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An Investigation of the Impact of iPad Usage on Elementary Mathematical Skills and Attitudes

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AN INVESTIGATION OF THE IMPACT OF IPAD USAGE ON ELEMENTARY MATHEMATICAL SKILLS AND ATTITUDES

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Abstract: An Investigation of the Impact of iPad Usage on Elementary Mathematical Skills and Attitudes

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Currently, many schools are implementing one-to-one initiatives, where the goal is to give every student in a classroom a tablet or laptop computer. However, there is a dearth of research backing up the assumption that they significantly improve student learning. This study explored the effects of these new instructional devices by focusing on two second-grade classrooms implementing a one-to-one iPad program. Specifically, it investigated how iPad usage affects student and teacher attitudes toward mathematics, student mathematics performance in and out of app environments, the instructional purposes for which iPads are used in the classroom, and implementation issues of the technology. This primarily observational study used both quantitative and qualitative methods to capture a picture of an active program to serve as a source for further questions that may be better answered by experimenting with different treatments. Quantitative data was gathered on student performance in two apps, Addimal Adventure and Splash Math 2nd Grade, as well on the frequency and type of iPad usage. Qualitative data came from interviews with six students and two teachers near the beginning and end of the four month research period. While students generally reported they enjoyed doing mathematics on the iPad, half preferred paper and pencil. Teachers believed iPads helped students stay engaged in mathematics longer, resulted in more time spent on task, and enabled more differentiated instruction. Students performed better on quizzes for both apps than they had in either app environment. While the scores were positively correlated with varying degrees of strength, no evidence was found that app progress significantly explained student quiz scores. It was also found that iPads were being used in two different modes of instruction: free choice and focused. Based on these results, the education community needs to provide additional support to teachers, including technical and pedagogical trainings, focused apps for various skills, and a feedback channel for teachers to quickly report problems to developers. With an active and engaged support structure, educators can take advantage of the technological abilities of these devices and create a more responsive and differentiated environment of mathematics learning than has previously been feasible.

Keywords: iPads in Education, Elementary Educational Technology, One-to-one Device Initiatives

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Chapter 1: Introduction

In this chapter, the current status of programs to deploy mobile devices to schools and districts in the United States is discussed. The nature of these initiatives is also described, as well as the many types of devices, the technological advances required for such devices, and the possible instructional benefits of these advances. The debate between proponents and skeptics of the technology is briefly outlined. Finally, the importance and scope of this study is situated in mathematics education and the purpose and hypotheses of the study are discussed.

Present Technology Initiatives

Currently, tablets and laptops are being aggressively rolled into classrooms across the country at all age levels. However, this is not simply a hardware refresh of existing desktop or laptop computers in classrooms. Many of these programs are one-to-one initiatives, where the goal is to give every student in a classroom, grade level, school or district one of the devices. This approach has been popular for several years, especially due to the falling prices of laptops (Penuel, 2006). While some districts see it as simply keeping classroom technology up to date, others see this as an opportunity for schools to respond to the massive changes that have occurred in mobile technology over the past decade. As Schnakenberg & Vega (2013) put it

> In the last decade, education has taken on a new rhythm in the lives of students and society. No longer is learning done at specific hours of the day in specific locations (generally schools and universities). Now education is something that occurs whenever a learner has a question or wonders about something and

> possesses a device to help him or her answer the query. Mobile learning is the present-day form in which education occurs. It is not only supported by mobile technologies, but also characterized by the mobility of the learners and the knowledge itself. (p. 589)

No longer is a computer a stationary device sitting on a desk, designed to be only occasionally accessed for information or to process data. Advancements in technology have created a world in which we have constant access to computing in the form of smartphones, tablets, laptops and even wearable computing devices. Most importantly, these devices are not operating in a vacuum; each is able to communicate wirelessly with other devices to varying degrees, as well as connect to the larger internet. This has not only changed our perception of computing and information, but perhaps the very nature of human knowledge and learning as well (Carr, 2008). Students today grow up in a world where information is freely available and where ideas can travel around the world in an instant. Almost any question can be answered in a few moments using a search engine—and if it cannot be readily found, the problem can be crowdsourced using social media. All of these factors affect the way students learn outside the classroom, and the modern classroom must therefore adapt.

These one-to-one initiatives are occurring in an environment of both staunch skeptics and advocates (Mango, 2015). Skeptics often argue that similar technology initiatives in the past—namely efforts in the 1990s to place computers in almost all classrooms—have typically had little lasting effect on the educational environment or student outcomes (Murray & Olcese, 2011). Even as Tyack & Tobin observed in 1994, the “grammar” of schooling is exceptionally difficult to change. The forces of “instructionalism” originally organized K-12 schools in the United States around “passive disciplinary knowledge and encouraged passive learning strategies based on knowledge absorption” (Halverson & Smith, 2009). This model would seem to control the learning experience, making it one in which teachers dispense knowledge to students who are expected to absorb it and deliver it back in the form of traditional assessments. Especially in mathematics, this has been the case for decades. The instructionalist model has proven quite “resilient” and has survived technological revolutions before by either “co-opting tools that reinforce existing practices” or “minimizing the threat of disruptive technologies through marginalization or banning” (Halverson & Smith, 2009). Coupled with the expense of instituting one-to-one device initiatives, such skeptics argue the resources required for deployment would be better spent on traditional, durable analog equivalents (Murray & Olcese, 2011).

