For example, Garrett said, "It's usually something that we use to go over things that I have already taught. I'm using it to supplement the curriculum." Mike said that he used "an iPad to download videos related to lessons. Students, in turn, are able to upload these videos using their iPads and complete lesson activities in class." Finally, teachers used mobile devices to differentiate learning and create alternative types of assessments.

For example, Ashleigh explained how she used an application on the mobile device with a special needs student:

So I was able to go and find a Teletubbies app that really got him…I mean the first day he actually sat down for ten minutes doing this Teletubbies app, which was amazing. I mean, his attention span was about three minutes with most other things.

On assessment, Mike clarified, "Students are no longer limited to paper writing. I am able to have creative assessments. An example of this is having my students to create an iMovie using the play *Romeo and Juliet*."

So, when teachers have their students use MCDs, they aim for creativity, motivation, reinforcement of their teaching, and finding alternative types of assessing the work of their students.

Two of the teachers, Steven and Laura, used MCDs without students having or using devices. Steve and Laura owned their own devices and used these directly in class to plan, document learning and behavior, and teach. Their schools did not provide devices to students and their schools did not allow any BYOD policy. Steve used his own iPhone to document students' work and attendance.

For example, Steven said: One of the programs I use with my laptop and phone…is called Evernote. And what it allows me to do is input things through my phone or computer for later viewing. So for example, if somebody in class does something or says something, that I think needs to be documented, maybe it's inappropriate, maybe it's showing a knowledge deficit, that I think is a major problem, I can type out a quick note on my phone, and it will save it and it will sync to my computer automatically, so that I can look at that later whether in a conference meeting with parents. Or if I'm meeting with the administration or the counseling department, I have that record … on what day that student said or did what.

Another purpose was to check for student's progress. For example, Steven said that he could use his iPhone to "pull up every document I've ever scanned in and get a much bigger, much more accurate picture" of a student's progress. Laura used her Teach-for-America-issued iPad, to "check for understanding in an instant [rather] than do exit slips every day."

Out of the all the participants in the study, Pam was the only teacher whose students determined how and when they used the mobile devices. While the school owned the MCDs, Pam gave up control of the devices to the students. As such, students used iPads to upload class notes, record lectures, use e-Readers, or edit and stream videos. Pam was quite comfortable with technology and her students had freedom to use iPads as needed.

Theme 2: Administrators champion teachers' uses of MCDs especially for student accountability. The participants described their administrators who were very supportive of teachers using mobile devices and encouraged teachers to use them to make students accountable for their work. The use of ShowMe and Evernote applications were described as documentation tools for student work. Mike said,

> My principal likes the idea of my making students accountable for their actions by requiring them to download their own notes for class. He also visits frequently to observe my class engaging in lesson using their iPads …. My principal has allowed me the flexibility of conducting classes in other locations such as outside and in the auditorium in order to give children the opportunity to interact in different learning environments.

Steven described how he used the Evernote application to record assessments, work, and behavior. "I showed [my principal] everything, and she was just sold on the level of organization and documentation that it gave me per student," he said. The principal at Pam's school was proactive about getting the devices and providing training support: "When the principal first came to me about getting the iPads, I called Apple and did some research on it...Then she asked teachers if they wanted to attend iPad training and we had about eight that did."

This type of support from an administrator appeared to be important when implementing the use of MCDs. Previous researchers (e.g., Grant, Ross, Potter, & Wang, 2005; Silvernail & Lane, 2004) have reported the need for key individuals and administrators to champion a technology integration effort in order for it to be successful. During analysis, our team remarked that MCDs were in general early in school implementations, so administrators may play a stronger role when approving untested technologies. In addition, we considered that these teachers may be early adopters (Rogers, 1995) and they may provide unbalanced, positive views. We saw from these teachers that principals and superintendents can provide the impetus for acquiring mobile devices, and this support allowed for their continued use in the classroom.

Theme 3: Teachers use devices to enhance their curricula and as motivation for their students. The participants noted specific curricular uses of MCDs. For example, Michelle described an activity with PuppetPals, an application for iPad that records audio and characters' movements on the screen:

> Because I'm Spanish, I will tell them that one [student] has to narrate the story about what happened, and the other two [students] would have to act out what's going on. They create the dialogue using the present tense.

