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Tablet Usage in Secondary Mathematics Education and Recommendations for Improving Its Effectiveness in the Classroom

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Abstract

As part of my honor's thesis project at Assumption College, I have been researching the ways that teachers are currently using tablets in their secondary mathematics classrooms. My thesis compares the benefits and drawbacks of having tablets in classrooms, tablets for every student, or no tablets at all. In the spring, I collected survey feedback from mathematics teachers in four different local school districts. I analyzed the data in order to determine the ways tablets are being used in classrooms, the reasons preventing teachers from fully integrating tablets into their instruction, the impacts training has had on tablet use, and what can be changed in order to make teachers more comfortable with integrating tablet technology. Teachers' main problems were lack of resources, lack of preparation time, and lack of training. This thesis provides evidence that enforces the idea that with proper training, the other obstacles that keep teachers from integrating tablets dissipate and allow for teachers to effectively use tablets as a supplemental tool that increases adaptability, efficiency and engagement and enhance learning in the classroom as a whole.

Introduction

Picture this: a student is struggling to understand the meaning of "congruent" on a math homework assignment. Now picture that same student doing homework with a stylus on the tablet and coming across the word congruent. The student taps on the word and the definition appears on the screen. Similarly, a student having trouble visualizing a sine graph can use their tablet to watch an animation instantly or open a graphing program to plot points and see how one is made. In the past five years, tablets have changed the technology market as well as the classroom. When teachers integrate tablets into their classrooms, the students have an enhanced learning experience that can improve their understanding of the subject.

Tablets are writing pads that use digital ink technology to provide a screen that responds to touch with writing and other actions. These devices have all the capabilities of computers with increased portability. The first tablet was called the RAND tablet, released in 1962. This tablet was connected to a monitor, where the writing would appear. Despite its debut in the 1960s, tablets did not become a for-sale product for the average user until 2010, when production skyrocketed. Data from the Statista (2014) shows that tablet sales went from an impressive 10.8 million sold to an astounding 57.3 million between 2010 and 2014 in the United States alone, and is expected to reach 60.1 million sales by 2016.

The term "tablet" can refer to tablets or tablet PCs, which are both multifunction portable devices. Tablet PCs often include keyboards, such as the Microsoft Surface. For the sake of consistency, I will be using the word "tablet" whenever I refer to either of these machines. Some types of tablets that are currently popular are the iPad Air, iPad Mini 2 with retina display, Google Nexus 7, Sony Xperia Tablet Z, LG G Pad 8.3, Google Nexus 10, Microsoft Surface Pro 2, Apple iPad mini, Amazon Kindle Fire HDX 7, and the Samsung Galaxy Note Pro 12.2

(Prasuethsut, 2014). Tablets have only recently been incorporated into classrooms, and even more recently, schools have started adding one-to-one tablet programs, where each student and teacher have a tablet. Although tablet use in schools is more prevalent than ever before, it is generally not being utilized in the best ways possible, due to teachers' lack of knowledge and confidence on the ever-expanding field (Gentile, 2012).

It is only recently that there has been an increase in both the production and sales of new tablets. From 1962 to 2010, 29 tablets were released, making the number of tablets produced each year less than one, about 0.6 per year. From 2010 to 2014, a four year span, 32 tablets came onto the market, bringing the number of types of tablets to eight per year (McLellan, 2014). With the sales and consumer products rising so rapidly, tablets have become a disruptive technology. Disruptive technology, as defined by Clayton Christensen in his book *The Innovators Dilemma*, is a technology that is initially not as good as current technology but then grows to replace and surpass incumbent technologies. Tablet technologies are displacing laptop PCs, and sales are only continuing to grow.

Another process the tablet is beginning to disrupt is the traditional method of classroom education (Pambudi, 2013). Mathematics teachers in secondary school have been working on establishing ways to integrate technology into their classrooms. From the graphing calculator to the interactive whiteboard, technology has enhanced the productivity of the classroom and has provided students with more resources for learning. Within the last five years, tablets have been added to this list. The structure for tablet integration can be one of two types: one-to-one and classroom-based. In a one-to-one tablet structure, each student and teacher has their own tablet that they are allowed to keep. In a classroom-based tablet structure, the teacher has tablets to distribute to classes throughout the day as needed (Jackson, 2009). Typically, tablets in the

classroom–based setup will be stored in a charging cart, which can be wheeled around the room or from classroom to classroom. For simplicity, I will refer to classrooms with this tablet structure as cart classrooms. Although tablet integration has become a growing practice within the last five years, there is little research on how tablets can be used in secondary mathematics classrooms. Moreover, many teachers are either unsure about how to integrate the tablet or feel it will hinder their teaching. This study will focus on what needs to be done to help teachers more effectively integrate tablets into secondary mathematics education to enhance learning, improve efficiency, increase engagement, and heighten adaptability.

Overall, students' learning experiences can be enhanced by the incorporation of tablets into classroom instruction in order to help them understand a topic on a much deeper level. However, teachers must be conscious of the misconception that tablets are "magic learning machines" that can completely replace traditional pencil and paper mathematics learning. Tablets need to be used in the right place at the right time (Russo, 2014).

I have witnessed firsthand the benefits of using technology in many classes throughout my school career. In one course, the use of TI Calculator Navigators allowed the entire class to enter answers into their calculators, which were then displayed anonymously on an interactive whiteboard. This helped my class gain a deeper understanding of the content because it provided instant assessment and feedback. In this way, the teacher was able to immediately address common mistakes and explain how to avoid them. I also benefited from my teacher's use of an overhead projector in my high school geometry class. In this class, my teacher would write the notes on transparencies and we would follow along. In doing this, she modeled note taking that effectively appealed to the student perspective. (This is similar to a technology I use now in college called a document camera, which projects 2- and 3-dimensional objects, in color, onto a

screen.) Integrating technology into instruction allowed me to better process the information because it enabled the teacher to pair her speaking with her written notes. This helped my sensory memory and organization, as I was able to directly follow the teacher's notes in my own. The notes then helped me easily recall the connections my teacher was trying to convey in the classroom by activating my memory in the same way it was during class. I have had positive experiences with growing technologies, and these experiences have motivated my desire to determine how tablets can be used beneficially for students in high school mathematics classes.

Additionally, I am studying to be a secondary mathematics teacher and have been inspired by the use of technology in classrooms. Not only do I wish to help other teachers by adding research on the best uses of tablets, but I also plan to integrate these techniques into my own classroom. This study is relevant to teachers, parents, and students. When a tablet is integrated successfully and used as a supplement to traditional teaching methods, students may have a more enjoyable as well as heightened learning experience. Furthermore, the integration of tablets and online schooling systems gives families constant access to students' grades and homework assignments. Classroom materials such as textbooks are also available to students from different resources on their tablets.

This thesis introduction was hand-written on my iPad. I used script conversion technology, converted it to text, and copied it into a text application. The hybrid nature of my iPad, with the portability of a small notebook and pencil but the technology of a laptop computer, granted me the ability to write from any location effectively and efficiently. Script conversion technology is only one of many functions a tablet possesses that can enhance secondary mathematics learning. The tablet can enhance student learning experiences in ways no other technology has offered before.

Literature Review

Technology Use in Mathematics Classrooms

Technology use in the mathematics classrooms is rapidly growing. From the addition of the scientific graphing calculator in 1995 into Advanced Placement mathematics classes, to a current teaching method called flipping the classroom (when a student watches videos of the lessons and studies the work outside of class, then comes into class with questions and homework). These are just some of the ways that technology is becoming more commonly used in the mathematics education environment (D'Orio & Wojciechowski, 2014). This new development in education is bringing up many questions about how and why technology should be used in the classroom. Holden, Ozok, and Rada (2008) found that teachers primarily reported using technology to increase the productivity of their classrooms through usages related to keeping attendance, recording grades, and providing drill and practice. According to Posamatier (2002), due to the advancements being made with technologies and their applications for the classroom, drill and practice does not accurately show the potential learning possibilities that technology can add to a classroom. Technologies can be beneficial for the actual learning, as opposed to merely practicing learned concepts.

When technology is utilized, it has the power to transform a classroom experience. Programs and studies are being developed to test whether or not technology has the ability to better student learning. One such program, which examined nine middle schools in Maine, discovered that, in mathematics classes where technology was used effectively, grades were moderately higher by the end of the school year, as if students had received two extra months of mathematics schooling over the course of two years. Thus, the use of technology showed a positive impact on student achievement (Oliver & Corn, 2008). Utilizing technology in the

classroom can allow students more time to develop and absorb the concepts teachers want to instill in students. Through integration of technology, students can develop a better understanding of math as a whole as well as its connection to other subjects (Toumasis, 2005). Technology can do much more than improve test scores. School experience overall can become more enjoyable, leading to increased attendance. Schools should incorporate technology to: enhance students learning experiences, engage students in more effective activities, increase efficiency for teachers, and adapt to all students' learning needs (Oliver & Corn, 2008).

According to Holden, Ozok, and Rada (2008), Owre (2006) discovered that the teachers they surveyed used technology for the main purpose of drill and practice. Moreover, only 31% of the teachers used technology daily. Two years later, Holden, Ozok, and Rada (2008) found that the main reason teachers were using technology was for their own instructional purposes rather than the students' benefit, such as grading papers and taking attendance. When these teachers were asked if they would like to see more technology use in their classroom, 65% agreed. Researchers found time, training, and preparation constraints to be an obstacle to teachers' technology integration. Due to the large percentage of teachers that are showing strong interest in this topic, the next step should be addressing these problems.

Factors negatively influencing technology integration. Despite all of the benefits of technology use, there are limitations that have severely reduced the advancement of implementing new technologies and programs into mathematics classrooms. These limitations include the cost, concerns about misuse, training needed for integration, and reliability of new technologies. The cost of equipment, such as iPads or document cameras (used to display written documents onto a screen), is a big limitation for many schools. However, it is rarely addressed with more than a sentence in most articles because these studies would not have been conducted

without the availability of the technology to the researchers. Many schools do not have the money to invest in a tablet for every student. Grants that provide funding to buy these devices are available to schools, underscoring the ultimate goal of improving their students' learning experiences.

Even when the technology is available, many teachers are concerned with their ability to control student misconduct involving technology. The ability to customize and instantly alter the content on tablet technologies provides users a constant feeling of amusement, which can make it hard for teachers to use them as an instructional tool, especially where teachers are unable to monitor their students' screens (Hennick, 2014). Students must be able to ignore distractions that technology can provide and focus their attention on the technology's instructional purpose (Russo, 2014).

One common misconception is that supplying teachers and students with technology will be enough to successfully implement new programs that will enhance learning in classrooms (Holden et al., 2008). Many programs that have been approved by grants, or have become a large investment for the school, ultimately fail. In reality, teachers must be taught how to use the technology, be able to show the students how to use it, and be able to decipher where it is best applied within their lessons. When asked about why they do not implement technology, teachers admit that they are afraid to use something when they only possess a limited understanding of it. Teachers need to be instructed on how to use the technologies, as well as be kept up-to-date on the latest technologies and how they work (de la Cruz, 2013). We also need to make sure that the training that is being implemented is enough so that, when the training concludes, the teacher is ready to integrate technology into their teaching (Toumasis, 2005).