Proponents believe these sorts of mobile devices will significantly change the way educators teach and the way students learn—finally realizing the dream of effective, individualized computer-aided instruction. While the reality is often more “prosaic and less transformative”, the possibilities offered with new technology can tempt any teacher (Murray & Olcese, 2011). Certainly an obvious benefit of one-to-one initiatives is that students would have constant access to the technology. When computers were primarily confined to labs in schools, the technology was used less often for instruction than it might have been otherwise due to scheduling difficulties and the time and energy commitment of transporting students to the lab (Penuel, 2006). Rather than using the technology in such a supplemental role, the new approach makes possible a more frequent and integral role in instruction. There is also the hope that such initiatives will provide more equitable access to new technology for low socioeconomic status (SES) schools. For this reason alone, such technologies are seen as an important element in efforts to improve results in underperforming schools (Warschauer, Knobel, & Stone, 2004).

Of course, the expense of a one-to-one initiative may be prohibitive to many schools and districts. Some schools have chosen to work on a smaller scale by only issuing a device to the teacher; others use a classroom set on a cart that can be reserved much like the computer labs previously discussed (Bennett & Martin, 2013). Other schools have explored Bring-Your-Own-Device (BYOD) programs, which allow students to bring their own devices from home for use in the classroom. While this option clearly reduces the cost to the school, it brings challenges of device support, distraction, and issues of inequity for students who do not own their own devices (Emery, 2012).

Types of Devices and the Effects of Design on the Classroom

As important as it is to consider the implementation strategy before deploying mobile technology to a school, the type of device also has a large impact on its possible uses in the classroom. Different companies usually bring different design perspectives that can fundamentally affect the learning environment. Two broad categories of devices can be described in today's educational market—laptops and tablet. Throughout this work, "laptop" refers to a "portable microcomputer having its main components (such as processor, keyboard, and display screen) integrated into a single unit capable of battery-powered operation" (Merriam-Webster, n.d.). Furthermore, the primary input of a laptop is through the keyboard, mouse, or trackpad, and the form factor is such that the device folds open like a book to expose the display and the keyboard.

“Tablet” refers to a wireless, portable personal computer that primarily accepts input from a touchscreen interface, rather than a keyboard or mouse. These devices are thin and typically have no other visible components than a bezel that wraps around the screen and provides a location for power switches, connection ports, and control switches. The tablet category will be considered to contain smartphones as a subset, since the line between the two devices continues to blur with so-called “phablets”, which are devices described as either large phones or small tablets (Thorn, 2014).

Tablets and smartphones run what are commonly referred to as “apps”. Originally short for “application,” the word has come to mean software that is intended for a single purpose, as opposed to “applications,” which are software programs designed for multiple purposes (Blankenhorn, 2010). As these devices typically run the same operating systems, and apps are often compatible across device sizes, the functionality is similar. Of course, smartphones may not be as useful in the classroom as tablets, due to size limitations, but they are often still useful in certain situations and are likely integral to an effective BYOD program.

However “futuristic” these devices may seem, the concept of the tablet computer is nothing new. In a recovered taped question and answer session following a 1983 talk, Apple co-founder Steve Jobs said

> [Apple's] strategy is really simple. What we want to do is we want to put an incredibly great computer in a book that you can carry around with you and learn how to use in 20 minutes ... and we really want to do it with a radio link in it so

> you don't have to hook up to anything and you're in communication with all of these larger databases and other computers. (Panzarino, 2012, p. 1)

This would seem to foreshadow the tablet computer in form factor and wireless internet in connectivity, several decades before either was a technical possibility. Going even further, Microsoft released a series of tablet PCs in 2000, but failed to gain any real traction in the education market (Page, 2000). Several technological factors had to change over the years to allow effective tablet devices to be built. Many of them have a direct effect on the instructional possibilities of the devices as well.

Perhaps the most fundamental advance was in processor technology. Processing density, combined with advancements in power management and consumption, allowed tablets to be constructed that could last for almost an entire day of moderate use without the need to connect them to a charger. In the classroom, this is an important barrier to interaction that must be removed if the device is to be treated as a tool at the ready, rather than as a learning opportunity that must be planned around battery life cycles.

Another important hardware advance was the multitouch capacitive display. This allows the device to receive touch input from multiple points of contact simultaneously, making for much easier manipulation of digital objects through the use of multiple fingers. It also allows the possibility of multitouch gestures, which involve pre-defined gestures involving multiple fingers to trigger commands. As useful as this input feature is, the capacitive display is perhaps the more transformative feature. Unlike resistive screen technology, which requires the pressure of a touch to bring two plates in contact and transmit an input signal, a capacitive screen registers an input through the capacitance of the object touching the screen (Kim, Lee, & Yun, 2011). As humans are somewhat conductive, this allows the screen to register the touch of a finger as an input. Therefore, the interface of the device can be designed for touch, without the need for a stylus or other input devices—such as a mouse, keyboard, or trackpad. This is especially useful in the early grades, where such input devices can not only represent a distraction if they need to be carried about with the device, but can represent a slight detriment to the device's ease of use. Touching is a very natural means of interacting with our world. The hope is that this advancement makes the device more intuitive to begin using and allows the interface of it to recede into the background of the user's attention (Kim et al., 2011). This allows the student's attention to be focused on the app being used, rather than on the act of using the device.

