Abstract:

Many schools are beginning to adopt one-to-one computing with the goal of developing students’ 21st century skills, which allow students to learn not only content but also acquire critical skills (e.g. creativity, collaboration, and digital literacy) that will lead to future careers. Technology offers teachers the ability to transform the quality of instruction – to achieve a more student-centered learning environment, have more differentiated instruction, and develop problem or project based learning, and demand higher order thinking skills. A number of barriers and influences have emerged from the findings of this study on teachers’ practice and integration of technology into their classrooms. This study examines how these barriers, both internal and external, influence classroom pedagogy. Using a TPACK framework, this paper examines the classroom practice of middle grades math and science teachers integrating a 1:1 initiative and how they deal with the barriers in their classroom practices.
Teacher Efficacy in 1:1 Tablet Integration

Introduction

Many schools are beginning to adopt one-to-one computing with the goal of developing students’ 21st century skills, which allow students to learn not only content but also acquire critical skills (e.g. creativity, collaboration, and digital literacy) that will lead to future careers (Pellegrino & Hilton, 2012). The Next Generation Science Standards (Achieve, 2013), emphasize the relationship between science, engineering and technology and the application of such ideas, that allow scientists and engineers to “develop or improve technologies, often [raising] new questions for scientists’ investigations (NRC, 2012, p. 203).” Technology offers teachers the ability to transform the quality of instruction – to achieve a more student-centered learning environment, have more differentiated instruction, and develop problem or project based learning, and demand higher order thinking skills (Penuel, 2006). Additionally, technology integration, specifically mobile one-to-one technology, into the classroom offers many benefits to student learning. According to Lipponen (2002), technology can enhance peer interaction and group work, facilitate knowledge sharing, and distribute knowledge and expertise among the learning community.

By having technology used on a daily basis in the classroom, teachers are improving their practice as well as their students’ learning and knowledge advancement. Researchers (e.g. Keengwe, Schnellert, & Mills, 2012) have demonstrated that technology integration is essential to meet this goal, however the existing technology infrastructures are often insufficient to develop the desired outcomes of these implementations (Greaves, Hayes, Wilson, Gielniak, & Peterson, 2012). Many current classroom teachers have yet to incorporate technology into their teaching practices. Currently, there has been little research (e.g. Fleisher, 2012; Greaves et al.,
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2012) that examines teacher appropriation of the tablets into their pedagogy. Teachers often do not understand or have the time to spend learning about the functionality of the devices.

According to Ifenthaler and Schweinbenz (2013), a majority of teachers are open to integrating tablets and feel they would enhance their practice, but others are not confident about using a new device in their everyday instruction. In addition, how teachers actually integrate devices into their practice is often dictated by school culture (Fleisher, 2012; Greaves et al., 2012). When teachers lack the knowledge of how to use technology, their attempts to integrate technology successfully are often limited (Koehler, Mishra, Kereluik, Shin, & Graham, 2014). Others (e.g. Kim, Kim, Lee, Spector, & DeMeester, 2013) have shown that internal barriers, attitudes, beliefs and efficacy with technology still impact levels of technology integration. With the United States Government distributing Race to the Top funds for one-to-one mobile initiatives developing a protocol for successful implementation of technology would benefit schools, teachers, and students.

Using a TPACK framework (Mishra & Koehler, 2006), this research project examines the classroom practice of middle grades math and science teachers integrating a 1:1 initiative in their classrooms. The following questions guide our research:

1) What types of external and internal barriers exist within the classroom and school environments that influence technology use and integration by teachers?

2) How do internal influences effect teachers’ perceptions of their own pedagogical practices integrating technology?

Background Literature

Currently, there has been little research that examines teacher appropriation of the tablets into pedagogical practices (e.g. Fleisher, 2012; Greaves, Hayes, Wilson, Gielniak, & Peterson,
2012). When teachers lack the knowledge of how to use the technology, they are often less successful when integrating the technology into their practice (Koehler, Mishra, Kereluik, Shin, & Graham, 2014). Many teachers are resistant or not sure of how to integrate technology into their everyday teaching (Greaves et al., 2012). Ifenthaler and Schweinbenz (2013) found that the majority of teachers in their study are open to integrating tablets and feel they would enhance their practice, but some teachers indicated they are not confident in using a new device in their everyday instruction.

Teachers are an integral part of integrating technology into K-12 classrooms. When technology is used regularly in the classroom, teachers’ practices as well as students’ learning improve (Kim et al., 2013). Classroom technology is integrated into content and pedagogical practices at the teacher’s discretion; not all teachers will integrate technology into their practice, and those that do use technology adopt the technology in varying degrees of integration. Typically, teachers who have more student-centered pedagogical beliefs will integrate technology as a part of their classroom whereas teachers who are more teacher-center are more likely to use technology as an enrichment activity (Kim et al., 2013).

Barriers, both internal and external, exist for teachers integrating technology. An external barrier can be described as institutional resources such as having access to available technology, time with technology, technical support, and the technical infrastructure to adequately support technology integration (Hew & Brush, 2007). Internal barriers include attitudes, beliefs and efficacy with technology which all have a large impact on teacher technology integration (Kim et al., 2013). Specifically, one barrier that prohibits teachers from integrating technology into their practice is teachers’ own beliefs, and comfort levels with technology. In an early study by Ertmer (1999), barriers were categorized into two types: first and second order barriers.
Teachers cited first order or external barriers, such as a lack of computers, computer software, and limited access to the internet as reasons why they did not use technology in the classroom (Ertmer, 1999). Second order or internal barriers were not as frequently cited as the main barrier for technology integration (Ertmer, 1999). When Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, and Sendurur (2012) revisited the original study ten years later this trend had reversed. They found that a majority of teachers listed internal barriers such as teacher attitudes and beliefs as the main reason for lack of technology integration. When teachers were “asked to name the biggest barrier, overall, to technology integration in their schools, . . . [majority] described other teachers’ internal barriers” (Ertmer et al., 2012, p.433). Other internal barriers identified in the prevention of technology integration were teachers’ confidence with technology, beliefs about how students learn with technology, and teachers’ perceived value of technology in the classroom. In a one-to-one initiative school many of these first order or external barriers are no longer a predominate issue; however teachers’ second order or internal barriers still inhibit technology integration.

Professional development support in using technology could be an important factor for successful implementation by teachers in their classrooms. The different types of technology available for classroom use pose a variety of problems for teachers; yet, at the same time offer many unique teaching opportunities. In a study by Kim and colleagues (2013), they demonstrated that when teachers had access to technologies, workshops, technical and pedagogical assistance the level of teachers’ technology integration were not the same. Instead, what was found was that teachers’ pedagogical beliefs played a larger role. The teachers who had more student-centered pedagogical beliefs were better at integrating technology as a part of their classroom whereas those who had teacher-directed pedagogical beliefs were more likely to
use technology as enrichment to the lesson (Kim et al., 2013). Additionally, when teachers lack the knowledge of how to use technology, their attempts to integrate it successfully are often limited (Koehler et al., 2014). This built on previous work by Vannatta and Fordham (2004) who found three factors that best predicted how a teacher integrated technology: time commitment, his or her willingness to change, and the amount of technology training.