Mike also noted how "students [were] able to use iPads to write papers for class and submit them electronically." He then used "the iAnnotate app to insert comments and suggestions and electronically send the papers back" to his students. With math, Pam described how she used an interactive whiteboard application:

> They write a problem out, like if they had $2x + n = 4$ or something like that, and then … it's projected and they go up and teach the steps using the vocabulary and everything.

So, the curricular implementations varied based on the discipline.

Two of the teachers noted that students' time-on-task was higher when using the devices. Isabella commented on how iPads helped excite her students in math. "[Students] sit there quietly and they'll do all this math if I let them use the chalkboard app as opposed to just using a sheet of paper, " she said. Tony noted changes in management issues: "I became more mobile when observing my students during lessons. As a result, students were more on task than before."

From all of the teachers who used MCDs with students, the emphasis, however, seemed to be focused on motivating and engaging students with the devices. For example, Pam saw an increase in interest from students: "The one's whose classes I go into [with the mobile devices], they love it. We have the students'

attention." She also saw changes in how students arrived at answers:

> What's good about it is they have all these creative juices going, [and students say things like] "Let me show you what I can do! I can do this!" And if they're doing math, one might say, "I can work it this way," and then I let them put both of [their strategies and answers] up and I'll say, "See, same problem, same answer, different way of doing it."

In addition, Garrett said,

> It's really just to get the kids involved, they like using them….The students were lot more excited about the material. They were really into it. They really wanted to use the iPads, because most of them have not had the opportunity to handle the iPad, so their enthusiasm was through the roof when we started using them.

Our findings here corroborate those of Kiger, et al. (2012). The teachers expressed students' enthusiasm for using MCDs and how these devices might influence learning. Admittedly, this enthusiasm and descriptions of student motivation should be considered in light of any novelty effects for educational technology. Though usually associated with brief interventions (Cheung & Slavin, 2011), novelty can be attributed to new technologies as Garrett noted in our findings that many of his students had "not had the opportunity" to use these devices. As MCDs become more commonplace and used in classroom instruction, students' engagement, persistence, and increased attention to these devices may diminish over time (Clark, 1983).

Theme 4: Teachers receive and seek out relevant professional development. Previous researchers (Farenga & Joyce, 2001; Lowther, Inan, Strahl, & Ross, 2008; Ward & Parr, 2010) have indicated that school districts offered insufficient professional development to ensure meaningful technology integration. Our findings were mixed with regard to corroborating previous research. In contrast, some participants indicated that they received the training needed to incorporate MCDs within their schools. For example, Michelle explained, "You have to get trained on [the iPads]," and professional development occurred monthly at her school during the academic year. Corroborating the previous findings, though, some teachers also sought out ways to learn more about MCDs on their own, depending heavily on tutorial websites. For example, Isabella noted a mix of external professional development, and self-training: "I went to [a professional development conference] and mostly that was on the apps and what would be appropriate with the curriculum. And then I just do a lot of research on my own." Similarly, Garrett noted he had to go beyond the professional development that was provided,

> I think that the training was adequate; however, it was one of things that you had to do trial and error to. I had to go in and see how to utilize it to the best ability of my students.

However, because Steven was using his own personal device in the classroom, he had received no professional development.

So overcoming Ertmer's (1999) first-order barriers for professional development and training opportunities was mixed with our participants. Empirically-based recommendations for teacher professional development include an (a) alignment with specific curricular content and focus on pedagogy (Penuel, Fishman, Yamaguchi, & Gallagher, 2007) and (b) sustained learning opportunities over time (Garet, Porter, Desimone, Briman, & Yoon, 2001; Polly & Hannafin, 2010). Evidence of these components were also mixed among our participants. Of all of the participants that received some type of professional development, they felt it was useful in becoming more adept at integrating MCDs in their classrooms—whether the professional development included a curricular or pedagogical focus. Some of the professional development participants received was sustained; however, it was not solely focused on MCDs. More often, the participants described workshops or one-on-one sessions.

Theme 5: Technical issues were common, but support was available. Teachers who determined how and when students used MCDs identified their schools' insufficient network infrastructure. For example, Garrett described the network issues he experienced as, "They happen kind of frequently. But they are usually errors with the school network and wireless connections, not the actual iPad malfunctioning." Similarly, Michelle described her school's lack of network capacity. She said, "There are too many people … at the same time … and it won't function. It won't work.