The internet and the increasing ubiquity of wireless local area networks (WLAN or Wi-Fi) have changed the way tablet devices function as well. They need not be tethered to a computer for management and updates. The devices can be freely moved about the classroom and online resources accessed whenever needed. For rooms equipped with Apple TVs or other similar media-hub devices, a local wireless network allows for wireless projection of any of the device screens to the main projector in the room. Hence, students can project their screen for the entire class to see for a presentation or discussion, as can the teacher for a demonstration.

Competing Devices for Education

The primary competitors in the tablet space are the Apple iPad, Android-based tablets, and Microsoft Surface tablets. Each brings its own set of opportunities and challenges. The Apple iPad was introduced in April 2010 to an industry already transformed by advancements in mobile technology over the previous years—certainly since the introduction of the iconic iPhone in 2007. According to Apple, since the product's introduction, at least 7 million iPads have been sold to the educational market (Dilger, 2014). While tablets based on Google's Android mobile operating system have been in the market since 2009 (McLean, 2009), their adoption numbers in education have remained low, with only about half a million sold to education in total (Dilger, 2014). While Microsoft was one of the first companies to pursue tablet computing in 2000, their Surface tablets only entered this race in 2012, much later than their competitors. Perhaps partially due to this, they have also found it difficult to gain traction in education. While exact numbers have not been reported, industry analysts believe the number sold to educational institutions to be quite low (Dilger, 2014; Foley, 2013).

Given how many choices there are in the market, it's difficult for schools to know who the winner will be and on which device they should standardize. It is also the case that it is not always the *best* device that wins out in a market. This problem is compounded by the nature of the app ecosystems for each device. Each operating system maintains its own distinct app marketplace. The two largest such marketplaces are for Apple and Android.

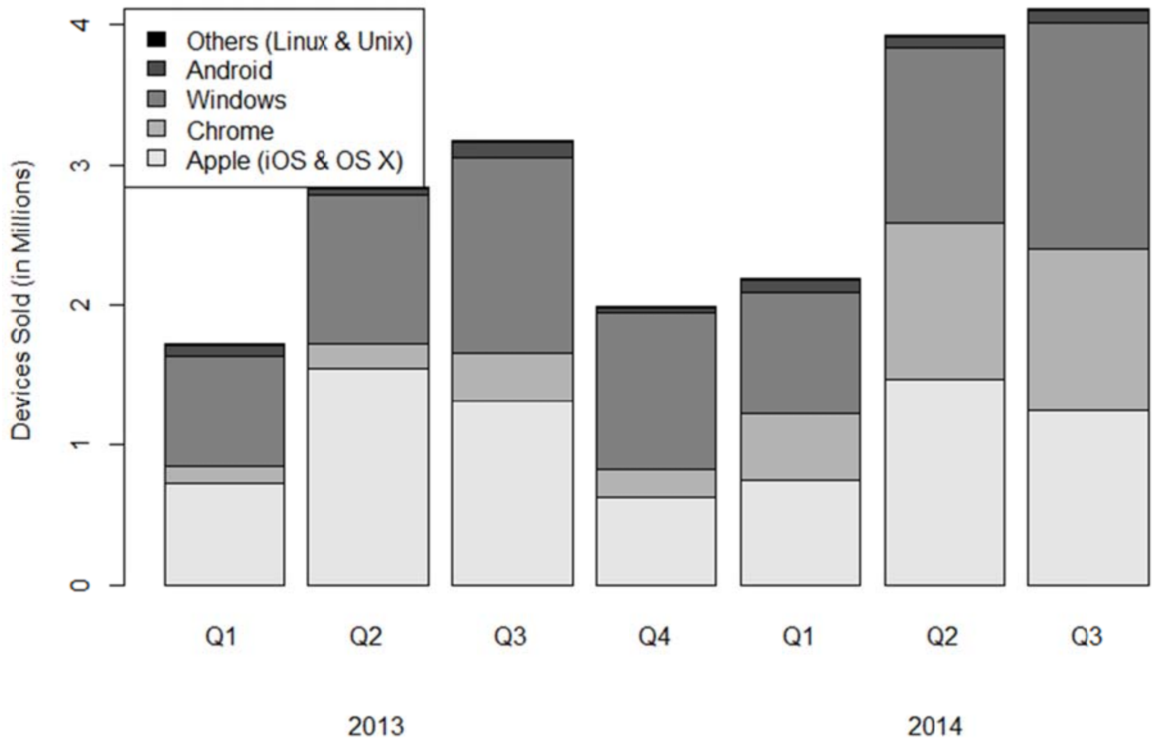
These two platforms provide a useful lens through which to view the pedagogical role of these devices in education. Apple's App Store is the only source for apps for their devices and, while it has a large developer base, the review process for apps is notoriously opaque. Developers often have trouble "threading the needle of the censor" and frustrations arise when some apps are allowed, while others are rejected for no apparent reason (Hestres, 2013; Thornburg, 2013, p. 45). However, Android app marketplaces, such as the Google Play store and Amazon's Appstore, are often more transparent and permissive with app developers (Remneland-Wikhamn, Ljungberg, Bergquist & Kuschel, 2011; Thornburg, 2013, p. 45). Also, most Android devices have the ability to install third-party apps from any source with the change of a setting. This example reveals a fundamental difference between the two platforms—Apple's iOS platform is more controlled, while Android-based devices are more open.