Another factor limiting teachers' technology use is its unreliability. Sometimes, technologies fail to work with no explanation. In order to prepare for this ahead of time, teachers must think of something to replace the lost activities (de la Cruz, 2013). Having a back-up plan for every lesson would be as if the teacher were planning two full lessons for every one lesson they taught. This is extremely time consuming and thus, can make the idea of technology very unappealing to teachers when they are looking for ways to improve their students' classroom experiences. Despite these limitations, there are many reasons why teachers should consider implementing technology into their lessons. This study will focus on one form of instructional technology, tablet technology.

Benefits of tablet use. According to Holden, Ozok, and Rada (2008), teachers reported that they wanted the students to have a greater satisfaction with their school experience. Teachers wanted to complete more technology-based activities and increase their personal skill set and understanding of technology. The following sections highlight the ways in which teachers can use tablets to enhance learning, heighten adaptability, increase engagement, and maximize efficiency.

Enhanced learning. One way that tablets enhance learning is by stimulating higher order thinking. In their study students' benefits of tablet use, Bonds-Raacke and Raacke (2008) examined the effects of a professor using a tablet to write on PowerPoint slides while giving a presentation on student learning. At the end of the class, the students' perspectives on the technology use were obtained through survey data. They found that 94% reported that the technology use enhanced their learning experience in the classroom. Furthermore, the students expressed positive attitudes toward the technology and indicated that their learning experience benefited from the use of the tablet.

In the Bonds-Raacke and Raacke (2008) study, the students were following along and taking notes while the professor used a tablet to write on the PowerPoint slides. Writing on a PowerPoint presentation is one of the main uses of digital inking, which allows the user to annotate their presentations right from their tablet screens when the document is in a Microsoft Office program. The tablet and projector act as an interactive whiteboard, which uses touch detection for user input (for example scrolling and right mouse-clicking) in the same way as normal PC input devices (Steinweg, Williams & Stapleton, 2010). This is a helpful tool at all levels of education and is an innovative way to have students show their work on the board while allowing other students to see instantly what their classmates have done. This process was used in an elementary mathematics methods course for prospective teachers. When they used digital inking to share their work with the whole class, the students valued the ability to develop a shared understanding of their work. However, one limitation of the study was the prospective teachers were more encouraged by seeing their own work than interested in learning what others interpreted from the lesson (Ellington, Wilson, & Nugent, 2011). The disinterest in other students' work on the board will be a challenge at first, but as the novelty effect of the tablet wears off, the students will be able to benefit from seeing multiple strategies used for the same type of problem. Increasing the number of examples available to students and exposing them to the thinking processes of others will deepen their comprehension of the topic.

In another study, performed by Lin, Shao, Wong, Li, and Niramitranon (2011), children interacted with a program on their tablets for virtual tangrams, dissection puzzles consisting of seven flat shapes called tans which are put together to form other shapes. Since the tangrams were virtual, the teacher and students were able to manipulate the size of the tangram and show how the pieces fit together. The use of virtual tangrams enhanced the students' spatial reasoning,

and resulted in the narrowing of the gap between lower and higher achievers. This is a direct result of how tablets were able to better these students' learning experiences.

Gorgievski, Stroud, Truxaw and DeFranco (2005) examined college students' perceptions of the combination of flipping the classroom and integrating tablet technology. In this case, the professor would provide notes to the students, which they were responsible for downloading and studying before class. The professor then used digital ink technology on the previously studied notes to answer the students' questions. When asked about the effectiveness of this model, one student observed that, "The tablet helped because instead of writing on the board the professor could address the class and get a better understanding of their comprehension" (p. 96). This study makes clear that classrooms benefit from the teacher's use of the tablet. However, tablets in the hands of students can offer even more opportunities to enhance student learning.

In Fister and McCarthy's article, *Mathematics instruction and the tablet PC* (2006), the benefits of single tablet (where only the professor has a tablet) and one-to-one classrooms at Murray State University were analyzed and compared. In the single tablet classroom, the professor used the tablets to create notes, to annotate existing PowerPoints, and to use specific mathematical software, such as Virtual TI and Math Journal. These software programs have mathematical equations and figures built in for more efficient use in a mathematics class. Using these programs allowed students to archive the notes of the professor and look at them any time. On a scale of one through five, five being strongly agree, a survey showed that students liked the constant availability of the archived notes. The mean of the survey was a 4.37, ± .17. The students also agreed that the tablet increased the professor's effectiveness during class and it promoted student learning. In the one-to-one tablet classroom, there was an additional benefit of

being able to analyze and critique problems directly on the tablets. The authors described the benefits as "two-fold," showing that students took ownership of their learning in the class. The concrete evidence comes from the 16% increase in scores on an identical test given to students in a tablet classroom versus students in a traditional classroom. The authors found this to be true for one-to-one as well as single tablet classrooms.

All of the aforementioned studies found a common conclusion: students were able to have an enhanced learning experience as a result of the use of the tablets by increasing their ability to comprehend the material. Consequently, student achievement also improved.

High adaptability. Using tablets in the mathematics classroom expands the teacher's ability to individualize learning. Particularly, tablets can be helpful for students with special needs as well as students with varying learning styles. Multiple representations of the same topic, as well as interactive representations, can be shared with ease utilizing tablet technologies. Multiple representations supported students who learn in different ways and proved to give these students a stronger chance of comprehension (Fister & McCarthy, 2006). When learning is individualized from student-to-student, it increases their chances of understanding and success.

One form of technology that has been used to support auditory learners is a Talking Tactile Tablet (TTT). As the name suggests, this tablet is able to speak to students that have visual impairments and tell them what they are looking at. This specifically makes elements in mathematics, such as graphs, more accessible. It also allows students to work at their own pace. This device has audio files that correspond with each visual so that when the visual is touched the audio plays it aloud. It was found that students with visual impairments using TTT performed better on tests than those using current accommodation tools that do not have integrative audio capabilities (Landau, Russell, Gourgey, Erin, & Cowan, 2003).

Not only do tables help those students with visual challenges, but they also have allowed students with individual education plans (IEP) to utilize accommodations for their unique academic needs. O' Malley, Lewis, and Donehower (2013) conducted a study in a special education school of kindergarten through eighth grade. The purpose was to assess students on the Autism spectrum scale, examining the effects of a class-wide intervention using an iPad application for basic mathematics activities on their independent task completion and mathematics performance. This study found that the iPads were very easily adapted to the needs of each student. On top of that, students did become more independent with their task completion and improved their assessment scores. The iPad allowed for more practice, encouraged the students to work at their own paces, and catered to each student's individual set of skills. The generalizability of these results are limited by the fact that the set of data points were small and that it was performed in a school with students that all needed individualized help. A more applicable representation of this study would use more data and involve an inclusion classroom to see if iPad use helps the students to succeed in the regular classroom. Nonetheless, the experiment showed the adaptability of tablets to help diverse learners.

Everyone learns differently, which makes the individualized teaching capabilities of tablets helpful to any student whether or not a disability is present. Creating an individualized education experience has received a positive response from parents and students alike. In addition to supporting students' individual needs, technology integration can increase students' motivation to learn (Luckin et al., 2005).

Increased engagement. Active engagement is essential in classrooms to keep students' attention. Learning today is a "constructive process that builds on prior knowledge" and allows students to develop brain pathways to access new and old information (Roschelle et al., 2007).

Engaging in learning helps students to create more pathways in their brains. Interaction, communication, and collaboration are just some of the ways to engage students. *Group Scribbles* and *Classroom Presenter* are two programs for tablets that are made to increase the learner's active engagement and participation in the classroom. *Group Scribbles* allows for an interactive improvisation of classroom tools such as sticky notes, bulletin boards, whiteboards, pens, and pencils. These boards can be made public so the students and teacher can actively communicate and collaborate through the program. Similarly, *Classroom Presenter* allows for students to write on their own tablets and have it appear on the projection screen. The students' writings can then be organized by the teacher's tablet. This provides a class-wide work ethic, as opposed to an individual one. Making a class engaging decreases the possibility for a student to detract from the lesson (Roschelle et al., 2007).

Tablets have the ability to free up class time from unnecessary busy work that comes with having to draw out every graph or equation, which opens up more time for engaging students in practicing mathematics instead of copying from the teacher's notes. If students have copies of the class notes available and archived on their tablets, they have the ability to engage in class discussion more attentively. Archived notes allow the students to more effectively process the teacher's explanations and ask questions when they arise. Additionally, the class has more time to be exposed to the expert thinking methods of the teacher or professor. In the study by Gorgievski et al., (2005), the students surveyed were also asked if the tablets allowed them to pay more attention in class. One student responded, "I found that I didn't waste time during lecture copying down information so I was better able to focus on what was being taught" (p. 97) Another said, "It most definitely made the lecture easier to follow! All I had to do was follow the problem steps rather than write EVERYTHING down which is hard to do while trying to

comprehend" (p. 97). As a result, these students were able to more effectively engage in the lesson and comprehend the information at a deeper level because of the tablet integration.

Using digital ink, students have the opportunity for greater engagement in class discussion. Harless (2011) takes digital ink and applies it to different specific mathematical practices, such as generalizing the polygon sum theorem. In what he calls "scribing," students are able to collaborate and communicate by use of tablets. Scribing gives students the chance to see the work of other students, engaging them in others' learning processes and furthering their level of understanding. Harless finds that scribing improved the class discussion and allowed students to focus on the ideas of the lesson rather than on listening to the professor. It also motivated students to gain the best understanding they could of the topic.

Practices such as the TTT study show that through communication and collaboration of students with tablets, students are actively engaged in class more than in a traditional classroom. They are more likely to participate in the lesson, as well as comprehend the material better than they otherwise would have if the technology was not used (Lin et al., 2011). Although in many instances technology is seen to be an anti-social activity, the way mathematics teachers are using it in the classroom allows for more social interaction, participation, practice with concepts, and confidence with the content.

High efficiency. One of the greatest benefits for teachers that the tablet brings to the classroom is increasing efficiency. Technology has the power to maximize success and learning within the allotted class time. Teachers report that using tablets saved time in class as well as were easier to use than a whiteboard or an overhead projector (Galligan, Loch, McDonald, & Taylor, 2010). The only limitation to the efficiency of the tablet that was found was the time it took to set up. Once teachers had their tablets set up, they were able to use the technology to its

full potential. The accessibility of the tablet and its speed can improve teaching by decreasing the time it takes to give feedback on homework, assessments, and students' questions from days to minutes (Roschelle et al., 2007). In the scribing activity by Harless (2011), students are able to have immediate feedback because they are able to effortlessly share their work and are then required to defend their ideas in class, as opposed to writing down what they think and waiting for the teacher to correct and return it. The access to immediate feedback addresses misconceptions in class and makes homework more effective.

Tablets also provide the efficiency of preparing complex graphs or concept maps before the start of class so that students can spend more time comprehending the material and less time copying it (Roschelle et al., 2007). In the study by Gorgievski et al, (2005), the students agreed the tablet was effective when asked if it was an efficient way to discuss the mathematical content. The students saw that the professor had more time to cover the material that they needed to get through in class, which allowed for more questions to be answered by the teacher. Another way students were able to experience an improvement in efficiency with tablets was through their immediate access to searchable notes from class. This feature saves students time studying and looking for the correct model for their current homework. The main benefit of the efficiency of tablets is providing teachers and students with more effective class time and easier and faster access to class resources.