When examining technology integration into science specifically Guzey and Roehrig (2009) found similar results to Kim et al. (2013). Guzey and Roehrig (2009) observed four beginning secondary science teachers’ technology integration over the course of one school year after the teachers had attended a summer Professional Development focused on technology integration in secondary science. Guzey and Roehrig (2009) found that two of the teachers who had prior experience with technology described themselves as “technology enthusiasts” and were more comfortable with technology overall and looked for more opportunities to improve their technology integration into their science instruction. The same two teachers in Guzey and Roehrig’s (2009) study also exhibited a more student-centered pedagogical style than the two teachers who struggled to integrate technology into their classroom instruction.

One area of research that has not been fully is examined is teacher self-efficacy, a teachers’ belief about their classroom practice (Paraskeva, Bouta, & Papagianni, 2006), or teacher computer self-efficacy, one’s belief about their ability to use technology in the classroom (Mueller, Wood, Willoughby, Ross, and Specht, 2008). Previous research primarily examined teacher self-efficacy and computer self-efficacy with general technology in the classroom. This study will begin to examine a science and math teacher’s efficacy in a one-to-one mobile school and the influence of professional development situated in the classroom on that efficacy.
Qualitatively, this research will examine how a teacher’s perceived classroom technology education differs, if at all, from the observed integration of technology.

Teacher technology efficacy is a difficult topic to measure using traditional experimental designs. Most of the quantitative research for studying teacher efficacy consistently uses descriptive research to help define the phenomenon that is happening. The studies use a sample at one point in time to determine teacher efficacy with technology in the classroom. The studies use a self-report survey to identify teachers’ efficacy with technology (Hermans, Tondeur, van Braak, & Valcke, 2008; Holden & Rada, 2011; Hsu, 2010; Kumar, Rose, & D’Silva, 2008; Mueller et al., 2008; Paraskeva et al., 2006; Teo, 2014; Vannatta & Fordham, 2004; Wozney, Venkatesh, & Abrami, 2006). There are both positive contributions and limitations to using a single time questionnaire to gather data about efficacy. Results from analyzing questionnaire data are easily generalizable to other populations because of the potentially large number of participants in the studies. It is also a way to determine a general consensus of a large group of individuals. A limitation of the single point sample survey method is that the questionnaires are comprised of self-report data. The data collected are representative of the participants’ view of their technology use in the classroom at that particular point in time. Each participant may have a different understanding of technology integration and thus respond to the questionnaire differently because of the differing viewpoints. This could affect the validity of the study through statistical regression, by creating extreme scores on the instrument and through personal variables generated by the individuals in the study. The quality of the self-report questionnaire also impacts the validity of these studies.

In a further examination of the literature, a few studies employed single-group experimental designs. Abbitt (2011) used a single group, pretest—posttest design to evaluate the
relationship between teacher self-efficacy beliefs toward technology integration and the teachers’ perceived knowledge in the technological pedagogical content knowledge (TPACK) domains. In another study, Kopcha (2012) employed the same design to determine the effects of situated professional development on teachers’ technology integration in the classroom. Both studies had the participants complete a pretest and posttest questionnaire. Abbitt’s (2011) participants partook in a 16-week course on integrating technology in the classroom. This study was beneficial because it examined the effect of the 16-week long technology course on the participants’ knowledge and self-efficacy with technology. One impediment to the study’s usefulness was that the study only gathered information about the participants’ perceptions of knowledge of TPACK domains and self-efficacy beliefs. There was not any evidence of demonstrated knowledge of ability with technology. Kopcha’s (2012) treatment was the implementation of situated professional development (PD) provided by the researcher. Situated professional development is when the teacher is an active learner, constructing their own knowledge, and the PD takes place in the classroom practice (Swan, Holmes, Jennings, Meier, & Rubenfeld, 2002). The study used qualitative methods as well as quantitative methods to collect data. The researcher conducted classroom observations of teachers using technology and one-on-one interviews to support the data collected via the questionnaires.

Research focusing on science teachers’ efficacy with technology is limited in scope. Graham, Burgoyne, Cantrell, Smith, St. Clair, and Harris (2009) studied teacher TPACK confidence prior to and after a professional development that focused on science subject-specific pedagogy and biology/earth science content knowledge. Graham and colleagues (2009) used a pre-post test questionnaire related to the four TPACK constructs that involve technology to examine science teachers’ confidence with TPACK. The study found that the highest confidence
was in participants Technology Knowledge (TK), which supports the authors’ notion that TK is foundational to developing confidence in the other three forms of technology knowledge. The participants’ lowest confidence was Technology Content Knowledge (TCK), this could be because TCK is most closely linked with doing science as opposed to teaching science. Educators are more confident in their ability to use technology to teach science (word processing, PowerPoint presentations, internet research) than they are in their ability to use technologies that are designed to do science (digital probes, digital microscopes).

Teacher efficacy has been studied through qualitative research methods, mainly through case studies, cross-examining the case studies, and meta-ethnography. There are a few ways researchers collect their data for case studies. One method is through interviews and classroom observations over an extended period of time (Ertmer et al., 2012; Kim et al., 2013) and by using a specific observation protocol (Looi, Sun, Seow, Chia, 2014). A few studies use the case study method when they are examining teacher beliefs and technology integration, teacher perception of technology integration, and teachers’ journey when using new technology in the classroom (Ertmer et al., 2012; Looi et al., 2014). Ertmer et al. (2012) developed their cases by examining teachers’ class websites using in-depth document analysis and conducting one-on-one interviews with the teachers. Looi et al. (2014) developed cases on four teachers implementing a 5E-Technology oriented science curriculum. The 5E-Technology model is a five-step model in developing lesson plans. The 5Es are Engage, Explore, Explain, Elaborate, and Evaluate. The cases analyzed how the four teachers used the same curriculum and professional development in different ways. Looi and colleagues (2014) used classroom observations as their case data. With each observation field notes, observation sheets, video and audio data were collected.
Cross comparing case studies allow for the researcher to gather data about individuals and find common and contrasting themes from the data. In a 2005 study, Hughes uses cross comparison case studies when she examines four English Language Arts teachers and how they use technology to support their practice. The four teachers have varying years of experience and were interviewed on three different occasions. Three technology-centered lessons were also observed to create each individual case (Hughes, 2005). Each case was presented and then crossed with the other cases to display common themes and trends. This method is beneficial because it dives deeper into teachers’ perceptions and thinking. By using both interviews and observational data the researcher is able to compare teachers’ perception of their practice to teachers’ actual classroom practice with technology. The limitation of case studies is that the teachers are not given a voice. There are no direct quotes from the teachers who participated in the study, which lowers the authenticity of the study. Hughes (2005) does, however, provide very thorough descriptions of the English Language Arts teachers’ technology use and how they compare to one another.