This difference also affects the devices' hardware and functionality. Apple has few models of devices, since they are made by a single company. They strive for elegance, often having very few ports and requiring more adapters for increased connectivity. For the sake of security, apps cannot interact freely or run simultaneously. On the other hand, Android devices are manufactured by several companies and have a multitude of options, making them very flexible. They often have many different devices with different connection options. Apps can freely run in the background and interact.

For this reason, some have claimed that Apple devices are more for "content consumption" while Android devices are for "content creation" (Thornburg, 2013, p. 45). This is a false dichotomy, as both devices can be used for either purpose, but the point is well taken. In deciding on a platform, educators must be aware of the types of apps available for each device, the nature of the developer environments, and the flexibility of the device in the classroom. While a device must be secure and controllable to some extent, one must also avoid stifling teacher creativity in how it is implemented.

Of course, laptop computers are still an important part of educational technology, especially at the higher levels. Recent reports show at least 20 million PCs and tablets were sold to the educational market (both schools and colleges) in 2013 and 2014 alone (see Figure 1).

Figure 1. 2013-2014 PC and Tablet Sales in U.S. Education Market (Dilger, 2014).



Of those, approximately 39% were Windows-based laptops. Also there are "hybrid" devices that combine elements of traditional laptops and tablets. Chromebooks are manufactured by several companies, and run Google's Chrome OS, which is based on the Linux operating system. These computers may look like traditional laptops, but are more similar to a tablet in the way they require remote storage (the "cloud") for large amounts of data and have limited offline capabilities. However, they are generally lower cost devices that are gaining traction in the education market. In the same report, Chromebooks accounted for 30% of sales to education (see Figure 1).

Statement of the Problem

Despite the numbers of mobile devices being deployed in education, there is a dearth of research backing up the assumption that they significantly improve student learning. (Diemer, Fernandez, & Streepey, 2013). In the past, researchers have attempted to evaluate new instructional technology by assessing student learning and engagement. Under the belief that technology encourages engagement with mathematics, they generally expect student engagement with tablets to improve some of their mathematical abilities. While most suppose that students will prefer classes using iPads, it is not yet known which factors contribute to student learning or engagement (Diemer, Fernandez, & Streepey, 2013).

In addition, it would be useful to know what effects the emerging technology has on teacher and student attitudes toward mathematics. This is especially of interest at the elementary level. The sequential nature of mathematics courses makes performance in them, especially in elementary and middle school, critical for access to advanced courses in high school and college (Singh, Granville & Dika, 2002). It is argued in the literature, and reported from the experience of most teachers of mathematics, that student attitudes toward the subject have a large impact on success, regardless of the level of technology (Fennema & Sherman, 1976; Singh et al., 2002). However, it is not necessarily an easy matter to change student attitudes. It has long been the hope of technology enthusiasts that computer-aided instruction might help to improve student interest in mathematics.

Certainly, the literature on the subject suggests that technology use can enhance learning through cognitive, metacognitive, and affective channels (Pierce, Stacey, & Barkatsas, 2007). Tablets especially lend themselves to a variety of modalities—visual, tactile, and auditory—which may allow them to adapt well to the needs of a many types of learners (Schnakenberg & Vega, 2013).

Purpose of the Study

The purpose of this study was to explore the effects of these new instructional devices by focusing on an elementary classroom with a one-to-one iPad program. Specifically, this effort sought to answer the following research questions:

- How does iPad or other technology usage affect student and teacher attitudes toward mathematics?
- How does student performance in an app environment translate to mathematics performance in more traditional forms of assessment?
- How much time is spent using iPads in the classroom and for what instructional purposes are they used?
- What issues are involved in implementation of the technology?

Hypotheses

It was hypothesized that students would have generally positive views of mathematics apps on the iPad, but they would likely express a certain amount of worry about mathematics in general. It was also suspected they would discuss mathematics in a more dynamic, or at least less procedural, manner than other students in the literature, but they might not make specific mention of the iPad—at least no more than others might refer to a textbook. If the iPads were being used for more exploration and discovery than might traditionally be seen in computer-based instruction, it was thought this sort of discussion of mathematics might reveal a more inquisitive and less deterministic view of the subject. Of course, in the early grades, the amount of arithmetic learned would limit the extent of this exploration. It was hypothesized that teachers would have generally positive views of mathematics and likely focus more on the changes brought about by the new technology in their instruction and student performance. The researcher further predicted that students would show lower performance on “paper” math problems than inside apps, due to the change in context. However, there would likely be a correlation in performance between the two environments.

Importance of Study

This study, and others like it, are important if districts and schools are to have successful deployments of these technologies to classrooms. In December 2014, the Los Angeles Unified School District suspended its $1.3 billion one-to-one iPad program due to concerns over cost effectiveness, accusations of corruption in the bidding, and the lack of specific and measurable expected outcomes. A report issued by the US Department of Education found the school district program was “too heavily focused on the iPad instead of being open to less-expensive alternatives” (Blume, 2015). They also found that teachers weren’t being provided enough training and there was an absence of district-wide instructional technology leadership (Blume, 2015).