Interestingly, Ashleigh had opted *not* to use her classroom set of iPads for internet-

based activities because of her previous network issues. She said:

I don't get on the Internet with the kids, so network issues have not been a problem at all. That's what's so wonderful about these iPads—is that last year we had issues constantly, and we had "Oh, we can't use the computers today." We have not had one moment where we have not been able to use those iPads.

In contrast, when teachers used their own device, the two participants, Laura and Steve, had few technical issues. This possibly stemmed from the fact that teachers were directly responsible for their own mobile device. Laura said, "The only technical problem I have is charging my battery." Steven stated that he only had a technical issue "maybe once a week."

As expected, technical support staff members were mentioned as important resources across all participants. For example, Michelle said, "The STEM Coordinator—he's kind of like the go-to guy, for everything," but he was only available for three days per week. Mike said, "The superintendent has given me total access to our [information technology] staff. Whenever I need any type of technology assistance, they are always there at my disposal." Garrett, similarly, identified his school's media center staff who has a "technology technician" available.

As teachers and students become more dependent on network-based technologies (e.g., MCDs, web-based applications), the reliability and capacity of school network demands also increase. The primary technical issue our participants experienced was with network capacity and reliability. Others (e.g., Edwards, 2003; Grant et al., 2005) have also described challenges with unstable or unreliable networks.

Discussion

The purpose of this study was to explore the use of MCDs in K-12 classrooms. Of the nine participants interviewed, only two used their own devices with their teaching. The others used school-provided devices and largely controlled how the devices were used in their classrooms. The teachers assigned the devices, designed lessons that used them, and instructed when and how they would be used. Mike's school was the only one in our sample that had issued a tablet computer to each student for use in class and at home, and Pam's class was the only instance where students had control over when and how they used the devices. None of the schools our participants were teaching in were implementing a bring your own device (BYOD) or bring your own technology (BYOT) program (see Johnson, Adams, & Cummins, 2012). Again, this research was conducted early during the adoptions of MCDs into schools and the majority of schools still perceived devices as disruptive (Lenheart et al., 2010).

Participants in this study used MCDs in many ways to enhance their curricula. Steven enjoyed the flexibility of mobile devices by holding class in locations other than his classroom, such as the auditorium and outside. Participants described how they taught students to take advantage of device applications, as well as communicating, recording, practicing skills, projecting, and news casting. This supports Gikas' (2011) descriptions of creating artifacts and communication; however, the uses of MCDs in this study were not mobile as students moved through their daily lives. On the contrary, the devices in most cases were a substitution for a desktop computer.

Professional development and support for the participants was mixed. The participants' experience ranged from no professional development, such as with Steven, to sufficient training and support, such as with Michelle. Many of the teachers described the need for exploration and "a lot of research" on their own. While we did not specifically look to explore the participants' schools and their directions toward integrating technology; two of the participants' schools, Michelle and Mike's schools, seemed to have a school-wide initiative or plan. Michelle's school had a STEM focus, and Mike's school was implementing a 1:1 iPad initiative. As such, the professional development and technical support for these teachers seemed to most closely align with recommendations for professional development to impact teachers (Garet, Porter, Desimone, Briman, & Yoon, 2001; Penuel, Fishman, Yamaguchi, & Gallagher, 2007; Polly & Hannafin, 2010). While the other teachers may have been (as Garrett described) "Lone Rangers" in their schools, the need for comprehensive professional development is warranted as schools continue to consider purchasing and implementing more MCDs.

Finally, network capacity and reliability was the primary technical issue participants experienced. This barrier is of chief concern as more technologies depend on Internet access. While data may suggest that schools

have been physically wired for some time (National Center for Educational Statistics, 2001), the network designs and capacities may be obsolete, or at least dated.

Limitations and Conclusion

The limitations associated with this study are relative to all qualitative research. The small sample size of nine participants limits the ability to generalize these finding to larger populations. As such, these results should be interpreted with caution and the extent to which these results can be applied in other contexts is situated with the reader.