Another example is found in the study by Tondeur, van Braak, Sang, Voogt, Fisser, and Otenbreit-Leftwich (2012). In this study, the researchers use a meta-ethnography to synthesize qualitative data from multiple studies focusing on technology training for pre-service teachers to make new interpretations of the data. Existing qualitative studies were examined to find common themes among the literature. These themes were then synthesized to create a model for teacher education programs to prepare pre-service teachers to use technology in their future classrooms (Tondeur et al., 2012). The study’s aim was to inform the technology education programs already in existence and influence their methods of pre-service teachers’ future technology integration.
This study will attempt to utilize the current research to advance the knowledge about teacher technology efficacy. It will develop an understanding of how teachers currently are using mobile one-to-one technology in the classroom and if content specific professional development increases teacher technology efficacy.

**Theoretical and Methodological Frameworks**

**Design Based Research**

This study is part of a larger design based research project (Brown, 1992) that is examining the use of iPads within specific content contexts. Design-based research emerged from the dialectic between theory and design in research, with theory suggesting an improved design and design suggesting new dimensions to theory. While theory and design can and do exist independent of one another, there is still an inherent connection between them. Design-based research is an iterative process that is based upon outcomes that can impact the modification of instructional practice through monitoring and self-regulation (Schoenfeld, 2006).

According to A.J. Brown (1992), the goals of design experiments are important educational goals. Students and teachers in these classrooms function as researchers, teachers and monitors of their own progress. With the help of technology, they are able to facilitate learning, collaboration and reflection. As a result, these experiments are able to produce data that enables those who are involved to draw warranted conclusions about student learning and what contributes to it.

Scardamalia and Bereiter (1989;1991;1994) have demonstrated in numerous studies that when instruction included the students’ collective responsibility for knowledge generation and content understanding, students feel empowered to take ownership in the discovery and refinement of information. This knowledge building includes ways in which the classroom
environment is designed to focus on:

- real ideas, authentic problems; improvable ideas; idea diversity; working toward more inclusive principles and higher-level formulations of problems; epistemic agency;
- community knowledge and collective responsibility; democratizing knowledge;
- symmetric knowledge advancement; pervasive knowledge building; constructive uses of authoritative sources; knowledge building discourse, and embedded and transformative assessment (Scardamalia, 2002, p.75).

**Technological Pedagogical Content Knowledge (TPACK)**

Technological Pedagogical Content Knowledge (TPACK) is the framework utilized in this study that provides a mechanism for teachers to understand the knowledge required to integrate technology into the classroom (Mishra & Koehler, 2006). This framework allows a teacher to draw on his/her knowledge of all three domains – content, pedagogy, and technology – in a synergistic manner. This framework builds upon the earlier work of Schulman’s (1986) Pedagogical Content Knowledge (PCK) that demonstrates how teachers must draw upon their own knowledge of course content and pedagogical approaches. TPACK allows for the integration of technology.

Previously, professional development around technology has focuses on introducing the affordances of the technology with the assumption that teachers could connect these to their teaching practice. TPACK provides the framework to organize teaching with technology allowing teachers to bring together content, pedagogy and technology. An educator’s TPACK or technology integration knowledge is operationalized when they identify an effective combination of curriculum content, a particular pedagogical approach and a use of a technology tool or resource to support the learning experience.
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Focusing on scientific content, Jimoyiannis (2010) developed Technological Pedagogical Science Knowledge (TPASK) framework based on Mishra and Koehler’s TPACK framework. The TPASK framework focuses not only the technological aspects but includes integration of pedagogical and instructional issues of educators. Jimoyiannis (2010) notes that the TPASK is more than just being a content specialist, or a technology specialist, it means that the science educator has knowledge of all components and how to utilize them in his or her classroom. Guzey and Roehrig (2009) and McCrory (2008) support this notion in their research and emphasize the importance of in-depth knowledge of scientific concepts, as well as the dynamic development of pedagogy and technology knowledge.

Research Design and Methodology

Study Context - School and Students

Caldwell Middle School is an urban middle school in the southeastern portion of the United States. The school is a Title I school with a diverse population (N=647). The demographic profile of the school consists of the following: White 8%, African American/Black 66%, Asian 3%, Hispanic 21%, Native American 2%, Multiracial 2%. Eighty-percent of the students receive free or reduced lunch with 81% being classified as ED, 11% LEP, and 19% are identified with disabilities.

Study Context – Teachers and Classrooms

This study focused on a sixth grade team (Students n=100; Teachers n=4) of teachers across the content areas. Teachers were purposefully selected with the assistance of the principal of the building. After the University Institutional Review Board and the District Research Office.

1 Pseudonyms are used for schools, teachers and students
approved the study design and the proposal, teachers were invited to participate. All members of the sixth grade team agreed to participate and returned the consent forms.

The participants were reflective of the larger teacher population at Caldwell and of the district, predominantly white. This is in contrast to the student population, which is predominately African American/Black. When breaking down the teacher demographics of the school, the following information was determined. Twenty-two percent of the teachers are male and seventy-seven percent are female. A large portion of the faculty is white (63%). The remaining 37% of the faculty are broken down as follows: African America/Black 34%, Hispanic 2%, Native American 0%, Other 0%. Teachers in the building are largely veteran teachers with 14% teaching 0-3 years, 46% teaching 4-10 years, and 41% teaching 10+ years. Ninety-four percent of the teachers at Caldwell meet the federal guidelines for highly qualified, with 39% having advanced degrees. Four teachers in the school are National Board Certified Teachers.

According to the state teacher effectiveness data, 100% of the teachers were proficient or above for standard 1 (teacher leadership), standard 2 (respectful environment), standard 3 (content knowledge), standard 4 (facilitation of learning), and standard 5 (reflection on practice). When breaking down standard 6 (academic success of students), 24% of the teachers did not meet expected growth, 60% meets expected growth, and 16% exceeds expected growth. There is a high degree of teacher turnover of 23% in the school.

Two members of this team were the focus of this study, Jake and Isabelle. Jake and Isabelle were classified as highly qualified teachers with Masters degrees. Both were white, had 5+ years of teaching experience, and were traditional in their instructional approaches, relying primarily on didactic instruction such as lectures and worksheets. Some demonstrations were
presented, but students were not active participants in these activities. Both teachers appeared to have well equipped classrooms with lab equipment for inquiry.