Factors negatively influencing tablet integration. The factors influencing tablet integration parallel those influencing any other technology. However, there are some added concerns to integrating tablets into the classroom, one of which involves the setbacks of training discussed earlier. Teachers are more familiar with laptop technology and, although they want to

integrate tablets, they are not willing or do not have the time to learn how to use a new technology.

Schools that are implementing tablet technology need a way to train their teachers to use tablets. Traditional ways of training are professional development days in which teachers are introduced to new methods or programs that are usually sequential and progress in a linear pattern through different levels of difficulty (Beauchamp, Burden, & Abbinett, 2015). Most of the time, teachers across multiple disciplines engage in the same professional development programs with this model. Is this enough to help teachers effectively implement the new form of technology? Studies like that of Beauchamp have shown that traditional methods of training are not an effective way to implement professional development for teachers in technology.

One reason the traditional method of professional development is not effective is that all teachers have different levels of skill and confidence with tablets (McCrea, 2014). Teachers with higher levels of skill and confidence, particularly digital natives, do not need to go through training that covers general uses of a tablet. Conversely, some teachers will not benefit from any type of specialized training until they receive preliminary training on general tablet use, such as connecting to Wi-Fi or changing settings.

Learning in a sequential manner with a lecture is also less effective for teachers because there is no one right way to learn how to use a tablet, and many teachers have different interests. Moreover, the applications that are relevant for teachers in one discipline may not be relevant for other disciplines. For instance, mathematics teachers will not want to sit through a lecture on history applications because they have no use for them. Tablets have no linear progression because, once the basics are learned, it then becomes a question of which applications will be the

best to use in any one teacher's classroom. Therefore, there is no one mold that teachers can fit into as they have in past traditional professional development methods.

Another reason traditional professional development does not work is that there is simply too much to learn in one professional development day and too much to remember after one session. Teachers most likely will not remember how to use many of the applications taught to them during their sessions, as they do not have scheduled time to practice and therefore struggle to apply the new techniques and applications into their own classrooms. Even during a newly implemented training method researched by Bridget McCrea (2014), a business technology writer, administrators of professional development were aware that teachers would not be able to retain or learn everything during a short training period.

Despite the shortcomings of traditional professional development in implementing tablet technology into the classroom, through this training, teachers are able to realize the benefits of using tablets. This idea is exemplified in a study done by Shaw (2004), the Director of Academic Technology at Dwight Eaglewood School. Shaw noted that teachers in his study were always enthusiastic about learning new uses of their tablets and showed a commitment to learning them. Nevertheless, teachers with only traditional professional development were unable to transfer skills from their training into their classrooms. Those teachers were hesitant to use tablets, believing that using tablets would take too much time and increase the risk of misconduct (Beauchamp, Burden, & Abbinett, 2015). Educators are then left to find a new way to train teachers who wish to implement tablets into their classrooms.

Evans (2012) reported some of the benefits and downsides of integrating iPad tablets into teaching. Some teachers found the iPads had limitations, such as the lack of familiar programs like Microsoft Word and PowerPoint. Teachers also had trouble transferring work to other

devices or onto the iPad tablet because it did not have a USB port. Other teachers noted that they did not feel that notetaking and other writing was efficient on the iPad (Evans, 2012). For this reason, teachers are concerned about the realistic potential and possibility of implementation.

Many teachers are also concerned with the students' responsibility of owning a tablet. Tablets are fragile and not durable enough to be tossed into a backpack. Cases are needed to keep tablets in good shape (Ullman, 2015). Sturdy tablet devices are needed to make sure they last in the hands of students. The consequences of a broken tablet can mean the student does not have the ability to participate in certain activities in class or the school and family has to provide more money to get a new tablet for the student.

Other negative influences worthy of consideration concerning tablets surfaced from the schools that Clarke and Svanaes (2014) researched. They felt tablets prevented the development of writing skills, and the teacher-preferred textbook availability was found to be limited. Teachers also indicated it was hard to plan lessons on the tablet and again expressed concerns about tablets being a source of distraction to students.

Conclusion and Significance of Literature Review

After reviewing how technology in general can be used in the classroom and recognizing its benefits and drawbacks, this literature review details how tablets can be used in any classroom setting. Many of these studies on tablet usage in the classroom were performed at the college level, with far less in secondary, middle, and elementary settings. The purpose of this study is to fill this research gap at the secondary level. This study examines the ways in which teachers are currently using tablets in their classrooms and determines how to make better use of the technology in mathematics classrooms by comparing the results to the existing literature.

The research questions that guide this inquiry are: Now that teachers are beginning to recognize the benefits of integrating tablets into their classrooms, are teachers using tablets to their full potential? If not, what are the reasons preventing teachers from utilizing tablets to enhance learning, increase engagement and adaptability, and improve efficiency?

Methodology

The topics and sub-questions proposed in this thesis will be evaluated by way of an online survey which will be given to a targeted population of teachers. The survey is attached in Appendix B.

Participants

The target population for this study was mathematics teachers in secondary education classrooms. Particularly, the teachers were from four public schools in the Worcester County School District. Twenty teachers completed the survey and answered questions applicable to them. The teachers' ages ranged from 25 to 54, and their years of experience ranged from 1 to 23. For certain parts of the data, the teachers were split into two categories of age: 35 and under and over 35. There were twelve teachers in the 35 and under group and eight in the over 35 group. Two of these schools had one-to-one tablet integration, where every student and teacher received a personal tablet. The other two schools had cart classrooms, where the teachers had a cart of tablets in their room which may be distributed to students when desired. Of these twenty teachers, seven were in one-to-one classrooms while the other thirteen were in cart classrooms.

Teachers in this study were asked to participate voluntarily and were gathered based on my knowledge of schools in the Worcester County School District that have cart classrooms or one-to-one tablet availability. The teachers were asked for their willingness to participate in the survey via email. When a teacher did not respond, follow-up reminders to complete the survey

were sent to the teacher via email one week and two weeks after the original distribution time, respectively.

Data Collection

An online survey was designed to collect data needed to answer the research questions. Information about the project and survey was sent to the principals of the schools via email. Within this email, they were instructed to contact me if they did not wish to let their mathematics department participate in the survey. If the principal did not decline the invitation within a week, information on the project and the survey itself was sent to the mathematics department. By completing the survey, they gave their consent to participate. The survey investigated the ways that teachers use tablets inside and outside of the classroom, the ways they have their students use tablets, and why they use tablets the way they do (benefits and drawbacks). It also asked the teachers about their personal opinions on the use of tablets in the classroom. Sending a survey to these teachers was the most effective form of collecting data because it took the least amount of time out of the teachers' days and allowed for quantitative, as well as qualitative, analysis.

The survey. There are five different sections within the survey. It is modeled after the study conducted by Holden, Ozok, and Rada (2008) in their research on *Technology use and acceptance in the classroom*. They explain their survey specifically between pages 118 and 127 in their article.

The first section includes general questions about the person, such as their name, age, school, email, gender, number of years teaching, current grade levels teaching, and current math courses teaching. These questions helped to recognize patterns within the data such as a correlation between age and tablet use.

The second section of the survey asked about the teacher's home and personal tablet use. The teachers were asked if they own a tablet that they use outside of work, how often they use their tablets for non-work related reasons, and what those reasons are. This section helped in analyzing the teacher's familiarity with tablets and determined if their use of tablets out of the classroom correlates with their use of tablets in the classroom.

The third section asked about the teacher's work related tablet use. The teachers were asked to specify whether their classroom is one of four categories: one-to-one, single classroom, only the teacher has a tablet, or whether they do not use tablets. There was also an option for the teachers to specify another type of tablet classroom that may not have been listed. In the study by Holden, Ozok, and Rada, (2008), there were four types of tablet classrooms indicated. However, only two applied in this case: one-to-one classrooms and single classrooms, which are referred to as cart classrooms in my study. Since every school in this study is either one-to-one or has a cart of tablets, I split my data into these two categories in the results. They were then asked questions about their training with tablets, such as if they had any at all, how effective it was, and in what form they received the training. They were also asked if their training was on a specific tablet program and were given space to explain their answer. Lastly in this section, the teachers were asked to state how often they use their tablets for certain in-classroom tasks, such as keeping school records, making presentations for lessons, creating tests or instructional materials, giving instruction, giving assignments, and communicating with others. The purpose of this section was to find out what types of training programs there are for teachers on tablet use and how many teachers that use tablets are getting the opportunity to train for them. It also shows a correlation between the use of tablets in the classroom with the above sections as well as with the amount of training received by teachers.

The fourth section of the survey was about student tablet use. Teachers were asked to specify how often the students in their classroom use tablets to take notes, work on projects, complete assessments, conduct investigations, perform calculations, and record lectures. Next there was an open-ended question asking if there are any other ways students use tablets in their classrooms. This section also asked teachers to list specific applications they use in their classroom and rate them from one (least effective) to five (most effective) and to state the applications best features. Lastly, this section asked the teachers to explain if they utilize tablets to accommodate for individual students' needs. The purpose of this section was to collect data on what the students were actually doing in the classroom with tablets. These data will be used to research more information on specific applications and training for teachers and provide teachers with a resource on the most effective training methods and the best applications to use to receive their desired results of enhanced learning, heightened adaptability, increased engagement, and maximized efficiency. I will use this data to research more information on specific applications for teachers. In the future, I plan to create a worksheet that can be distributed to the schools of the Worcester County School District that provides teachers with a resource on the best ways to use tablets and the best applications to use to receive their desired results.

The last section asks about the benefits and drawbacks of tablet use in the mathematics classroom. Here, the teachers were asked to choose reasons they do not use tablets in their classrooms from a list including lack of motivation, lack of good instructional software, lack of time to learn, lack of time to train, lack of training, lack of preparation time, lack of money, concerns about student misconduct, and an option to list anything else that turns them away from tablet use. The next question required teachers to rate some suggestions that may make them more inclined to integrate tablets. The suggestions are better instructional software, more time to

become proficient in classroom tablet integration, more training available, more funding available to support a tablet program, more time to prepare for tablet lessons, better monitoring systems, and more ways to avoid student misconduct. They were then asked to explain their reasoning for the why they feel it is the most important. The teachers were then asked to select some reasons they do use tablets in their classrooms, such as being beneficial to the teacher, being beneficial to students, to promote learning, to promote confidence, to promote achievement, to promote relationships, to increase motivation, and an option to write another reason.

Lastly, the teachers were asked to specify reasons that they use tablets to improve their lessons. They were asked if the tablets make their lessons more interesting, fun, difficult, easy, time consuming, diverse, efficient, and an option for other reasons. They were then asked to explain their most important reason for the previous question. Next, the teachers get a chance to answer an open-ended question that asks them what they feel could improve their use of tablets in mathematics classrooms. The last question the survey asked was if they feel they have the right balance of tablet use in their classroom and to explain why or why not. This section will also help to provide feedback to the teachers and schools for what should be the next step in integrating tablets into classrooms, and puts an emphasis on how to improve their integration.