Future research can address many of these limitations, as well as other related questions. For example, while studies such as that of Liu (2007) and Osmon (2011a, b) show how teachers are using MCDs to support learning for computing efficiency, there is still little confirming research determining the effectiveness of these devices on learning performance. In addition, as this study allowed any tablet, smartphone, or iPod, it would also be interesting to consider whether or not the type of device matters in supporting instruction or increasing student achievement. Moreover, as we have discussed, we found no evidence of combining formal and informal learning. More research is needed with schools, teachers, and students who are using MCDs inside and outside of classrooms. Potentially, schools or districts that are implementing BYOD or BYOT programs may be opportune in exploring how learning in multiple contexts may occur.

Finally, a number of schools across the US are piloting tablet computers and ereaders as viable alternatives to print textbooks (e.g., Ferlander, 2012; Gleason, 2012; Hu, 2011). Some schools are also considering MCDs as financially viable alternatives to desktop or laptop computers (e.g., Kiger, Herro, & Prunty, 2012). Most recently, the Partnership for the Assessment of Readiness for College and Careers (PARCC assessment) accompanying the Common Core State Standards for Math and Language Arts announced that it would be compatible with iPads and Android devices (see http://www.parcconline.org/technology). So schools have added incentive to consider these devices.

Michael M. Grant *is an Assistant Professor in the Educational Technology program at the University of South Carolina, Columbia, SC. Please direct correspondence regarding this article to him via email at michaelmgrant@sc.edu.*

Suha R. Tamim *is a part-time faculty member in the Instructional Design and Technology program at the University of Memphis. She also works as an instructional design consultant. In addition, she serves as the interim book editor for the Interdisciplinary Journal of Problem-based Learning.*

Dorian B. Brown *is Adjunct Faculty at The University of Memphis and can be contacted via email at: d.brown@memphis.edu.*

Joseph Sweeney *is the Director of the Mississippi Teacher Corps and instructor at the University of Mississippi and can be contacted via email at jsweeney@olemiss.edu.*

Fatima K. Ferguson *is an Instructional Training Specialist and can be contacted via email at fkfrgson@memphis.edu.*

Lakavious B. Jones *is a doctoral student at the University of Memphis.*

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Appendix A: Interview Protocol

Hello! Thank you for consenting to participate in this study on mobile computing devices in K-12 classrooms. Once again, let me go over the purpose of the study. The purpose is to get a deeper understanding of how teachers use mobile computing devices with teaching and learning and how they implement it in their classrooms. Our interview will consist of a series of probing questions that will help me collect the data that I need for the study. I will also be taping our interview for the purpose of accuracy of the data, and I will be taking some notes.

Do you have any questions for me before we start the interview? (Give teacher clarifications as needed).

Great! Lets' start then ...

First I will collect some demographic data to help me describe you.

Number of years you have been teaching at this grade level	
Number of years you have been teaching in total	
Number of years you have been using mobile computing devices	
Subject-matter you teach	
Private or public school	
Class size you teach	
Ethnicity	
Age	
Gender	
Type of device(s) you are using	

1. Describe how you use the mobile computing devices in your classroom. Describe how you use the mobile computing devices in your classroom.
    a. Give examples.
    b. What times of day?
    c. What subjects?

2. What procedures are in place to access these devices?
    a. How often are they accessible for your use?
    b. Do you share between others in your grade/department?
    c. Do you have a sufficient number of de vices for implementation of lesson?
    d. Why or why not?
3. In your opinion, what are the best uses of mobile computing devices and why?
4. Describe uses of mobile computing devices by other teachers and others students that you have seen.
5. List ways you are using mobile computing devices for instruction.
6. How are you using mobile computing devices to align with your school district's curriculum?
7. How do other teachers feel about you using these devices?
8. How are you being supported using the devices in your classroom?
    a. Give examples of specific supports.
    b. Describe how supports are made avail able to you
9. Describe the support needed to meet your specific needs in terms of using mobile computing devices.
10. What type of assistance is available to help troubleshoot when issues arise with mobile computing devices?
    a. How often do you experience equip ment malfunctions? (ex: network errors, log-in errors, broken equipment?
11. What training opportunities have you had to equip you for effective use of mobile computing devices?
    a. What types of professional development is offered in your school or district as training for these devices?
    b. Do you feel that you received adequate training to incorporate the mobile de vice in your instruction? In terms of us ing MCDs to differentiate instruction, across subject areas?