**Data Sources**

Multiple sources of data collection are part of this study. These include: Semi-structured interviews with teachers, circle of influence diagrams (See Appendix A), field notes and observations, teacher lesson plans, and video data. This allowed for the triangulation of the data. The data collected documents teachers’ perceptions and uses of technology, mainly the iPad, in their pedagogy. We examined interview transcripts, field notes and lesson plans and evaluated the data using a constant comparative method (Corbin & Strauss, 2008). Data collection and analysis was an iterative and inductive process. Data was organized into core categories (Corbin & Strauss, 2008), which provided a framework for observing and analyzing teachers' efficacy and use of technology in their classroom. Teacher reasoning was captured through the interviews. As part of these interviews, teachers participated in the construction of a circle of influence diagram. In this diagram, the teachers talked through the influence of different types of technologies on their instructional practice. Using Inspiration software, they moved these technologies towards or away from their circle of instructional practice, indicating the type of influence a specific technology had on their practice. Through a think aloud protocol, additional insight was given to the reasons for the placement of the technology. This data supported and refuted the emerging hypothesis about teachers’ efficacy and use of technology in their classroom practice.

**Data Analysis**

Interview data was transcribed and analyzed using HyperTranscribe and HyperResearch. Members of the research team, including faculty researchers and doctoral students,
independently reviewed data from the larger study and coded the responses using a grounded theory, constant comparative method (Strauss & Corbin, 2008). We developed an initial set of codes that emerged from this open coding. Code lists between researchers were compared and condensed into a draft-code sheet. This draft code sheet was used to code additional interviews. In this second iteration, the researchers looked for codes that were present in the interviews, but absent from the draft code sheet. Coding results were compared and formal descriptions were developed for each code that had a high level of agreement (See Table 1). Discrepancies were discussed and the reasons that they occurred were identified. Once definitions were decided, a third set of interviews was coded and an interrater reliability of $r=0.95$, was established. Cohen’s kappa ($\kappa$) was calculated to show that $\kappa = 0.84$ which indicates that the frequency with which raters agree is stronger than by chance alone. Once final coding schemes were established, the remaining interviews and field notes were analyzed. Data was triangulated across interviews, field notes, lesson plans and classroom observations in order to increase trustworthiness and validate the findings of this study (Lincoln & Guba, 1985).

Once data coding was completed, we reviewed the coded data and further grouped the codes by relating code categories and properties to each other using both causal and generic relationships. This allowed for the synthesis of individual codes into larger, overarching themes. Developing these themes by adding and moving codes was a reciprocal and iterative process. We used these themes to organize and summarize the data through narrative. We discuss these themes and provide examples of evidence in the findings section that follows.

**Results and Discussion**
A number of barriers and influences have emerged from the findings of this study on teachers’ practice and integration of technology into their classrooms. Ertmer (1999) described both external and internal barriers that plagued teachers as they attempt to integrate technology into the classroom. The external barriers focus mainly on infrastructure and institutional barriers that are in place and whose intention is to help support and structure the technology use, though they tend to create more frustration and confusion. The internal barriers are those that are teacher induced and come from each individual teacher’s own personal experience with technology and their own biases. The two teachers, math and science, in this study share the same external barriers but present their own unique individual barriers that prevent their technology integration into their lessons. These barriers and how they influence classroom pedagogy are explored in the sections that follow.

**External Barriers**

Teachers face many external barriers when it comes to gaining knowledge of, access to, and using technology. Though these barriers can be varied it is fact that they will experience some type of barrier (Ertmer, 1999). Ertmer (1999) also found that teachers do not just list one external barrier that prohibits their technology integration but rather a “laundry list” of concerns. The external or Institutional barriers such as connectivity issues, policies on app acquisition, and professional development are a few of these external barriers that create a hindrance for teachers.

**Connectivity** - Having the school infrastructure established to handle the hundreds of iPads that need to be on the Server at any given time is important. Students need to be able to access information quickly and seamlessly. If they are working on a project that requires access to the Internet but the students are constantly inputting their credentials to gain access they will
not be able to complete the intended work. Isabell, the math teacher explained her frustration and why she did not work to integrate the iPads more frequently in her classroom instruction:

- They’ll get stuck at different parts. When I try to put [the document] up they have to re-enter their credentials and this will go slow and . . . the Internet you know connectivity and I’m like oh this is so annoying. I think I am resistant to it because I had, you know, bad experiences when I do try to use it.

The constant inaccessibility appeared to lead to both teacher and student frustration, resulting in a decline in technology use:

- Do I feel like I’ve had a successful iPad experience? No, because even when I feel like it is a good lesson and it is gonna be good. Half of the kids don’t get on and I have to give it to them in a worksheet form...I don’t have time to plan an iPad lesson and a back up lesson.

When teachers must plan for two lessons their focus is not on meaningful technology use that stimulates creative lesson design and student engagement but situates itself in teacher-directed worksheets. The lack of connectivity also limited the overall use of the iPad. A number of the apps that were being used required Internet access in order to run. Without this connection, the apps were rendered useless.

**Professional Development** – Professional development needs to be structured to fit the technology needs of the teachers. Just like with our students and differentiating instruction to fit the needs of different learners, teachers too have different technology integration needs. In previous research, Paraskeva et al. (2006) stated that teachers needed to overcome their resistance to technology by having professional development that is specific to the teachers’
content needs, while Mueller et al. (2008) found that focusing teacher technology learning within a classroom context improved teacher confidence and displayed technology as a potential instructional tool.

Caldwell Middle School has teachers participate in weekly technology professional development. These professional developments were usually comprised of multiple grade levels and content areas. The teachers are presented a skill for the week and in some cases they must use with their students before the next technology PD. The topics discussed were often varied and according to the teachers in the study they primarily focused on dating mining and basic technology skills. Isabell (math) stated multiple times that she would prefer to have professional development tailored specifically to content. However, the majority of the professional development offered at the school were introductory episodes that focused on basic skills needed to navigate a website such as Google docs.

*Umm so [the professional development] are very basic most of the time because we have all different levels of teachers with technology in regards to technology. They are not always that useful for me because a lot of it is stuff you can figure out on your own but I need them more about programs for math, things like that, they are not specific to content. For instance at the beginning it was like here is a Google doc, this is what you can do with it, here is how you can use it for your kids to collaborate...stuff like that, which is like if you’ve been using Gmail you’ve been doing this on your own the whole time.*

Isabell had the most resistance to using technology in the classroom. She did not see the potential of using the iPad with math content or having professional development that provided
examples of how the iPad could potentially increase the iPad’s value to her as an instructional tool. By engaging teachers in content relevant technology professional development Isabell might be able to begin to understand the affordances of integrating a tool such as the iPad. Without content specific examples, however, teachers like Isabell will not see the benefits and instead will focus on traditional pedagogies.

Jake described their professional development as being focused on data mining and other whole group initiatives:

*We have PD all the time . . . a lot of data mining and whole group implementation for things like, for example reading plus, which is an online reading program. But they also want you to be able to mine the data that comes off of it and analyze the data [for student] progress over time.*

While these uses of technology are important for tracking student progress on standardized curriculum it does not improve how the teachers present the curriculum. Jake did not experience science content specific technology PD thus keeping the use of the iPads with respect to science inquiry at a minimum in his practice.