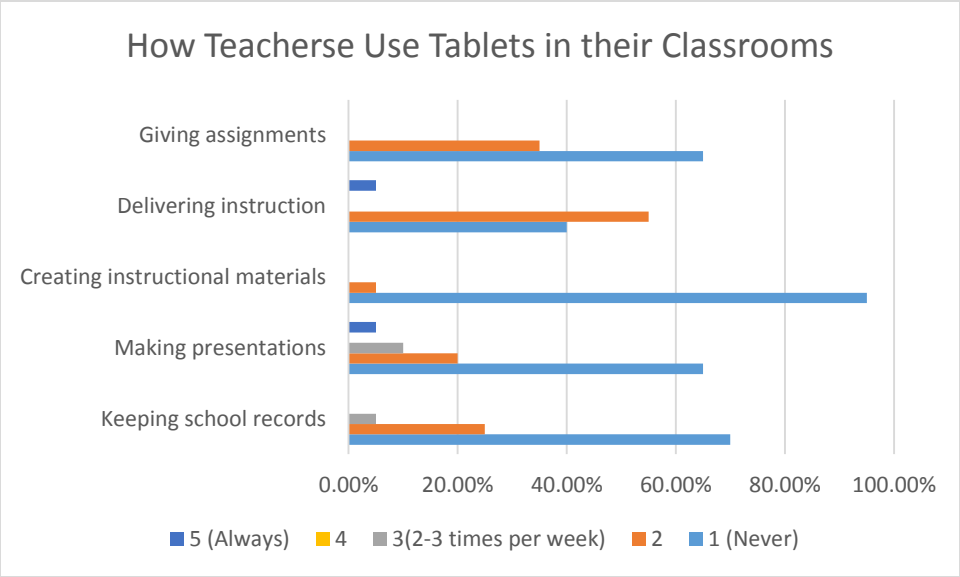
Results

Tablet Use

Teachers were asked about the ways they and their students use tablets in their classrooms and also in what ways students use tablets in their classrooms. Overall, it was found that the teachers and their students were rarely employing their tablets for the functions studied. Figure 1 graphically depicts the frequency teachers are using tablets for the specified functions.

The majority of teachers never used their tablets for any of these reasons, except instruction, where the most teachers use their tablets about a two out of five, which means less than two to three times per week but more than never. More than 95% of teachers said they never used their tablets for creating instructional materials. Similar to the teachers, the majority of students also never use tablets for recording lectures, performing calculations, conducting investigations, completing assignments, working on projects, or taking notes. 42.11% of students used their tablets to perform calculations at least once a week. The data regarding how often students used tablets in the classroom for certain functions is displayed in Figure 3.

Figure 1: How often teachers use tablets in classrooms for certain functions.



Teachers also indicated some applications they use for these functions. One teacher indicated that their students use *Notability* to take notes. Teachers also *suggested Explain Everything*, *Google Classroom*, and *Google Slides* as good applications that students could use for projects and that teachers could use for lesson planning. Some applications teachers indicated that they use for mathematics applications were *Fluid Math*, *TI Nspire*, *Desmos*, *Hands-on Equations*,

Free Graphing Calculator, and *TenMarks Math*. Some other useful applications teachers responded with were *Online Google Drive*, and *Safari*

Figure 2: Percentage of teachers that use their tablets for these functions at least once a week.

Teacher uses	Percentage of teacher usage once or more per week. n=20
Keeping school records	30.00%
Making presentations	35.00%
Creating Instructional Materials	5.00%
Delivering Instruction	60.00%
Giving Assignments	35.00%

Note: n=total number of teacher responses for each section. This is an accumulation of the percentages of teachers in the above graph that used their tablets in the range from 2-5 on the 5-point Likert scale (where 1= not effective and 5= very effective).

Figure 3: How often students use tablets in classrooms for certain functions

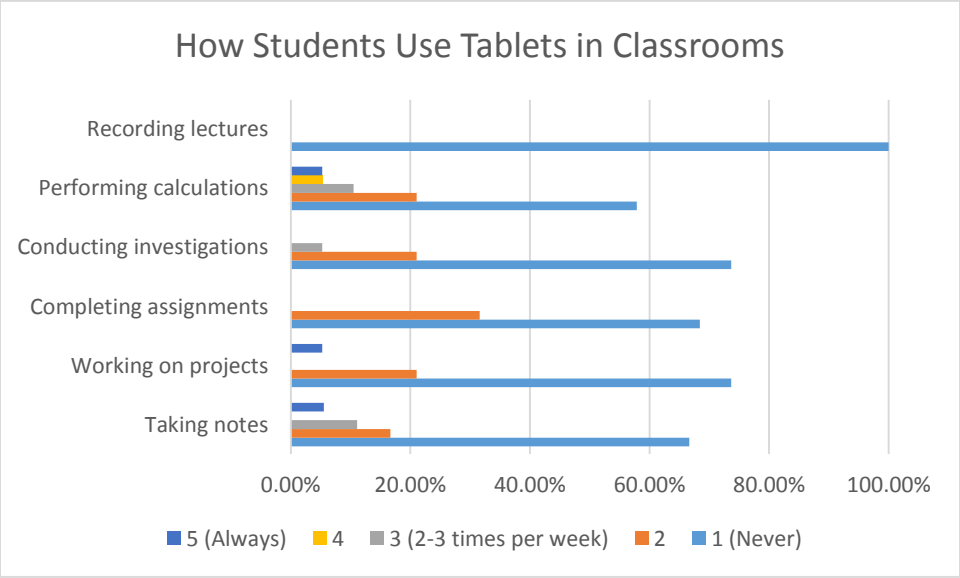


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Figure 4: Percentage of students that use their tablets for the included functions at least once a week.

Student uses	Percentage of teacher usage once or more per week n=19
Take notes	33.33%
Work on Projects	26.32%
Complete Assignments	31.58%
Conduct Investigations	26.32%
Perform Calculations	42.11%
Record Lectures	0.00%

Note: n=total number of teacher responses for each section. In the record lectures and take notes sections one teacher did not answer, so for those sections n=18. This is an accumulation of the percentages of students in the above graph that used their tablets in the range from 2-5 on the 5-point Likert scale (where 1 = not effective and 5 = very effective).

Factors Influencing Tablet Use

General. Figure 5 highlights teachers' top reasons for not using tablets were more time to become proficient in classroom integration as well as more ways to avoid misconduct. In both sections, 13 out of 20 teachers said this was a factor influencing their use of the tablet. Close behind, 12 out of 20 teachers said more time to prepare for lessons was influencing their use of the tablet.

The following results focus on two different comparisons. First the correlation between age and tablet use were analyzed to see if growing up in the digital generation influenced tablet use in the classroom. The responses examined included the teachers' opinions on training

effectiveness, teacher's tablet use in the classroom, students' tablet use in the classroom, and what would make these teachers more inclined to use tablets. This data was split into two age groups: 35 and under and over 35.

Figure 5: Reasons that would make teachers more inclined to integrate tablets.

Factors that make teachers more inclined to integrate tablets into their lessons	Number of teachers
Better instructional software (n=18)	9
More time to become proficient in classroom integration (n= 19)	13
More training available (n=19)	11
More funding available for support of a school tablet program (n=17)	8
More time to prepare for tablet lessons (n=18)	12
More ways to avoid student misconduct (n=18)	13

Note: this data is based on a 7-point Likert scale, (where 1 = most important and 7 = least important). The above results are the number of teachers that rated these categories a 3-1 on the Likert scale.

Second is the correlation between classroom type and the responses from teachers on training effectiveness, teacher tablet use in the classroom, student tablet use in the classroom, and what would make these teachers more inclined to use tablets. The two types of classrooms being compared are one-to-one classrooms, where every student and teacher has their own tablet, and cart classrooms, where a mobile cart of tablets are kept in the school and there are enough tablets for a class of students.

Age. When examining age as a factor, the teachers were split into two categories: 35 and under and over 35. There were twelve teachers in the 35 and under group and eight in the over 35 group. However, not every question applied to every teacher, so some questions had fewer

responses than others. Each average was found using the number of responses received, not by the number of teachers in that age group.

Age and Training Effectiveness. In comparing age with the effectiveness of training, it was found that the seven teachers in the age 35 and under group who had received tablet training, rated the effectiveness of their training, on average, as a 3.14 out of 5, on a 5-point Likert scale (where 1 = not effective and 5 = very effective). The five teachers who had received training on tablet use, and were in the over 35 group, rated their training as less effective than the 35 and under group (with an average of 2.8).

Age and Tablet Use. When teachers were asked if they use their tablets for making presentations and for creating instructional materials, the average responses separated by age group were slightly different. This data is rating how often teachers use their tablets to perform certain actions, using a 5-point Likert scale (where 1 = never and 5 = every day). Figure 6 shows that the teachers in the 35 and under group, on average, used the tablet more for making presentations, creating instructional materials, and delivering instruction than their colleagues in the over 35 group.

When teachers were asked if their students used tablets for taking notes, working on projects, conducting investigations, and performing calculations, all of the averages of each function shared similar results. The general findings were that teachers over the age of 35 are more likely to have their students use tablets for simpler processes such as performing calculations and taking notes, whereas teachers ages 35 and under had their students use tablets for more advanced functions that required more preparation by the teacher, such as working on projects and conducting investigations. Figure 7 presents the averages for all the student usage according to the teachers' ages.

Figure 6: Comparing the frequency of tablet usage for different functions in two age groups.

	Average Response	
Tablet uses	35 and Under (n=12)	Over 35 (n=8)
Making Presentations	1.750	1.250
Creating Instructional Materials	1.083	1.000
Delivering Instruction	1.830	1.625

Note: n=total number of teacher responses for each section. The averages are on a 5-point Likert scale (where 1 = never and 5 = every day).

Figure 7: Teachers' average responses to how students are using tablets according to age group.

	Average Response	
Tablet uses	35 and under (n=12)	Over 35 (n=7)
Taking notes	1.546	1.714
Working on projects	1.583	1.143
Conducting Investigations	1.500	1.000
Performing Calculations	1.916	2.714

Note: n=total number of teacher responses for each section. One teacher in the 35 and under group did not respond in the taking notes category, so n=11 in that case. The averages are on a 5-point Likert scale (where 1 = never and 5 = every day).

Age and Factors Influencing Tablet Use. Next, we compared the ages of teachers with their responses regarding the factors that would influence their inclination to teach using tablet technology. The choices of factors included better instructional software, more time to be proficient in classroom integration, more training available to the teachers, more funding available for tablets, more preparation time for tablet lessons, and more ways to avoid

misconduct. Figure 8 shows the average responses of the teachers in regards to what would improve their tablet use.

Figure 8: Teachers average responses to what would make them more inclined to using tablets in their classrooms according to teacher age.

	Average Response	
Tablet uses	35 and under	Over 35
Better instructional software	3.727 (n=11)	2.635 (n=8)
More time to be proficient in classroom integration	3.2727 (n=11)	2.125 (n=8)
More training	3.545 (n=11)	2.625 (n=8)
More funding available	4.000 (n=10)	4.143 (n=7)
More time to prepare	2.600 (n=10)	2.125 (n=8)
More ways to avoid misconduct	2.818 (n=11)	2.571 (n=7)

Note: n=total number of teacher responses for each section. The averages are on a 7-point Likert scale (where 1 = most important and 7 = least important).