As concerning as this situation is, it is only one out of many such initiatives occurring throughout the country. While exact counts are not available, it is estimated that every state has some sort of a one-to-one device program in effect (Dilger, 2014). Considering reports of at least 20 million devices being sold to the educational sector, and that the 2011 U.S. Census showed approximately 83 million students in the United States (in schools and colleges), it is clear such devices cannot be considered rare in classrooms (Davis & Bauman, 2013). All of the companies have been reporting growth in these sales, implying the trend will only be increasing (Dilger, 2014; Thornburg, 2013, p. 44).

Scope of Study

Of course, providing a complete answer to these questions is an arduous task. This study only considered students and teachers in two second grade classrooms. An in-depth analysis of student learning and attitudes toward mathematics and technology, in addition to teacher attitudes toward these subjects, provided a useful snapshot of this school's implementation of iPads in the elementary classroom. This information will prove useful in designing any future study attempting to compare such classrooms in larger populations, as well as promote best practices to other districts implementing similar one-to-one device initiatives.

Summary

This chapter discussed the types of device initiatives, technologies, design philosophies, and devices that will affect the way tablet devices are integrated into mathematics education at all levels. The challenges of effectively implementing such technology often depend on the design choices of manufacturers and limitations mentioned. These will prove useful points of reference as the researcher attempts to answer the stated research questions and explore student performance and attitudes in mathematics in second-grade classrooms with a one-to-one iPad initiative.

Chapter 2: Literature Review

Introduction

This chapter reviews research findings on the topic of educational technology as it pertains to this study. However, in order to discuss how students and teachers interact with technology in the classroom today, the history and issues of technology integration must be considered. Hence, in the first section, the topics discussed are the first and second digital divides, how they interact with gender and socioeconomic status, and technology usage at home and school. Attention is then turned to topics relating to student and teacher interactions with the technology in regards to mathematics. These include student attitudes toward technology and mathematics, teacher beliefs and attitudes regarding new technology, new forms of assessment, and professional development opportunities around technology.

Background

While tablet technology may be new to the classroom, computers are not. As the educational system approaches four decades of digital technology in the mathematics classroom, it's a worthwhile endeavor to look back and reflect on how the technology has changed schools, students and teachers—and whether it has had an effect on learning. There are some educators who would argue that technology has not noticeably improved student achievement in mathematics, bemoaning the impulse to immediately use the calculator in lieu of mental calculation or to look up a hint online before spending hours working on a problem without progress (Guerrero, Walker, & Dugdale, 2004; Murray & Olcese, 2011).

However, others would argue that such criticism is ultimately unproductive. Many think the emergence of technology in the classroom was inevitable—as the computer revolution began to transform our culture, it was unreasonable to assume the classroom could remain untouched as the world changed around it (Weston & Bain, 2010). In fact, technology was seen as a potential "equalizer;" a way to level the playing field for students in low socioeconomic status (SES) schools (Gorski, 2009; Warschauer & Stone, 2004).

The introduction of digital technology in the classroom progressed through many stages. Its course was often determined by classroom use, teacher beliefs, professional development, and technological advancements. Initially, the focus was providing students access to computers—however, the use of technology in schools varies greatly and is key to student learning (Weston & Bain, 2010). Such variation has the potential to create a "digital divide" that results in inequitable instruction (Attewell, 2001; Warschauer & Stone, 2004).

The First Digital Divide

Attewell (2001) defines the first digital divide as one of access to technology (p. 253). Even as some of the first microcomputers were being introduced during the 1980s, many worried that the disparity between schools in high and low socioeconomic status (SES) areas would exacerbate the educational opportunity gaps for those student populations (Zakariya, 1984). Other known education opportunity gaps, such as rural vs.

urban, white vs. minority, gender, or native English speaker vs. English as a Second Language (ESL), are also related to the introduction of technology and each brings along a particular set of concerns as to how it affects various student groups (Attewell, 2001; Kim & Chang, 2010; Thompson, 1990). Of course, for many, all these gaps had the simple solution of provisioning schools with computers and software—as was noted in a literature review of student and teacher attitudes toward technology and mathematics by Disney, Lelko, Swicegood & Swift (2013).

While many schools previously had a few computers available per classroom, the 1990s saw tremendous growth in technology acquisition by schools and the possibilities of their implementation were multiplied by the simultaneous maturation of the internet (Staples, Pugach, & Himes, 2005). Public opinion and policymakers were certainly focused on this type of access and many believed this fully addressed issues of inequality (Van Dijk Hacker, 2003, p. 316). To be fair, convenient physical access is a necessary first step, but doesn't sufficiently change the way students learn. Anyone who has seen obsolete and barely used desktop computers in a classroom knows there is more to the situation than simple access—how the computers are used is extremely important.

Although he was speaking of the history classroom, Wenglinsky (2005) noted that lessons should not revolve around the technology, but rather allow students to use the technology as a tool in an effort to deepen their thinking, and therefore the meaning of the material. This observation applies to the mathematics classroom as well and leads to a concern over a second digital divide—one not of access, but of usage.

The Second Digital Divide

Attewell (2001) defines the second digital divide as one dealing with the use of technology (p. 253). The situation has now evolved to a point where it is not a matter of whether or not the school maintains the requisite computer equipment, but how accessible these computers are “to students and teachers in the pursuit of teaching and learning” (Gibbs, Dosen, & Guerroro, 2009, p. 11).