The skills that the current professional development structure concentrated on did not generate a creative or innovative technology environment. Instead, it fostered the belief by teachers that technology is a separate piece of their lesson as opposed to an integral part of lesson construction as suggested by the TPACK framework. Technology was viewed in isolation from pedagogical practices and content knowledge. In many instances, the students could have used pencil and paper to collaborate on their assignment instead of using the google doc.
Jake also experienced frustration at the quality of professional development that was offered at the school.

*We have a surplus of technology and a lack of hands on training. Because for you... for you to have 30 minutes of PD... its not gonna cut it. You almost need a buddy system. Its like you said a coaching model, you almost need a buddy system until you get your feed wet. (Science teacher)*

The teachers’ individual needs were not being met through the current professional development, with both Isabell and Jake seeing little value in the current Professional Development being offered. Both have expressed a desire to continue PD but only if it was structured to fit their needs within their content specific classrooms. Jake and Isabell’s desire to have content specific PD is supported by research in science content and technology integration. Jimoyiannis (2010), Niess (2005), and Guzey and Roehrig (2009) all found that teachers’ confidence with technology integration with science content increased once the teachers had experience using the technology in content specific ways. Additionally, based upon classroom observations, teachers’ at Caldwell had different levels of technology knowledge within the school suggesting the types of professional development that they require would be different. The current structure where only one skill is focused on and pedagogy and content are ignored is problematic.

*Application Acquisition* – Polices and procedures existed within the institution and district for the process of getting Applications (apps) downloaded to student iPads. These policies were another example of an external barrier (Ertmer, 1999) that teachers must overcome when using the technology in their classroom. The current school policy states that teachers
must submit a request for an App to the IT department. If approved, the App is downloaded to ALL of the iPads in the school. There is currently no curricular or grade level differentiation (Field Notes, 2014). Both Jake and Isabell stated on several occasions that having everything exactly the same did not meet all teachers and students’ needs. While there are a few production/creativity Apps that could be used in all three grade levels, content Apps should be varied and tailored to the specific content needs of the grade level. This would account for the TCK, the technological content knowledge specific to each discipline (Mishra & Koehler, 2006).

Additionally, teachers only had administrative access on the “Teacher iPads,” not the students. As a result, if a teacher finds an App they wish to use with their class through their own preparation and exploration, they must go through the acquisition process which can often take up to several months. Because of this time consuming process, teachers did not bother to ask for new apps to be downloaded to student iPads. Frequently, by the time the download process has been completed, the teacher has moved on in their curriculum. Jake emphasized this frustration:

*Applications that I have on my iPad that they [the students] don’t have access to.*

*Kids don’t have it but we [teachers] have it and so it is used for whole class instruction at that point …… They [IT/Administration] do have they tendency to have the school on a lock step . . . they [IT/Administration] wouldn’t want to download one app onto a set of tablets without doing it for the whole school.*

*(Jake - Science)*

This was another example of an external barrier where the IT/ administration imposed curricular decisions across grade levels taking the pedagogical decisions away from the teachers. The barrier issue of control was a highly predominant theme throughout the study. Limits were
set and student iPads were locked down, taking away the ability of the teacher to create lesson plans based upon ideas that emerged from their classrooms. By imposing these types of restrictions it changed the use of the iPads from a one to one, potentially student driven classroom to a whole class teacher driven classroom with the teacher’s iPad connected to a projector displaying the app, taking away from the purpose of a 1:1 initiative.

One example of this emerged during an iterative learning cycle in the science classroom around the concept of sound waves, further illustrating the barriers associated with app acquisition:

*The science teacher became excited about the Decibel 10th App that was being used in the science lesson. The science teacher pulls the technology support administrator into the classroom to discuss getting the App put on student iPads for next year. The tech support administrator seems skeptical and reluctant to confirm that the Decibel 10th App could be downloaded. The researcher indicates that the App is free and the tech support administrator then notes that he does not like free apps because of the ads. The researcher assures the tech support administrator that there are no ads. The Tech support administrator then wants to know about in app purchases. The researcher again confirms that it is completely free.* (field notes)

Jake was excited about the student-inquiry lesson that was presented in his classroom and wanted to obtain the app for future inquiry labs. The reluctance of the tech support administrator to support the teacher in his excitement for the app is an additional barrier to teacher’s technology use for lesson construction. It further perpetuated the denial of access to technology tools that
teachers’ want and need to improve technology integration in their classrooms and contribute to student science learning. The denial of access prevented Jake from envisioning other inquiry labs with the iPads in his classroom; Jake continued to rely upon worksheets, concept maps, and demonstrations to present the science content, continuing the trend of passive student engagement.

**Internal Barriers**

Teachers may also have internal barriers that prevent them from utilizing technology in the classroom. Recall that internal barriers are those barriers that come from each individual teacher’s personal experience with technology as well as their own biases and could be even unknown to the teacher that they exist (Ertmer, 1999). Internal barriers are much more personal, more deeply ingrained, and may require a pedagogical change in the individual over time in order to overcome the barrier (Ertmer, 1999). These reasons make overcoming internal barriers much more difficult than the external barriers previously discussed. These barriers can include, but are not limited to, teachers’ own knowledge about technology, teachers’ perception of their technology practice and the value placed upon the technology itself.

[Insert Figures 2 and 3 about here]

**Technology Knowledge** – Technology knowledge in this study is defined as what the teachers know about technology available for classroom use. Technology ranges from the actual device to the various programs, apps, and websites that are available to support the device. Information is readily available, however many teachers do not understand how to use the technology in classroom settings. In a study by Koehler et al. (2014), the researchers found that teachers’ lack of technology knowledge often limits their attempts to integrate technology
successfully. Both the science and the math teachers in this study cited several of these reasons to justify why they were not integrating iPads into their instruction. These reasons included not knowing what apps were available, the lack of time to learn these new technologies (apps), and better professional development. Additionally, Jake and Isabell, through the course of their interviews, were not aware of many of the different forms of technology present on the circle of influence (See Figures 2. and 3.) In these instances, these technologies had to be described to them. When further pressed, they also demonstrated a misconception of how these technologies could be used to improve their pedagogical practices and support the development of content knowledge, as shown by Jake:

Jake (science teacher): Ok virtual worlds...would that be like a sim simulation?

Interviewer: It could be a sim simulation, it could also be something...have you ever heard of Quest Atlantis?

Jake: Quest for Atlantis?

Interviewer: No, Quest Atlantis

Jake: Quest Atlantis, I’ve not heard of it.

Interviewer: of Whyville?