This analysis showed that teachers over the age of 35 rated every choice as more important than teachers ages 35 and under. Although ratings were similar for both age groups, the averages in the over 35 group were always closer to one than the averages for the 35 and under group on a 7-point Likert scale (where 1 = most important and 7 = least important). When the teachers were asked what could improve their use of tablets in their classroom, teachers in the 35 and under group focused first on gaining better resources and mathematics applications and second on needing more time to prepare. The teachers over 35 also focused on having better resources, but these teachers said they also wanted more training on how to use these resources.

Classroom Type. Four classroom types were indicated in the survey and the study by Holden, Ozok, and Rada (2008), but every classroom in this study can be grouped into one-to-one or cart, so they were put only in these two categories. Of the twenty participants, seven teachers were in one-to-one classrooms and thirteen were in cart classrooms. However, not every teacher answered every question. Therefore, each average was found by how many responses there were to each question, not how many teachers were in each category.

Classroom Type and Training Effectiveness. In comparing classroom type with the effectiveness of training, it was found that the four teachers with one-to-one classrooms that received training rated the effectiveness of their training as a 2.5 out of 5 (where 1= not effective, 5 = very effective). The five teachers with cart classrooms who had received training on tablet use rated the effectiveness of their training as more effective than the teachers in one-to-one classrooms (with an average of 3.25 out of 5). Similarly, teachers in cart classrooms rated application-specific and subject-specific training as more effective than the teachers in one-to-one classrooms. No one in a cart classroom had received tablet training that was categorized as general training (not subject-specific or application-specific). Teachers in one-to-one classrooms rated the effectiveness of professional development on general tablet use higher than subject-specific and application-specific training. This finding may be deceptive because of the small number of teachers who rated the effectiveness of each type of training, and therefore may not be indicative of the population. See figure 9 for the average effectiveness ratings of each type of training received by the teachers in the two classroom types.

Figure 9: Effectiveness of each type of training according to the type of classroom.

	Average effectiveness rating by classroom	
Type of Training	One-to-one	Cart
General	3.0 (n=1)	n/a (n=0)
App Specific	2.0 (n=1)	3.3 (n=6)
Subject specific	2.5 (n=2)	3.0 (n=2)

Note: n=total number of teacher responses for each section. Ratings were given on a 5-point Likert scale (1= not effective, 5=very effective).

Classroom Type and Tablet Use. It was found that teachers in one-to-one classrooms were more likely than those in cart classrooms to use tablets for keeping school records, making presentations, and giving assignments. Conversely, teachers in cart classrooms were more likely to use tablets for creating instructional materials and for instruction than those in one-to-one classrooms. Figure 10 illustrates the average frequency of tablet use by the teachers in each of the two classroom types.

The teachers in these classroom settings were also asked, on the same 5-point Likert scale, about the ways their students used tablets. The resulting data showed that students in one-to-one classrooms used the tablets more for every option listed, including taking notes, working on projects, completing assessments, conducting investigations, and performing calculations. The two tasks with the biggest differences on the Likert scale were taking notes and performing calculations, as shown in Figure 11.

Figure 10: The averages for what teachers use their tablets for according to classroom type.

	Average usage rating	
Classroom Type	One-to-one classrooms (n=7)	Cart classrooms (n=13)
Keeping School Records	**1.429**	1.308
Making Presentations	**1.714**	1.462
Giving Assignments	**1.429**	1.308
Creating Instructional Materials	1.000	**1.077**
Delivering Instruction	1.714	**1.769**

Note: n=total number of teacher responses for each section. The averages are on a 5-point Likert scale (where 1 = never and 5 = every day).

Figure 11: Average student usage of tablets according to classroom type

	Average tablet usage by students	
Classroom Type	One-to-one classrooms (n=7)	Cart classrooms (n=12)
Taking Notes	2.5714 (n=7)	1 (n=11)
Perform Calculations	2.8571 (n=7)	1.1667 (n=12)

Note: n=total number of teacher responses for each section. One teacher in a cart classroom did not respond in the taking notes category, so n=11 in that case. The averages are on a 5-point Likert scale (where 1 = never and 5 = every day).

Classroom Type and Factors Influencing Tablet Use. The teachers were also asked what changes would make them more inclined to integrate tablets, including better instructional software, more time to become proficient in integration, more training available, more funding, more time to prepare lessons, and more ways to avoid student misconduct. These questions

involved a 7-point Likert scale (where 1 = the most important and 7 = the least important). Teachers were instructed to rate each category using a different number between one and seven, however some teachers rated more than one option as the most important.

Figure 12 shows that the one-to-one classrooms found better instructional software, more training, more time to prepare lessons, and more ways to avoid misconduct to be of higher importance than the teachers in tablet classrooms. Alternatively, teachers in tablet classrooms found more time to become proficient in classroom integration and more funding as the most important changes that needed to be made. Additionally, teachers in cart classrooms rated funding as more important for them to be able to integrate tablets into their classrooms than those teachers in one-to-one teachers.

Figure 12: Factors that could improve teachers' use of tablets in the classroom

	Average reasons to improve integration of tablets	
Classroom Type	One-to-one classrooms (n=7)	Cart classrooms (n=12)
Better Instructional Software	2.857	3.636
More Training	2.857	3.333
More Time to Prepare	2.286	2.455
Better Ways to Avoid Misconduct	1.857	3.273
More Time to Become Proficient in Integration	3.143	2.583

Note: n=total number of teacher responses for each section. One teacher in a cart classroom did not respond in the better instructional software and better ways to avoid misconduct categories, so n=11 in that case. The averages are on a 7-point Likert scale (where 1 = most important and 7 = least important).

The teachers were also asked an open-ended question about what could improve their use of tablets in the classroom. Figures 12 and 13 show the main improvements that teachers specified that would allow them to more effectively integrate tablets into their classrooms, compared with their use of tablets for classroom integration that they had specified earlier. In one-to-one classrooms, a common theme was access to subject specific mathematics applications, while the main problem for those with cart classrooms was concern for time to practice and train in general.

Figure 13: One-to-one classrooms frequency of use for delivering instruction and what teachers need to be more inclined to use tablets.

One-to-one classroom type

Frequency of tablet use for delivering instruction	Responses: What could improve your use of tablets in mathematics classrooms?
1	More resources. I need places to go to find ideas.
2	More math specific professional development.
2	No response
2	Access to a TI graphing calculator app
1	Non-time consuming apps that improve achievement and learning over "traditional" methods.
2	If I knew some great math applications or other ways I could use it (training is key).
2	Professional development and time to prepare lessons.

Note: no changes were made to the grammar of this table, they are all completely original responses. Only minor changes in spelling were made if a word was spelled wrong. The frequency of tablet use for delivering instruction is on a 5-point Likert scale (where 1 = never and 5 = every day)

Figure 14: Cart classrooms frequency of use for delivering instruction and what teachers need to be more inclined to use tablets.

Cart classroom type

Frequency of tablet use for instruction	Responses: What could improve your use of tablets in mathematics classrooms?
2	Getting to a 1:1 environment. Ability for tablet to be locked out of certain apps by the teacher.
2	better math apps, better apps in general
1	Better training for implementation. Not much at the high school level, but there seems to be tons at the lower levels.
2	Time (not during the summer) to prepare lessons and practice using the apps on a regular basis.
1	No response
2	Just having them
1	tablets, internet, and access to the right applications
2	No response
1	No response
1	No response
2	More training and more technology, like a projector.
1	No response
5	I would need more time to adjust to preparing lessons to use on it. When the students have access to the tablets I will also change the culture of the class.

Note: no changes were made to the grammar of this table, they are all completely original responses. Only minor changes in spelling were made if a word was spelled wrong. The frequency of tablet use for delivering instruction is on a 5-point Likert scale (where 1 = never and 5= every day).

The teachers were also given a list of reasons they may not be using tablets in their classroom and asked to check off all that apply. These reasons were similar to the ones shown in Figure 12, and the results mirror many of the results depicted in Figures 12, 13, and 14. Most selected reasons by teachers in one-to-one classrooms were lack of training, lack of preparation time, and concerns about student misconduct. Teachers in cart classrooms selected lack of

preparation time and concerns about student misconduct as well but a majority also selected lack of money to support the program. Figure 15 shows the number of teachers that selected that reason as a concern. There were six teachers who responded from one-to-one classrooms and eleven in cart classrooms. Figure 16 shows the highest ranked reasons teachers chose for not using tablets.

Figure 15: Teachers' main reasons for not using tablets in their classrooms

	Number of teachers referencing each as a factor negatively influencing their use in the classroom.	
Reasons for not using Tablets	One-to-one (n=6)	Cart (n=11)
Lack of Motivation	0	1
Lack of good instructional software	1	2
Lack of time to learn	2	2
Lack of time to train	1	3
Lack of training	3	1
Lack of preparation time	3	5
Lack of money	0	5
Concerns about student misconduct	5	4
Other	Not conducive; Students learn more effectively through hand-writing notes.	Little benefit of tablet until they are 1-1; Better internet in school; Not necessary for success

Note: n=total number of teacher responses for each section.

Figure 16: Teachers' primary reason for not using tablets in their classrooms

#1 Reasons for not using Tablets	Number of teachers referencing each as the primary factor negatively influencing their use in the classroom.	
	One-to-one (n=6)	Cart (n=10)
Lack of Motivation	0	0
Lack of good instructional software	0	1
Lack of time to learn	0	0
Lack of time to train	0	0
Lack of training	2	0
Lack of preparation time	2	4
Lack of money	0	3
Concerns about student misconduct	2	2
Other	Specified wanting training in math and classroom organization; Another asks again for specific math programs; more resources.	Not relevant until 1-1; Does not want to be recorded, camera makes cheating easier; all necessary; Internet problems; creating lessons that use apps more effectively than regular teaching

Note: n=total number of teacher responses for each section.

When asked to indicate the most important benefit of tablet use in the classroom, it was found that more teachers chose benefits to students, promoting learning, and benefits to the teacher than the other options for both one-to-one classrooms and cart classrooms. The number

of teachers referencing each as the more important factor influencing their tablet use in a positive way is shown in Figure 17.

Figure 17: Factors making teachers more inclined to use tablets in their classrooms.

	Number of teachers referencing each as a reason they are more likely to use tablets	
More likely to use tablets if:	One-to-one (n=5)	Cart (n=9)
Beneficial to you	3	6
Beneficial to students	5	7
Promote Learning	4	5
Promote Confidence	1	1
Promote Achievement	1	2
Promote Relationships	0	2
Increase Motivation	2	2
Other		Tablets are a common place outside the classroom

Note: n=total number of teacher responses for each section.

However, a difference in the reasons the one-to-one and cart classroom types are using the tablets was found when examining the responses teachers gave regarding the ways they use tables to improve their lessons (see Figure 18). The three most selected reasons teachers in one-to-one classrooms are using tablets are to make their lessons more fun, more interesting, and more diverse, while teachers in cart classrooms most selected reasons involving using tablets to make their lessons more fun, more interesting, and more efficient.