To address this concern, one must consider precisely how computers can affect student learning. Certainly one component could be their effect on the initiative and interest of the student. The hope for many is that computers will somehow excite the student and engage them more fully with the material—to this end, educational computer games are extremely popular and are being produced at an increasing rate (Habgood & Ainsworth, 2011).

In order to accurately describe the second digital divide, researchers need more usage data than they might get from a single study. For this reason, many make use of the data from the National Assessment of Educational Progress (NAEP). The NAEP has measured student achievement in mathematics, as well as other subjects, for over 40 years (Beaton, Gonzalez, & Gorman, 2011). The NAEP offers teachers, administrators, and policymakers a wealth of achievement data by which to evaluate the effectiveness of instruction in a variety of subject areas and to measure the progress of students from a nationwide sample. Interestingly, the NAEP also offers researchers a breadth of data beyond achievement scores. Students, teachers, and administrators complete surveys addressing a variety of factors that may impact achievement, such as student attitudes about subjects, classroom instructional practices, teacher professional development, and access to and use of instructional technology (Disney et al., 2013).

The NAEP has also documented varying levels of achievement among groups of students based on a variety of demographic factors, such as race/ethnicity, gender, socioeconomic status (SES), native language spoken, and rural vs. urban school settings. The existence of achievement gaps in the NAEP data is well established, but how to narrow these gaps has been a focus of research for as long as the NAEP has been administered (Lubienski, 2008).

Of course, there are questions as to how effective the different forms of technology are and how they interact with the various educational opportunity gaps. In Kim & Chang's study (2010) of a group of 4th graders, computer games were found to have negative effects on mathematics achievement for boys when played over a certain amount of time per day, but a positive effect when played less frequently. Interestingly, this negative effect was only observed for the English-speaking group and was not present for the English Language Learners group. On the other hand, male students who played mathematics games less frequently (once a month to twice a week) outperformed the male students from the control group. From the perspective of gender, this study also found that males were positively affected by computer games, while females were not. However, another study found a common improvement in both genders (Kim & Chang, 2010). It is possible that apps and games have complex interactions with all the different types of divides discussed above (rural vs. urban, white vs. minority, gender, or native English speaker vs. English as a Second Language (ESL)) (Attewell, 2001; Kim & Chang, 2010; Lubienski, 2008; Thompson, 1990).

These interactions also depend on the type of technology application. The findings of a meta-analysis by Cheung & Slavin (2013) investigating prior evaluations of technology applications in the K-12 mathematics setting were that they produced a "positive but small effect." They also found that computer-assisted instruction (CAI) had the largest effect on mathematics achievement. Applications in which students used the programs more than 30 minutes per week were more influential than those requiring less than 30 minutes per week (Cheung & Slavin, 2013).

Also of interest to this research, previous meta-analyses found the use of educational technology had a larger effect on elementary students than it did on high school students (Li & Ma, 2010; Slavin, Lake & Groff, 2009). While Cheung & Slavin (2013) found this to be the case as well, the difference was not statistically significant. A possible explanation of this might be found by looking back at J. Kulik, C. Kulik, & Bangert-Drowns (1985), who argued that high school students "apparently have less need for highly structured, highly reactive instruction provided in computer drills and tutorials. They may be able to acquire basic textbook information with the cues and feedback that CAI systems provide" (p. 71). Of course, others would argue that the effectiveness of computers in the classroom heavily interacts with other developmental factors, such as gender. This and other factors would need to be carefully controlled for in a study in order to draw any significant conclusions about the two age levels (Niemiec & Walberg, 1985).

This might lead one to wonder whether more dynamic applications of technology would be more effective. Li's (2008) study of this topic included the use of video conferencing, while working with 35 female students from two ninth grade classes over a three year period. This study found that students gained new perspectives on the application of personal interest and career options connected to the math and science fields when technology is integrated into a classroom in a dynamic way, as opposed to just drill.

This point was also previously stressed in Schacter's (1999) review of research in CAI, integrated learning systems technology, simulations and software that teaches critical thinking, collaborative networked technologies, and design and programming technologies. His analysis showed the implementation of these technologies increased student achievement, but that there needs to be a clear intention in how the technology will be used in the classroom; specifically the technology needs to have a connection to an educational goal, and not be used for the sake of being used (Disney et al., 2013).

Digital Divides and Student Socioeconomic Status

There are stark differences between low socioeconomic status (SES) students and their higher SES counterparts (Disney et al., 2013). In one study, SES was the strongest predicting factor as to whether or not technology would positively or negatively affect test scores (Wenglinsky, 2005). Not only are there different approaches to implementing technology in schools in general, but these appear to differ greatly between high and low SES schools as well. While the 1996 NAEP data indicates that poor students actually worked with the computer in school more often (Wenglinsky, 1998), it was also found that students in high-poverty schools use computers more for rote learning—a technique referred to as "skill and drill" in a later study by Gorski (2009). This "skill and drill" approach to technology use in the classroom was shown to have a negative impact on academic achievement at all levels by Wenglinsky (1998).

Warschauer, Knobel, and Stone (2004) found five low SES and three high SES schools in Southern California "had relatively comparable numbers of computers and of Internet-connected computers" (p. 571). In the same study, within mathematics courses it was observed that the high SES students were using technology for statistical analysis, whereas low SES students used the technology for individualized drill and practice.