Jake: I’ve heard of both of them but I’ve not figured out how to incorporate them in the sciences yet...in regards to computer and video games...I would say that um...I would say that I use that to some extent...We’ve used um...we’ve used Destination Math or Destination Success.
Jake contradicted himself during the interview and demonstrated that he had little knowledge of how simulations and virtual worlds that could be utilized in the science classroom. Two virtual worlds, *Quest Atlantis* and *Whyville*, were mentioned that have science components embedded into them. For example, in *Quest Atlantis – Taiga*, students investigate a fish kill in the river system, analyzing water samples and making observations and predictions about the surrounding environments (e.g. Barab et al., 2005; Barab et al., 2007); however, due to Jake’s limited knowledge about this available technology he states that he has “not figured out how to incorporate them in the sciences yet”. With a better understanding of the affordances of these technologies he might be able to recognize that he did not have to incorporate the worlds, but, instead, work to decide which parts of these worlds fit the needs of his classroom and students. Jake also mentioned *Destination Math* and *Destination Success*, which are math and reading curricular programs that are not simulations or virtual worlds. These two programs were, in fact, not related to science curriculum at all.

Jake’s limited knowledge was echoed in his comments about professional development. He stated on numerous occasions “we have a surplus of technology and a lack of hands on training”. This is a key point in successful technology integration. Previous studies have suggested that teacher professional development needs to be technology and content specific (Mueller et al., 2008; Paraskeva et al., 2006), hands on (Judson, 2006; Paraskeva et al., 2006), and promote positive interaction with the technology (Kim et al., 2013; Mueller et al., 2008; Vannatta and Fordham, 2004). It was clear from his interview and observations that this was not occurring at Caldwell.

However, with the research team Jake did experience several examples of how to integrate technology with science content. The first model lesson was an inquiry focused *Sound*
Inventory where students used their iPads (e.g. Decibel 10th App) to collect and analyze sound data from around their school. The lesson was implemented by the research team and was structured such that students developed argumentation about sound levels in the school. The second iterative learning cycle involved inquiry lessons on plate boundaries, movement, and the resulting physical land features. For this learning cycle Jake and the researchers planned the lesson together, giving Jake more opportunity to become familiar with different ways to create an inquiry lesson utilizing the iPads. Jake chose the app Puzzling Plate Tectonics to be the main component of the inquiry lesson. The app provided multiple modalities in presenting information about plate boundaries, movement, and the resulting physical land features. Due to the design of the app, students could work at their own pace in partners. They were given initial instructions and had a handout that helped guide the students through the different phases of the app. In this cycle, researchers modeled the inquiry for two of the classes with Jake implementing the lessons in the rest of the classes. These two experiences were situated in Jake’s classroom and he was involved in the planning and implementing of the technology infused science inquiry lesson. These offer two examples of the type of models that teachers can benefit from in increasing their technology knowledge with respect to content.

Likewise, Isabell exhibited limited technology knowledge similar to Jake but with respect to available math simulations and manipulatives as was demonstrated in this conversation:

*Simulations...tell me what you mean by that....So if you are relating that to math I could say like when we use like online manipulative...when I know of them...I Google... I don’t know of any [programs/simulations] There is one program and I’d have to look it up cause I used it last year. . . I forget what it is and I would*
have to go in my files to find it. Whenever I’m teaching things I Google so it’s not like I have a set list that I could go to for manipulatives. (Isabell – Math teacher)

Isabell needed a description or definition of a simulation; she then compared it to an online manipulative which she expressed interest in using. Her main problem was a lack of knowledge about math manipulative resources. She also stated that she “googles for resources” when she needs them but does not have nor does she know of a list of mathematics technology resources.

Teachers’ technology knowledge is not only limited to simulations, it transcended to what they considered technology. Items such as cell phones, DVR, TV were not considered technology; only computers, laptops, and tablet devices were seen as technology. This led Jake to note that he only spent 15% of his time with technology and the Isabell, 25% of her time. This was in spite of the fact that they both indicated that they constantly are on their laptops, using their cellphones, and DVR multiple television programs. Isabell even noted that she streams live sporting events through the Internet when the events are not available to watch on television, all of which qualify as technology use. The affordance of using everyday technology in the classroom was not apparent to either of these teachers.

Perception of Technology - Teachers own ideas or perceptions of how the technology could be used in the classroom was a second internal barrier. When teachers only see the technology as a tool they must use as opposed to a device that could enhance their instruction it limits the use of the device. Isabell demonstrated an example of this perception barrier in her views of using both the iPad and the Smartboard in her classroom to aide in instruction. From
her perspective, there is still a lot of value in paper and pencil practice, something she did not necessarily see in either the Smartboard or the iPad:

"Smartboards, ... I don’t um use them as much as I could because I don’t feel like I don’t have the knowledge of them in depth to use them as much as I could in a math classroom. Because I feel like if I’m gonna be really utilizing technology, Smartboards I feel like are more beneficial to me than the iPads at this point in time...but I don’t use it as a Smartboard, I use it as a projector."

Isabell’s perceptions about the integration of both Smartboard and iPad technology could be connected back to her lack of knowledge. Despite this, she still felt that the Smartboard technology was more valuable piece of technology than the iPads, even though she was only utilizing it as a projector. In classroom observations, Isabell did not use the Smartboard function during instruction. Upon inspecting the Smartboard pens the batteries were dead and the Smartboard software on her computer needed updating. The possible uses of the Smartboard had been diminished due to the lack of upkeep and knowledge about how to maintain and use the technology.

Isabell was not aware of the affordances of the iPad beyond a note-taking tool. She mentioned during the interview that the students could not take their iPads home; because of this, taking notes on the iPad in class would not be effective since students would not have access to them while working on their homework. This type of use also established a very teacher-driven style classroom, one where the teacher is the keeper of the knowledge that must be then be distributed to the students by the teacher.
Jake had a similar teacher-driven pedagogical approach to teaching. During instruction, Jake conveyed information, typically vocabulary, to the students. There was very little opportunity for science inquiry where students could explore and move at their own pace to discover information for themselves. Jake was observed performing demonstrations for his students on a few occasions.

Jake stood at the front of the classroom and did an experiment as the students watched from their desk; occasionally Jake would call upon a student to assist him. For example, during a conduction lab students were given the opportunity to feel the different utensils that had been sitting in the boiling water. Students were instructed to take notes on their iPad about what they had observed. Later that week students used the Poplet app to create a concept map about conduction, convection, and radiation. (Field Notes, 2014)

Jake’s teacher-driven pedagogy limited the use of the iPads in his classroom. Though as the school year progressed and Jake had the opportunity to experience different iterative learning cycles with the research team his pedagogy was observed to be moving slightly towards a more student-centered instructional approach.

Perceptions of Practice vs. Actual Practice - Individual barriers can also include the teachers’ perception of how they and others around them are using the technology in their classroom instruction. What was observed was that the teachers’ perception of how they use technology was often different than their actual practice. The teachers’ perception of others technology use also varied based upon how teachers viewed and valued technology in classroom instruction.
During Jake’s Circle of Influence Interview he indicated that iPads, QR codes, and specific websites such as Bob the Alien, Enchanted Learning, and Pete’s PowerPoint Site were the most influential technology pieces on his teaching practice. Jake placed these four items the closest to the circle, which indicated a higher influence on practice (See Figure 4). He justified the placement of the iPads due to the fact that “we are trying to be a one on one.” Jake uses a similar superficial justification when he moved the QR codes close to his circle of influence.