Figure 18: Reasons teachers want to use tablets in their classrooms according to classroom teacher and what the tablet can do for their lessons.

	Number of responses referencing these factors as ways they use the tablet to improve their lessons	
To make lessons more:	One-to-one (n=5)	Cart (n=9)
Fun	3	6
Interesting	4	8
Difficult	0	0
Easy	0	1
Time Consuming	0	0
Diverse	3	4
Efficient	1	8
Other	More accessible to students	More accessible to students; engaging (2); enhanced; practice math facts.

Note: n=total number of teacher responses for each section.

Teachers were also asked to indicate the most important reason for using tablets. The findings, depicted in figure 19, align with the findings shown in figure 18. The one-to-one classroom teachers' primary reason was to diversify their lessons. Cart classroom teachers' main reason was to make their lessons more efficient.

Figure 19: Teachers' primary reason for using tablets in their lessons.

	Number of responses referencing these factors as ways they use the tablet to improve their lessons	
#1 Reason to use tablets: Make lessons more…	One-to-one (n=5)	Cart (n=8)
Fun	0	0
Interesting	1	0
Difficult	0	0
Easy	0	0
Time Consuming	0	0
Diverse	2	1
Efficient	0	3
Other	Flexibility; accessible to students	Provide feedback; practice math facts, visual options to make learning easier for students to investigate; Opportunity for creativity and Collaboration

Note: n=total number of teacher responses for each section.

Summary of Results

This study was conducted to see if teachers were using their tablets to enhance learning, heighten adaptability, increase engagement, and maximize efficiency. Overall, the results of this study showed teachers are not using tablet much for any of these purposes. Although some teachers indicated they were using their tablets for some of the functions provided in the tables, the low averages for the usage of each category showed that most teachers, regardless of age and classroom type, were not using their tablets to their full potential.

Overall, teachers in one-to-one classrooms that are ages 35 and under have the most confidence in using their tablets and are more comfortable with the technology. However, teachers under the age of 35 who have cart classrooms are teachers who are using their tablets for the most advanced purposes. Teachers over 35 with cart classrooms require the most training to feel more confident with tablets. Teachers ages 35 and under with one-to-one classrooms are least likely have their students use tablets for more than simple tasks such as performing calculations and taking notes. However, all teachers in every category were barely using the tablets for these purposes anyway. The two highest averages were both in performing calculations, where teachers over the age of 35 averaged 2.714 on a 5-point Likert scale (where 1 = never and 5 = every day). One-to-one classrooms averaged performing calculations as a 2.857. Both averages are still significantly less than 5.

Discussion

This study was concerned with finding ways teachers can use tablets in their secondary mathematics classrooms to their full potential. The survey measures ways teachers can do this by enhancing learning, heightening adaptability, increasing engagement, and maximizing efficiency. A survey was given out to four schools, two one-to-one schools and two cart schools in the Worcester County School District. The survey was employed to determine if teachers were using their tablets for these reasons and if they were not, what was stopping them. The results of this study found that in the chosen school district the teachers were not using the tablets to their full potential, although the majority wanted to use them more. The main obstacle that was in the way of their tablet use was lack of proper training with the tablets.

Teachers in schools may not yet be using their tablets to their full potential, but the progress that has been made indicates we are on the path to tablet integration into the high school

mathematics classrooms. Teachers are most concerned with time, training, and misconduct. There is no way to control time, but improvement of training could lead to solutions not only on avoiding misconduct but also ways to save time.

As noted in the literature review, Holden, Ozok, and Rada (2008), report findings that a large percentage of teachers are showing interest in integrating technology into their classroom. This study is consistent with previous findings, showing 85% of teachers said they wanted to use the tablet more in their classroom, 10% said they have the right balance of tablet use, and 5% (one person) said they did not want to use tablets in their classrooms.

Age

Teachers ages 35 and under reported a higher degree of effectiveness of training than those over 35. One of the main reasons for this could be because teachers in the 35 and under age group have a higher comfort level with technology because they grew up with it. One teacher expressed the effects of not being a digital native on her tablet use: “As someone who didn't really grow up with all of this technology, it takes a lot of creativity too. Having more time and more resources to go to in order to find good ideas is key.” Students today have grown up with tablet technology and therefore are more knowledgeable when it comes to navigating tablets and maximizing their usefulness. However, that is not an inherent quality in teachers who did not grow up with the technology constantly at their fingertips. These results reflect existing literature which states that teachers admitted to being afraid to integrate technology because they feel they do not fully understand it (de la Cruz, 2013).

The results of this study highlight that teachers in the 35 and under age group are more likely to use their tablets to make presentations, create instructional materials, and deliver instruction. Even though they are more likely, teachers in this age group are still barely using

tablets for these purposes. This could be because it is simply easier to make a presentation in PowerPoint or Prezi on a computer, so there is no real improvement in efficiency or enhancement of a lesson when using a tablet. Many factors may be involved, such as the size of the computer screen, the ability to more easily navigate certain programs like PowerPoint on a computer, or even just that both devices have the same functionality for any purpose but people are more comfortable using a computer.

What comes next in this case for the tablets? Tablet designers need to find a way to not only match the functionality of a computer, but also a way to surpass it. If the tablet does not improve what teachers are doing, they are likely to use technology they are more comfortable with. The next step would be to research applications on tablets for making presentations, creating instructional materials, and delivering instruction to determine what abilities tablets have that computers cannot accomplish. However, in this stage of the integration of tablet technology into the classroom, it is easier and much more common for teachers to use desktop computers or laptops for the purpose of designing instructional materials and delivering instruction.

Another possibility is that mathematics teachers in general are less likely to use some form of technology to aid in their class for the purpose of instruction of new material. From personal experience, mathematics teachers would use less technology than teachers in any other discipline. While science and history teachers tend to use PowerPoint presentations, mathematics teachers tend to write on a board to model "expert thinking" of the mathematical process, and PowerPoint is many times not involved because it is most effective to see each step written out by hand (Lemov, 2010). Additionally, mathematical symbols and equations are significantly more tedious to type than to handwrite.

As shown in a study done by Wilson, Notar, and Yunker (2003) *called Elementary In-Service teacher's use of computers in the elementary classroom*, when computers first entered the education field, many professors did not use them or could not find a use for them. This could be foreshadowing of the future of tablets and their role in the classroom. As tablet developers begin to focus more on the tablets role in education, they will begin to create educational applications that not only make the tablet as useful as the computer but also enhance the experience for the teacher by making applications that improve the efficiency of designing presentations and delivering instruction.

When the teachers were asked what could improve their use of tablets in their classroom, teachers in the 35 and under age group focused first on having better resources and mathematics applications and second on more time to prepare. Teachers over the age of 35 also agreed that having better resources was most important but were more concerned with having better training than with more time to prepare. This ties into tablet comfort level because teachers ages 35 and under are not as worried about being trained on how to use the resources, but more concerned about just having them, while those over 35 were more concerned with having training in those applications. It also suggests that teachers over the age of 35 have less confidence with the capabilities of the tablet and how much it can be used for, so they only use it for convenient, simpler functions such as performing calculations. Ultimately, solving one problem can solve the other. If teachers have training in more specific mathematics applications, then their efficiency in preparing to incorporate the technology will increase, and therefore they will need less time to prepare. This is directly tied to the low levels of instructional use at all levels of school because current resources on the tablet are not efficient enough to justify using the tablet over already accessible tools. Access to more mathematics applications could change this and allow for more

instructional tablet usage. According to Toumasis (2005), it is extremely important to make sure teachers are properly trained or they will never feel comfortable implementing new technology. Providing teachers with the better training they need could lead to better resources and more efficient planning, solving many of the teachers' problems regarding tablets.

When teachers were asked about the changes that need to be made in order for them to use tablets more in their classrooms, those in the over 35 group rated every option as more important than those in the 35 and under group. This could again be because younger teachers are more comfortable with the technology and have more experience with its capabilities.

Through comparing age with the above categories, it is evident that all teachers need more subject specific training, but teachers over the age of 35 who may be less familiar with the technology may need preliminary training to learn how to use the tablet effectively before learning how to use mathematical applications to benefit their classrooms. This is not necessarily true for every teacher over or under this age group.

Classroom Type

When classroom type was compared with the effectiveness of training, the data showed that teachers in cart classrooms that had received training were more likely to rate their training as more effective than those in one-to-one classrooms. This result could be because teachers with cart classrooms do not have to use the tablets every day. As a result, what they are able to learn in training is enough for the few lessons they use tablets for throughout the year. On the other hand, teachers in one-to-one classrooms have the opportunity to use their tablets every day, but if they are not trained in subject specific applications that have every day uses, their training may not be as effective. Teachers in one-to-one classrooms have more pressure to integrate tablets every day.

General tablet training was rated higher in effectiveness than subject specific-tablet training by one-to-one classroom teachers. These results are contrary to most of our findings. In particular, most teachers specified that they wanted more subject specific training. However, these data involving rating the effectiveness of the different types of training could be skewed because only one person in the one-to-one group had general tablet training. There was a similar correlation for cart classrooms, where specific mathematics application training was rated at a lower effectiveness than those who received application specific training. This could again be because of the low number of responses to this question, resulting in skewed data.

When teachers in these different classroom types were asked what they used their tablets for, teachers in one-to-one classrooms used their tablets more than the teachers in cart classrooms for keeping school records, making presentations, and giving assignments. Teachers with cart classrooms used their tablets more for creating instructional materials and delivering instruction. The three tasks that the teachers in one-to-one classrooms used their tablets more than cart classrooms are tasks that are easily completed when the teachers have constant access to the tablets. It would be very hard to keep records or give regular assignments on a tablet that is only able to be accessed sporadically and only while in the classroom. Designing presentations was also something more common in one-to-one classrooms, which could again be because teachers have more access to tablets and therefore more time with them to make the presentations. On the other hand, creating instructional materials and using the tablets for instruction may be done more in cart classrooms because these classrooms are more likely to use the tablets to their full potential in the small amount of time they are able to use them. This could be because teachers with less access to the tablets are more likely to use the tablets for more in-depth tasks that require more time to make. This seems counterintuitive because they have less

time with the tablets, but this may be that teachers with less time with tablets are more likely to make the most of the time they have with them. Teachers in one-to-one classrooms have constant access and therefore may use the tablets more consistently for smaller tasks.

Just as indicated with age, teachers are using their tablets for keeping school records, making presentations, creating instructional materials, delivering instruction, and giving assignments. However, they were not using tablets very often for any of these reasons.

Teachers in one-to-one classrooms used the tablets more for taking notes, working on projects, completing assessments, conducting investigations, and performing calculations than teachers in cart classrooms. This data was not surprising, considering that students in one-to-one classrooms have constant access to their tablets and therefore more time to complete these tasks. Again, these differences between student usage in one-to-one classrooms and student usage in cart classrooms may simply be because some of these uses are more conducive in one-to-one settings, where there is consistent access to the tablets. For example, students would not take notes on tablets if they could not take them home and teachers would not reserve the tablets to complete something that they could do with the calculators already in their classroom. In a one-to-one classroom, completing these tasks becomes much more convenient with tablets. Applications allow for organized notetaking and performing calculations or graphing functions all with one device. However, even though tablets have more convenient uses in one-to-one classrooms, these uses do not reveal the full potential of the tablet to maximize the learning experience for every student.