Such studies would seem to indicate the first digital divide—that of access to computers—is no longer much of an issue. After controlling for other variables, such as school size, technological confidence, and the presence of computers at home, Delen & Bulut (2011) found that the student-to-computer ratio was not statistically significant in predicting student performance in math and science on the 2009 PISA exam. This trend of access has been corroborated by other studies as well (Warschauer, 2000; Warschauer & Matuchniak, 2010). Unfortunately, these studies also found that higher SES schools tend to utilize technology for simulations and critical analysis, while low SES students experience less effective drill and practice (Warschauer & Matuchniak, 2010).

However, the differences are not always simply in the style of instruction. Warschauer (2000) looked at two different schools in Hawaii, a college preparatory school and another described as a lower SES school. Both were seeking to do similar technological upgrades, but implemented them with different visions in mind. The preparatory school helped their students work with the technology in a scientific manner—using it in much the same way it would be used in a research laboratory at a university. The low SES school set out to ensure their students had marketable skills to apply in the workforce. Computers were used for basic software training and in ways more typically seen in business. This study did not necessarily observe a lower quality of learning in the lower SES school; rather it was a different type of learning, custom tailored to the student population of the school and the vision of the teachers and administrators (Warschauer, 2000).

Clearly, the situation is not as simple as choosing the more effective program for a given school population. If it is also a matter of choosing the school vision, this could include programs such as tracking—which carries many issues of equity for the students (Braddock & Slavin, 1992). Delen (2011) researched intra-class correlations in Turkey by examining data from the 2009 Programme for International Student Assessment (PISA), "an internationally standardized assessment administered to 15-year-old students (9^{th} graders) in schools" (p. 311). These results showed that most of the variability in science and mathematics scores could be explained by the variability between schools, rather than between social classes. It is worth noting, however, that this study was limited to 9^{th} grade students in Turkey, so the results may not generalize to other populations or countries.

For those students with technology in the classroom, implementation can be easily contrasted. Bottge, Grant, and Rueda (2010) had "a total of 303 students in 18 intact technology education classes at three middle schools in the Midwest [that] participated in the study" (p. 85). Classes were either given coursework in a Business as Usual (BAU) format or one of two versions of an Enhanced Anchored Instruction (EAI) for mathematics skills. The EAI group either had concepts explicitly presented to them or had concepts embedded with real world problems and projects. Students were asked to solve problems in their computer program lessons. Results indicated students taught with either version of EAI outperformed students in BAU in problem solving. Also, students in the EAI classes saw gains on key subsets of skills including performance in reading a tape measure and computing with fractions. In fraction computation, students in both EAI groups scored higher on the posttest than students in the BAU classes. However, only the students in the embedded concepts EAI group showed more improvement from pretest to posttest than students in the BAU condition. The scores of students in the EAI groups were higher on the posttest than on the pretest, but the size of their improvement only approached significance compared to that of students in the BAU group (Bottge, Grant, & Rueda, 2010). From this, one might conclude that both forms of EAI learning, both explicit and embedded, outperformed traditional mathematics instruction at this school.

Technology may also be used differently by students at different levels of academic achievement. Nzuki (2011) looked at high achieving and low achieving students from an Algebra II course at a low SES high school and offered a glimpse into students' perceptions of the graphing calculator. A high achieving student blended her mathematical and graphing calculator knowledge to interpret the calculator results. On the same problems, a low achieving student relied heavily on the technology, without taking the time to understand what the problem was posing, nor stopping to interpret the result computed from the calculator. The two students appeared to perceive the purpose of the technology differently (Nzuki, 2011).

Technology Access at Home

While studies have indicated that how technology in schools is used has an impact on student achievement, this is not necessarily the only access point for students. For example, according to a study of 9th grade students in Turkey, "technology usage at school was found to be a weak predictor of math and science achievement" on the 2009 PISA exam (Delen & Bulut, 2011). The same study found the presence of internet connected technology at home to be a strong predictor of performance in math and science. However, this study took place at a time when home computer access was quite common. Obviously, home technology access has changed over the past few decades. For this reason, it is informative to examine the research over this period for changes in findings.

In the 1990s, home computers were becoming more widespread. However, Wenglinsky's 1998 study of 1996 NAEP data found that fourth graders with a computer at home and access at school had lower math scores on the NAEP exam than their peers. Earlier, Giacquinta, Bauer, and Levin (1993) had hypothesized this performance decline may result from the fact that students used the computer for games and word processing, rather than utilizing it as a supplementary learning resource for computer-aided instruction.

Of course, another component of the situation may be familiarity with technology. Attewell and Battle (1999) found that students from more affluent families had greater success with the technology in home versus their lower income counterparts. Similarly, Wenglinsky found the "frequency of home computer use was positively related to academic achievement and the social environment of the school" (Wenglinsky, 1998, p. 5). Of course, other factors surrounding home computer use determine its effectiveness on student achievement as well.