*QR codes are actually interesting because you’re suppose to be 13 to actually access them. So, my kids are not 13 and you will see a disclaimer that says you need to be 13. You have to be able to do the consent thing….I will put the QR codes pretty close by even though there is that disclaimer. The kids really enjoy the QR code, the technology of being able to scan something.*

Jake described the technology as something the students’ enjoy, however the use of QR codes have not been observed in Jake’s classroom. Jake’s indication of websites that influence him are different than the observed websites. During Jake’s interview he indicated that Bob the Alien, Enchanted Learning, and Pete’s PowerPoint were a few sites he visited regularly and used for his classroom instruction. These websites were not the websites that were observed being used in his classroom. Jake regularly used Brainpop, Discovery Learning, and Quizzlet to support his instruction (See Figure 5). Jake also used AAAS, a question creating web-source that creates test questions aligned with the state end of year exam. On a regular basis Jake was observed using his Laptop, the Internet, and video clips to support his instruction. Despite this,
he did not indicate these items as being influential components of his classroom pedagogy on his circle of influence.

Likewise, Isabell had anomalies between her circle of influence placement and the observed use of technology in her classroom. Isabell stated in her interview that she uses her laptop and Smartboard mainly as a projector during her classroom instruction, which was observed multiple times upon visiting her classroom. These along with the word processing program were the only forms of technology observed during classroom visits. Isabell designated on her circle of influence that many different forms of technology such as podcasting, social media, Smartboard, and the Internet were very influential on her teaching practice. These forms of technology were never observed being used for classroom instruction. As noted earlier Isabell did not know what simulations were, though she placed this item relatively close to her circle of influence in comparison to things such as QR codes and calculators which she has used previously with her students (See Figures 6).

[Insert Figures 6 and 7 about here]

Through the interviews, both teachers indicated that iPads were very influential for their teaching, but at the same time, Isabell specifically stated that she did not see how the iPad could be used successfully in math instruction:

*Technology is difficult to use in math class because the students need to work out the problems and I really do not see a reason why the iPad needs to be used everyday.*

The perception that math always had to be worked out on paper was a barrier for Isabell. She did not see the potential for teaching and learning math in a different way. Isabell did show
an interest in using more technology, but only if she deemed it the best possible means for instruction as was shown during the interview:

*I would like to see, you know that I feel like I can do every piece of my lesson that needs to be done you know that the technology is the best means for it to be doing it on there.*

Isabell was not convinced that technology, in this instance – the iPad, was the best way to teach her curriculum content. Her perception of good mathematical pedagogy was that math would be best taught through direct instruction with notes and practice problems. Jake, however, did see value to using the iPads in his classroom and content area, which changed over the course of this study. Jake attempted to use the iPads to have the students create concept maps, complete web-quests, and play games through the website Quizzlet. During the interview Jake talked about an Internet site that could be used in his class that used the technology in different and unique pedagogical context.

*And this was something that was brought to my attention last year during a teacher conference, a science teacher conference. They have an app or a platform or a website called fakebook that’s very similar to Facebook, its done on the same model, the same structure. But you would like pick up a personification of something. Like maybe you would pick up the personification of sound and that would have sound’s friends and who sound has been in contact with and little conversations that go back and forth, likes and dislikes. I haven’t spent time to explore it but it seems like something that the kids would enjoy.*
Jake identified that this unique platform would be something the students would enjoy and it would be integrating the technology in a unique way. However, Jake has not used this identified format in his classroom. Instead, he has stuck to having students create concept maps using the Poplet App. The science content web-quests that Jake had his students complete dealt mainly with identifying information through web searches. We have observed over the course of the school year that he has been using the iPads more but stays within his area of pedagogical comfort. Despite this increased integration of the iPads, Jake still valued other forms of instruction over this integration:

*And we do use the Internet quite a bit. One thing that I like to do is I like to do a web search and find something that is going to be kid friendly. Cause it really is what I talk to the kids about, its um….there’s times where I tell them you really need to be using this book [points to textbook] because the book is tailored for a 6th grade reading level.*

Jake still holds more value in using the science textbook than on using the plethora of resources made available through the iPads. The reliance on the same activities displays Jake’s reluctance to move from his comfort zone. He is willing to try to use the iPads more in his science classroom but he is not ready to make a transition to implementing the iPad in an inquiry centered way. Niess (2005) suggests that because teachers have limited experience with learning their subject matter with technology they tend to rely on more traditional methods within their classrooms. The focus on using the science textbook, which is outdated, as a good source of information because of the reading level further, exhibits Jake’s lack of available technological knowledge and experience with learning with technology. By increasing his knowledge of the available Apps, iBooks, and resources on the Internet that exist at a suitable reading level for his
students, Jake may find himself less reliant on the outdated textbook material. It may also broaden Jake’s integration attempts as he becomes more familiar with science content through the use of technology.

**Value of Technology** – In a 2005 study by Hughes, it was determined that when teachers experienced more content-specific examples in workshops and professional development, they were more likely to see the value of the instruction and replicate it in their own classroom. How technology is valued at Caldwell Middle School has created an interesting dynamic between technology use and pedagogy. According to both Jake and Isabell, the teachers have been instructed by the administration that the iPad should be used 45 minutes a day during the 60-minute class period. There is however, no emphasis on the pedagogical quality, instead the focus is on the technology and the duration of use. Isabell indicated that she felt as though she was “the slacker” of her sixth grade team because she did not have the students use the iPads as much as the other teachers on her team. When asked to elaborate, she did not indicate what types of instruction the other teachers were engaging with the iPads; instead, she only mentioned that both the English Language Arts (ELA) and Science teachers appeared to constantly have the students working with iPads in front of them. This brings us to question, would instruction improve with content specific pedagogical coaching? Jake stated:

*There are sometimes that I find myself trying to just come up with an activity that will use the iPad where something else could be just as effective if not more effective.*

Isabell voiced similar concerns:
I have no problem with using it all the time; I just need to feel like it’s the best way for them [the students] to be learning the concept… You’re told you need to use it [the iPad] so often and I honestly…and people disagree with me, I don’t believe it should be used everyday anyway in the math classroom. I think that there is value to doing things on pencil and paper and having them [the iPad] with you at all times and I was overwhelmed. And I’m still overwhelmed this year because they’re [administration] saying they’re going to be coming in and watching and I’m not using it nearly as much as I should be using it.

She also stated multiple times the difficulty that students have with the curriculum. She believed that ensuring that she covered the necessary objectives was most important to her as shown below:

If it’s between me getting the curriculum done and me going further and doing something fun, I’m going to choose getting the curriculum done. Which is an issue I run into…But I feel like by the time I would be ready that they would be ready to do it… I would be like ready to move on… We just have a huge curriculum our kids are very behind… and it takes just so much to get them to the basics, which is a problem with my teaching in general. Because I need to be doing more higher level and I can’t always get there. . . Sometimes you can start out higher level but a lot of times you need to get them there.