No teachers reported that their students used their tablets to record lectures. This is not surprising, as recording lectures is not common in high schools. However, high schools have never had access to this type of recording technology before. Recording lectures is a form of

accommodation that could help many students that struggle with concepts or need to review what the teacher said while they are at home. It could also help those students who have trouble reading their own handwriting after class. Another positive effect related to recording lectures is that students can be prevented from worrying about taking down all the notes and can more closely attend to what the teacher says. Students are more likely to keep up with the teacher if they know that at home they can go back and review what they may have missed or did not quite understand.

One-to-one classrooms found better instructional software, more training, more time to prepare lessons, and more ways to avoid misconduct to be more important than those teachers in cart classrooms. This could be more important to teachers in one-to-one classrooms because teachers in these classrooms need software that can be used for more than just an occasional great lesson. In order to integrate tablets to their full potential, teachers need applications that can be used regularly and do not take copious amounts of time to create or learn. This could also have to do with the greater need to integrate tablets more often in a one-to-one classroom. If teachers receive training on one or two applications, they will not possess the skills needed to use their tablets to enhance learning, heighten adaptability, increase engagement, and maximize efficiency. It may also be because these teachers are not receiving as much subject specific training on mathematics applications as needed. Training on notetaking applications may be much more helpful to those in English or History classes than teachers in mathematics classes who need help teaching their students to graph. Access to training on subject specific applications could enable teachers' tablet use to become more efficient and effective.

Teachers in both types of classrooms rated time to prepare lessons involving tablets with similar importance. This could be because time is a problem for all teachers. However, teachers

in one-to-one classrooms are trying to prepare for lessons incorporating tablets every day, whereas teachers in cart classrooms may need to prepare tablet lessons less frequently. Moreover, the pressure to create tablet lessons is higher on those in one-to-one classrooms while they are given less time to do so.

Teachers in one-to-one classrooms have students who have constant access to their tablets at home and in school, and are therefore not as able to regulate the use of the students' tablets. This is a problem that five out of six one-to-one teachers noted as a reason they are not using tablets in their classroom. This could lead to more concerns with misconduct because the school is unable to monitor student downloads at home.

Teachers in tablet classrooms found more time to become proficient in classroom integration and more funding as more important changes that needed to be made. As stated in the literature review, this issue has been continuous and teachers are struggling to find ways to combat it. This study did not find anything different. However, there seems to be more and more grants for school to become one-to-one in order to give all schools a chance to have this opportunity. Teachers in cart classrooms have less time to become comfortable with integrating the tablets into their classrooms. This is important because due to the teachers having less time to become comfortable using the tablets they must spend more time preparing each lesson. Funding is more of an issue for teachers with cart classrooms because those teachers have less access to the tablet technology. This is important because without funding, the other improvements needed to effectively integrate tablets become irrelevant until the classrooms have the funding to become one-to-one. This is highlighted when one of the teachers answered "We have little funding for technology at the high school level in our district. Until this problem is resolved, there is no chance that any of the rest of these options is relevant."

Teachers in cart classrooms were also more concerned about not having enough preparation time. Schools that only have a cart of tablets are less likely to be able to give their teachers more time to practice and see which applications work most effectively for their classroom. Therefore every time they plan to use the tablets they have more work to do because they have to teach themselves how to use it first, making preparation time a main concern.

The main reasons teachers in any classroom are using tablets are to benefit the students and themselves, as well as promote learning. In order to do this, they hope that incorporating tablets into their lessons will make them more interesting, fun, and diverse. There is a great deal of importance put on having diverse lessons that are more accessible to all students. Having the same structure to a lesson every day is not only boring for the teacher and the students but also may not be effectively reaching every type of learner. Diverse lessons involving tablets, with resources for more than one type of learner, give teachers the opportunities to have more interesting and fun lessons that are successful for a variety of students. Although the study did not find that teachers were using their tablets for accommodating students, teachers may not have been looking at the question as simply adapting to diverse learning. Many teachers stated that they did not need accommodations this year. However, adaptability and accommodation does not only apply to students with disabilities, but students who learn differently. As stated in the literature review, tablets can be used to meet diverse needs of every student, such as auditory versus tactile learners (Luckin et al., 2005). There are many diverse ways to use tablets to help students with visual impairments or other learning disabilities, such as using the Talking Tactile Tablet (Landau, Russell, Gourgey, Erin, & Cowan, 2003). Teachers want to diversify their lessons, they just need the resources and skills to do so utilizing tablets. The only accommodation many teachers indicated was taking notes on tablets or posting the notes online

for students to see if they are missing or have an IEP that allows them to access extra notes. Although they are helpful, there are much better uses of adaptability with tablet applications.

The number one reason teachers in one-to-one settings are using tablets is to diversify their lessons. However, teachers with cart classrooms rated efficiency as the number one reason for using tablets. Teachers in cart classrooms may be less satisfied with the efficiency of their tablet lessons because although it can make planning more efficient, if this is the main purpose, the tablet may never be used to its full potential to benefit students and teachers. However, because classroom tablets require more preparation for every lesson, it is also much harder to develop efficiency. The main benefits of maximizing efficiency highlighted in the literature review are being able to use the tablet to its maximum function capacity because there is minimal time spent on set up, found by the study by Galligan, Loch, McDonald, and Taylor (2010), and that it significantly reduced the time it took for teachers to give feedback (Roschelle et al., 2007). Although these are helpful, they are not the main reasons tablets can improve the classroom experience for teachers and students. Maximizing the efficiency of tablets then allows the teachers to use the technology to their full potential for actually enhancing learning, heightening adaptability, and increasing engagement.

Limitations

If there was more time to continue this study, I would use a larger sample of teachers in order to receive more accurate data. I would also change the wording of some of the questions I asked about adaptability. I used the word accommodation and many teachers may have thought it just meant for students with disabilities when in reality I meant any way to meet the needs of diverse students. I would also make the Likert scales I used less confusing. All of the 5-point Likert scales used 1 to represent never and 5 to mean every day, except one scale. On that odd 7-

point scale, 1 referred to the most important and 7 meant the least important. This difference could have been confusing to some and may have resulted in inaccurate data. The low responses regarding the different usages of tables also lead me to consider that I may have needed to define the categories I had created. Lastly, I would do research on the possibility of bring your own device (BYOD) classrooms to provide feedback on an alternative for teachers who may have cart classrooms or no tablets at all.

When first researching tablet use in education for my literature review in the fall of 2014, there were not many articles on modified training methods for teaching teachers how to use tablets. However, when returning to the research in the fall of 2015, there were much more data on effective training methods than there had be one year ago. I also discovered some articles I had not seen when doing research before. This new research showed that teachers had been doing research on tablet integration and have found some effective methods. The new research found is explained under the professional development methods heading.

Professional development methods. Authors Frey, Fisher, and Lapp (2015) studied iPad development in an urban high school. They stated that just providing a school with tablets will not lead to successful implementation. However, as discussed earlier, traditional methods of training teachers to utilize tablets are unsuccessful. Now that it is known that a new method of training is needed to effectively implement tablets into education, it is time to try different methods to find what works best. Researchers and teachers have been testing new ideas and many of their articles stated different methods of training that all had effective results. One similar finding is that training should be individualized and continuous.

In a case study examining K-12 classrooms and mobile computing devices (MCD), Grant, et.al, (2015), it is suggested that there are three components professional development for

MCD should always have: an alignment with the specific content and curriculum, focus on pedagogy, and sustained learning opportunities over time. During the study, teachers received in-service training and support for their curriculum that was provided throughout the school year. This type of staff development is characterized as ongoing and "provides opportunities for modeling, practice, and reinforcement of technology use with curricula" (p. 34). Training should all be linked to the core curriculum that the teacher is implementing in his classroom as well as the teacher's goals or objectives (Grant et al., 2015).

Shaw (2004) designed his own three-day workshop for teacher professional development. Within those three days, there was a balance of presentations and activities as well as unstructured time to work on the tablets. Participants were allowed to practice whatever they wanted during the unstructured time. It could have been something they discovered and wanted to look at themselves or any of the presentations he had given that day. One downside to his training was that teachers who did not have much background with the tablets did not know what to do during the unstructured time and needed more preliminary training. He accommodated for this by adding more general tablet use functions to his training throughout the day. He then gave the participants access to journals from their session and allowed them to write new journals and questions, creating a community of learners with constant access to a stable support system for integrating technology (Shaw, 2004).

McCrea's (2014) research had to do with a professional development method implemented by Kristen Brittingham, district director of personal mastery learning in the Charleston County School District. In Brittingham's professional development program, they give the teachers the material before they actually came together to learn it, with the intent to be able to use the time together more effectively and get into more difficult questions during the

program. The professional development lasted for a couple of days during the summer, but then was continuous afterwards. The school district broke down the content learned in the summer sessions into "mini courses" that were always accessible to teachers on their devices through the cloud. McCrea also researched Douglas Country School District, where they found that it was also effective at their professional development days to allow the teachers to use the tablets in the way they or their students would be using them in the classroom. Another school district that McCrea researched, Encinitas School District, also used cloud based training that all the teachers have constant access too. Their cloud included "live online training, documentation, and all follow-up materials" to practice and implement their training (McCrea, 2014). The main thing that all of these different training styles had in common was ongoing access to the materials learned in professional development and a support system of teachers.

Mouza and Barrett-Greenly (2015) studied professional development in urban schools where they implemented three things: summer training, lesson design practice, and constant classroom support after training. The teachers were also provided iPads that had applications on them from the summer training session when it concluded. Through the training, teachers were instructed to design lessons. Doing this allowed the teachers to become more efficient and effective in creating tablet lessons. The authors also believed that individualized support for teachers' specific needs and having unstructured time to try the applications as well as hands on learning were beneficial. However, they also noted the importance that teachers must constantly stay up to date with the changing technology and be learning alongside their students about the best way to use tablets in their classrooms. They found that these were effective methods of professional development and that the teachers were able to use their training and apply it to actual practice within their classrooms" (Mouza & Barrett-Greenly, 2015).

In *An Updated Literature Review on the Use of Tablets in Education* by Clarke and Svanaes (2014), the authors synthesize current research on tablets and draw conclusions about professional development. They found that training includes many components, such as technical guidance, pedagogical discussions, sharing of applications and teaching activities, and time to practice the technology and become proficient in its abilities. The teachers that were given the tablets at earlier stages showed "reduced resistance to the initiative and promoted motivation." This motivation translated into better communication between teachers and students alike as well as improved individuated learning for the students (Clarke & Svanaes, 2014).

The new training methods just described all include components that Mouza and Barret-Greenly list from Desimone, (2009). Desimone lists five key principles to successful professional development implementation: "(a) focuses on content learning, (b) is of an extended duration, (c) involves teachers in active learning, (d) is collaborative, and (e) is coherent with local standards and expectations for student learning" (Mouza & Barrett-Greenly, 2015 p. 10). Professional development should incorporate the above criteria to help teachers to successfully integrate tablets into any type of classroom, including mathematics.

Conclusion

Overall, teachers who seem to be the most comfortable with using tablets in classrooms are those that are ages 35 and under and have a one-to-one classroom. One advantage to having a cart classroom is that teachers may be more likely to use their tablets for more advanced purposes such as conducting investigations because of their limited and valuable time with the tablet resources. Many teachers in the cart classrooms indicated they would like to be one-to-one classrooms because of the increased possibilities. The challenge now is to make sure that teachers in one-to-one classrooms have the resources and the training to exercise the tablets

potential. The possible benefits of tablets for instruction have not been fully discovered yet. The technology is so new that the possibilities are endless. The tablet has the potential to not only enhance instruction, but to replace calculators, computers, and notebooks into one portable all-encompassing machine.

The literature review found many ways for teachers to use their tablets to enhance learning, adaptability, efficiency, and engagement, along with effective training methods to encourage teachers to integrate tablets into their classroom. However, without the proper training that the schools in my study were lacking, it is very difficult to use tablets for any of these purposes. Without diversified training that allows teachers to feel more confident with their tablets, tablet integration will not advance the classroom experience for students and teachers.

The next step is to make training more subject-specific and efficient. Doing this will increase teacher confidence with using tablets, build efficiency in making tablet lessons, increase amount of students the teacher is able to reach with each diversified lesson, and build a stronger classroom overall that utilizes tablet technology. New tablet training methods are being tested constantly to find the most effective way to help teachers learn to integrate tablets into their classrooms. As this study as well as others in the literature review have shown, there is a very strong interest in integrating tablet technology into the secondary mathematics classroom. Teachers have the motivation needed to use tablets to enhance learning, improve efficiency, increase engagement, and heighten adaptability. Having suitable training could solve problems that are holding teachers back, such as lack of confidence and time consumption, allowing the movement of tablet integration to thrive in the educational environment.

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Appendix A

Current Applications that can be used in Mathematics

The following is a list of mathematics applications used and tested by researchers and teachers that have been proven to be effective in the mathematics classroom for various levels of education:

Algebra Touch: An application to teach algebra in a new, more conceptual way (Apple, 2013).

AnimalWatch: A program that focuses on mathematical word problems and has a range of visual abilities to increase accessibility to students with visual impairments (Beal & Rosenblum, 2015).

ArXiv: Free scholarly publications of mathematics and other sciences (Ekart, 2012).

Aurasma: An applications that uses image recognition to place tags on anything from printed material to 3D objects such as a building. When in the application and an image is recognized, the application with bring up and "Aura" which can hold videos about the tagged images (Betts, 2013).

Blackboard: Used to organize class content and provides a place where teachers and students can share resources and stay connected (Shaw, 2004).

Chalkboard App: Taking notes during lessons (Grant, Tamim, Brown, Sweeny, Ferguson, & Jones, 2015).

Common Core Standards: Reference point for teachers to tie their learning back to the common core standards (Logan, 2013).

Data Analysis App: Allows for quick and easy to read graph interpretations of data (Perry, Thrasher, & Lee, 2014).

DragonBox+Algebra: Offers demonstrations of algebra in all forms such as graphs and equations and allows students to find connections between them. It is a game to teach the rules of algebra (Cayton-Hodges, Feng & Pan, 2015).

Dragon Dictation: used to turn voice into text and record (Cayton-Hodges, Feng & Pan, 2015).

Numerosity: Allows students to play around with the multiplication tables (Cayton-Hodges, Feng & Pan, 2015).

Dropbox: Provides a place where students and teachers can collaborate and store materials in an organized and efficient way (Perry, Thrasher, & Lee, 2014).

Edmodo: Allows teachers to communicate and share with students at any time (Mouza & Barrett-Greenly, 2015).

Explain Everything: An application like keynote that students can use to make presentations or explain procedures (Noonoo, 2015).

FluidMath: Can take hand-written work and translate it into equations or graphs that can simultaneously change (Cayton-Hodges, Feng & Pan, 2015).

Geometer's Sketchpad: An application that focuses on functions, limits, and geometric transformations (Belbase, 2015).

Go2Stat's Statistics Visualizer: Turns data into graphs that are easy to read for students (Nadel, 2012).

Group Scribbles/ Classroom Presenter: Made to increase learner's active engagement and participations in the classroom (Roschelle et al., 2007).

Hands-On Equation: Gives practice problems but also allows students to watch video clips for help if they get the problems wrong. They then have to complete two practice problems before returning to their exercises (Cayton-Hodges, Feng & Pan, 2015).

HMH Fuse: Algebra 1 / Woot Math: Provides e-textbooks as well as instructional materials and assessments (Cayton-Hodges, Feng & Pan, 2015).

JavaBars: An application to teach the use of fractions (Belbase, 2015).

Kahn Academy: Provides tutorial videos in math and science that have subtitles which make the videos easy to scan to pass out to students. (Ekart, 2012).

Keynote: An application for producing presentations like PowerPoint (Mouza & Barrett-Greenly, 2015).

Long Division: A personal tutor that offers video clips with demonstrations of processes (Cayton-Hodges, Feng & Pan, 2015).

Mad Math 2: Games with math facts practice. Students write on the screen to solve problems (Nadel, 2012).

Math Champ Challenge: A math application with practice problems that scores based on correctness as well as speed of answer (Cayton-Hodges, Feng & Pan, 2015).

Mathgraph: Interactive graphing applications that can graph anything from polynomial functions to logarithmic functions. Sliders can be used to modify functions and change coefficients (Perry, Thrasher, & Lee, 2014).

Math 5 Testing Prep: Has exercises to help students to prepare for standardized tests (Mouza & Barrett-Greenly, 2015).

MathBoard: Turns the IPad into a digital chalkboard and lets students use their fingers to work on problems (Nadel, 2012).

Mathemateer: A game in which students complete math problems in order to build their own custom rocket with each right answer. Covers topics such as number sense, time, money, geometry, computation, and square roots (Logan, 2013).

Microsoft OneNote: Note taking program (Shaw, 2004).

Motion Math HD: Fractions!: Gives fractions in different representations and requires the user to find equal fractions (Cayton-Hodges, Feng & Pan, 2015).

Motion Math Zoom: Interactive number line that allows students to zoom in and out of animals to explore sizes (Nadel, 2012).

OmniGraph Sketcher: Gives users the ability to make complex graphs from new data as well as pre-existing data that they are able to share through email (Murray & Olcese 2011).

QR Codes: Codes that when scanned bring you directly to whichever information or website has been linked to the code. Easy to create and can be used for things such as homework assignments and projects (Brunsell & Horejsi, 2012).

Sine wave generation: Allows students to see manipulations of sine wave graphs on a pendulum and how to slow them down or speed them up (Brunsell & Horejsi, 2012).

ShowMe Interactive Whiteboard: To take notes digitally during lessons (Clarke & Svanaes, 2014).

Talking Tactile Tablet: A tablet to help tell visually impaired students what they are looking at (Landau, Russel, Gourgey, Erin, & Cowan, 2003).

Touchy Math: Has algebraic expressions with Arabic numerals only (Cayton-Hodges, Feng & Pan, 2015).

Scribing: Allows students and professors to integrate into the class discussion with digital ink technology by writing in their own comments that can appear in presentations for the whole class to see (Harless, 2011).

Virtual Tangrams: Puzzles consisting of flat shapes that can be put together to form different shapes (Lin, Shao, Wong, Li, & Niramitranon, 2011).

Appendix B

Survey

Appendix B is a copy of the survey that was used to conduct this research. Bottom of Form

Tablet Use in Secondary Mathematics Education

Name

Age

School

School Email

Gender

Number of years teaching

What grade levels do you currently teach?

What math courses are you currently teaching?

Home/Personal Tablet Use

Do you have a tablet you use outside of work?

How often do you use your tablet for non-work related reasons?

What are some of the non-work related reasons you use your tablet?
(e.g. a calendar, games, television, or other applications)

Work Related Tablet Use

What type of tablet classroom do you have?

- ☐ One-to-one (everyone has a tablet)
- ☐ Single classroom (tablets stay in the school and are distributed when needed)
- ☐ Only the teacher has a tablet (only you have a tablet)
- ☐ Neither (you do not use tablets in your classroom)
- ☐ Other:

Have you received any training in using your tablet to teach?

If yes, how effective was the training?

	1	2	3	4	5	
Not effective	○	○	○	○	○	Very effective

How did you receive the training?
(e.g. professional development, conference, IT support)

Was the training on general tablet use or a specific tablet program? Please explain.

How often do you use tablets for the following:

	1 (Never)	2	3 (2-3 times per week)	4	5 (Everyday)
keeping school records	○	○	○	○	○
making presentations for lessons	○	○	○	○	○
creating tests or instructional materials	○	○	○	○	○
instruction	○	○	○	○	○
giving assignments	○	○	○	○	○
communication with others	○	○	○	○	○

Student Tablet Use

Do your students use tablets for the following:

	1 (Never)	2	3 (2-3 times per week)	4	5 (Everyday)
take notes	○	○	○	○	○
work on projects	○	○	○	○	○
complete assessments	○	○	○	○	○
conduct investigations	○	○	○	○	○
perform calculations	○	○	○	○	○
record lectures	○	○	○	○	○

Are there any other reasons your students use tablets for your class?

Are there specific applications you and/or your students are using to complete the tasks above (e.g. taking notes, performing calculations)?
Please list the name of the applications, its best and worst features, and rate it on a 1-5 scale where 1 is not effective and 5 is very effective.

Do you use a tablet in your classroom to accommodate individual students' needs? If so, please explain.

Benefits and Drawbacks of Tablet Use in the Classroom

What are the reasons you are not using tablets in your classroom?

- [ ] Lack of motivation
- [ ] Lack of good instructional software
- [ ] Lack of time to learn
- [ ] Lack of time to train
- [ ] Lack of training
- [ ] Lack of preparation time
- [ ] Lack of money
- [ ] Concerns about student misconduct
- [ ] Other:

With the following would you be more inclined to integrate tablets into your instruction?

	1 (Most important)	2	3	4	5	6	7 (Least important)
Better instructional software	○	○	○	○	○	○	○
More time to become proficient in classroom tablet integration	○	○	○	○	○	○	○
More training available	○	○	○	○	○	○	○
More funding available for support of a school tablet program	○	○	○	○	○	○	○
More time to prepare for tablet lessons	○	○	○	○	○	○	○
Better monitoring systems	○	○	○	○	○	○	○
More ways to avoid student misconduct	○	○	○	○	○	○	○

Of the above options, what is the most important reason and why?

What are some reasons you use tablets in your classroom?

- ☐ beneficial to you
- ☐ beneficial to students
- ☐ promote learning
- ☐ promote confidence
- ☐ promote acheivement
- ☐ promote relationships
- ☐ increase motivation
- ☐ Other:

Do you use tablets to make your lessons more...

- ☐ interesting
- ☐ fun
- ☐ difficult
- ☐ easy
- ☐ time consuming
- ☐ diverse
- ☐ efficient
- ☐ Other:

Of the above options, what is the most important reason and why?

What could improve your use of tablets in mathematics classrooms?

In your classroom, do you feel you have the right balance of tablet use? Would you like more or less? Please explain.

Please explain

Submit

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