Until direct connections to the content areas are made for the integration of technologies, such as iPads, as a pedagogical tool, teachers like Jake and Isabell will continue to push back against the integration, relying on traditional methods and pedagogies.
Conclusions and Implications

During the early phases of this design-based study, themes have emerged from the science and math classrooms that provide insight to the implementation of 1:1 iPads at Caldwell Middle School. An analysis of this early data demonstrated rudimentary evidence of both external-first order and internal-second order barriers (Ertmer, 1999; 2012). This study suggests that science and math teachers, despite working in a 1:1 environment, still face many of these barriers when trying to integrate technology into their pedagogical design and practice. Data demonstrated that this was particularly evident in the classrooms of Jake and Isabell. External-first order (Becker, 1994; Ertmer, 1999; 2012) barriers such as connectivity, app acquisition, and lack of adequate professional development became sources of frustration for Jake and Isabell and were typically reflective of the school at large. These frustrations created deterrence from further integrating the iPads into instruction, thus negating the potential affordances the iPads were meant to provide. Challenges like these led Jake, Isabell, and the other Caldwell teachers to view the iPads as an external, and often irrelevant, component of their instruction.

Further, our findings suggest that internal barriers created obstacles to iPad integrated teaching. This was particularly evident in Jake’s science classroom. Internal barriers (Ertmer, 1999; 2012) including efficacy, beliefs and values of technology impacted how TPASK /TPACK (Jimoyiannis, 2010; Koehler & Mishra, 2006) was carried out by Jake through his practice. While Jake exhibited strong efficacy with respect to his science knowledge (CK/SK), this was not observed in either his technological knowledge (TK) or in his pedagogical knowledge with respect to constructivist, inquiry-based practices of science. There is an implicit assumption that science knowledge and its subsequent pedagogy will unfold organically. This, however, was not the case with Jake. Jake’s classroom was teacher centered; rather than have his students...
participate in open-ended inquiry, he would demonstrate inquiry experiences for them, creating a passive learning environment where students did not engage with science. Hands-on science became hands-off. His limitations resulted from his own internal barriers (e.g. efficacy or confidence) in both pedagogical knowledge (PK) involving inquiry and technological knowledge (TK) integrating iPads. This impacted how the iPads were integrated into his classroom instruction. While not as prevalent, Isabell exhibited similar barrier issues with respect to technological knowledge (TK). These ideas are supported by the literature on TPASK (Jimoyannis, 2010), TPACK (Koehler & Mishra, 2006) and institutional barriers (Ertmer, 1999; 2012).

Additionally, from our analysis, a dichotomy emerged between teachers’ perceptions of technology integration and observations of practice. Technology applications, like the QR codes noted by Jake, were frequently described in interviews, but were overwhelmingly absent from practice. This again can be traced back to Jake’s efficacy (Ertmer, 1999; 2012) as it related to both technological knowledge (TK) and pedagogical knowledge (PK) (Jimoyannis, 2010; Koehler & Mishra, 2006). We also posit that teachers, including Jake and Isabell, understanding of the interactions of content knowledge, technological knowledge and pedagogical knowledge resulted in integration of the technology in ways that did not always enhance the science content learning. While at this stage of our design study we cannot definitively assess student learning, we have observed that when new applications (TK) and methods (PK) were introduced and modeled in their classroom, teachers like Jake and Isabell began to extend their practice beyond their traditional comfort zones, creating new classroom environments that engaged their students differently from what we had previously observed. Students moved from being passive participants to active science learners. We observed this with Jake after the Sound Inventory and
Plate Tectonics inquiry investigations were modeled and implemented in his classroom. Following these iPad-integrated implementations, we noted that Jake began to integrate the iPads more frequently in his pedagogical practice. While his choices were still limited, and often became teacher directed, he was beginning to demonstrate increased confidence and efficacy thereby decreasing his internal barriers to technology integration (Ertmer, 1999; 2012). This suggests that content specific professional development and support that focuses on science content, technological knowledge and pedagogy is important to the successful integration of technology in science classrooms. We believe that given the appropriate scaffolding teachers, like Jake and Isabell, will develop their efficacy in both their technological knowledge and pedagogical practices resulting in more engaging learning environments for their students.

The Next Generation Science Standards (Achieve, 2013), call for an increase integration of technology to emphasize the relationship between science, engineering and technology. This is relevant in the science classroom, where technology plays an important role as a tool for scientific inquiry, visualization of abstract concepts, developing models and communicating ideas to others (Park & Slykhuis, 2006). Our teachers did not necessarily see this relevance due to the barriers that they perceived, both external and internal. Externally, teachers in our study still had issues obtaining apps necessary for science instruction. However, internal barriers were most pervasive in their integration of the iPads into instruction. Issues of efficacy (Ertmer, 1999; 2012) with technological knowledge and pedagogical implementation of the technology (Jimoyiannis, 2010; Koehler & Mishra, 2006) were at the forefront with all of our teachers, resulting in inadequate integration of the iPads. The belief that students could learn through this integration and the teachers’ value of its use in the classroom was disconnected from administrative demands. Jake and Isabell, like many others at Caldwell, would integrate
technology to fill a demand rather than enhance instruction. While the importance and value of technology was acknowledged in everyday life experiences, the teachers did not always make the connection to classroom practice.

We posit that the primary affordances of tools like the iPads in this 1:1 initiative in science and mathematics classrooms may be their power to engage students in the use of tools that provide mechanisms and contexts to think through complex science topics. The challenge may be, in moving forward, that teachers do not always see these devices as tools that can enhance their pedagogical instruction in these areas. The key will be to help those individuals, through content specific professional development and scaffolding, to recognize the power that these tools provide. While still in its early stages, we see the possibilities emerging from Jake’s response to early modeling-implementation cycles; we do believe that given the right supports, the iPads can be used as a way for teachers to engage students in science learning. Though we have not yet found the ideal way to bridge this gap in integration, these findings will help us to continue to refine the practices and integration of the iPads as an instructional tool in science and mathematics classrooms with teachers like Jake and Isabell.

This study provides us with early insight into how tools, like the iPads found in this 1:1 initiative, can help teachers, specifically science and mathematics teachers, engage and enhance student learning. It also provides us with insights into the challenges that have emerged in the classrooms of schools that are implementing these initiatives. It is our hope that continued work in these classrooms will help reveal the areas of professional development that are necessary for successful integration in science and math classrooms. Future studies should seek to examine the impact of identified professional development experiences on how teachers integrate and utilize iPads in their classroom. We also aim to analyze the impact on student learning in science
and mathematics, examining the connections between technology, content and student understanding. In closing, we believe that this study suggests that content based professional development for iPad integration may be beneficial in helping teachers to think about TPASK/TPACK, creating the opportunity for enhanced integration of the iPads within science instruction.

References