Due to the high cost of home computers at the time, there were interactions between the device's presence and other factors of the digital divides such as SES, gender, and race. Wenglinsky (1998) found, after reviewing NAEP data from 1996, "for both eighth- and fourth-graders, that black students were less likely to have access to a home computer than white students" (p. 3). For the fourth-graders however, of the African American students with access to a computer at home, 53 percent indicated on the NAEP that they used the computer once a week, if not more (Wenglinsky, 1998). He also found the type of computer use at home is important, and that the rural-urban divide may also be a factor. Wenglinsky (1998) stated in his analysis that students from poor, urban, or rural areas did not have the same sort of access to a home computer as their more affluent, suburban peers. In the same study, he also found that students with a low SES background and access to a home computer, use it just as much as, if not more often than, their higher SES peers.

Not surprisingly, most of these issues still exist today in one form or another, despite the changes that have taken place as home computers and smartphones have become more commonplace. It is likely still the case that there is an interaction present between computer use at home, math and science performance, and age. For example, in a study by Warschauer & Matuchniak (2010), a positive relationship was observed between home computer use and mathematics scores for eighth graders. They also concluded from their review of youth technology use that computer use at home, rather than at school, has a greater impact on academic outcomes. Teenagers with access to a computer at home were 6-8% more likely to graduate from high school than teenagers without a home computer. This was determined after controlling for family income, race, and parental education (Warschauer & Matuchniak, 2010).

However, racial factors also play a role in home computer use and access. A 2009 literature study revealed African Americans and Latino people are more likely to use computers for entertainment purposes outside of school (Gorski, 2009). There is also the issue of internet access, which can vary widely in cost and quality. Warschauer & Matuchniak (2010) found that Latinos had a much lower rate of internet access compared to other groups and hypothesized that it may be attributed to language barriers. They also found that home internet access has grown steadily among U.S. households over the past couple of decades, but that the largest gap in regards to internet access is between income and educational attainment (Warschauer & Matuchniak, 2010). However, more widespread access to smartphones has already begun to change this dynamic in recent years (Yardi & Bruckman, 2012).

Other non-school sources of computer access are libraries and community centers. Warschauer and Matuchniak (2010) found that 50% of youth report accessing the internet at libraries or friends' homes and less than 10% get their access at community centers. Those students who use computers at either the library or community center must also handle the additional hurdle of wait time and time restrictions with the technology. These sorts of inconveniences are often an overlooked barrier to access. As Gorski (2009) puts it, access is defined too broadly when only referring to physical access.

The previously mentioned review of studies by Warschauer & Matuchniak (2010) found that home computer use experiences were greatly affected by SES and recommended mentors and peer models at school to assist these students. This recommendation was the result of their observation that low-income and immigrant students have fewer friends and relatives that are "sophisticated users of digital media"

(Warschauer & Matuchniak, 2010). They suggest community centers may be more adept than libraries at supporting students with access to mentors and more advanced technologies to “develop authority through media use and mastery” (p. 211). Even twenty years earlier, it was documented that the attitudes and abilities of a child’s parents and siblings use of technology play a role in how successful a child is in the realm of education (Giacquinta, Bauer, & Levin, 1993). This may be yet another factor in the explanation as to why low-SES students show little progress in test score achievement (Disney et al., 2013).

Of course, student interactions with tablet computers have developed differently in recent years than they did with desktop computers in the previous decades. When desktop computers were first appearing in schools, the devices were quite expensive—often several thousand dollars. It was not uncommon for students to first encounter these devices in the school environment, years before prices fell and home computers became more prevalent (Kafai & Sutton, 1999). As this occurred, increasing numbers of students entered the classroom already familiar with the technology. In the case of the iPad however, the exceptional popularity and swift adoption of the device has been astounding.

Perhaps attributable to initial costs in the hundreds of dollars as opposed to thousands of dollars, since the iPad’s introduction in 2010, it is estimated that 7 million of the devices have been sold to education in the U.S. (Dilger, 2014). However, this is dwarfed by the 200 million iPads Apple reports they have sold in total, with an estimated 80 million sold in the U.S. alone. This is not even considering the other 600 million iPhones and iPod Touchs they have sold, which run the same iOS operating system. In addition, Google reports they have activated over 900 million Android-based devices to date (Ingraham, 2014). It is therefore not surprising that most students have already encountered some form of mobile touch-based technology before they reach the classroom. Given the overwhelming popularity of mobile games, it is also likely their primary experiences with such devices were entertainment related, rather than educationally based (e Silva & Hjorth, 2009; Furini, 2007).

It should be noted, however, that technology in the classroom and at home does not strictly indicate the success or failure of students in mathematics. As Nzuki (2011) notes: "While the use of technology can augment students' learning of mathematics, their mathematical knowledge can foster the acquisition of more knowledge of technological tools" (p. 36). Therefore, as important as the digital divides may be the role of technology in the classroom also depends on the mathematical knowledge of students and other factors such as their beliefs and attitudes toward mathematics.

Student Attitudes toward Mathematics and Technology

It has been the hope of many that having computers and mobile devices in the classroom would help to increase student engagement with and attitudes toward mathematics (Vu, McIntyre & Cepero, 2014). Indeed, there have already been indications this is the case. For example, in a controlled study by Riconscente (2013), an iPad application called Math Motion, a tilt-based game that has the player place a fraction between two points on a number line, was given to fifth grade students at two separate Los Angeles schools. While intended as a means to teach the beginning concepts of fractions, it was found that the application helped solidify students' understanding, which also improved students' attitudes toward the concept (Riconscente, 2013).

Of course, student attitudes toward the technology and mathematics will have a large effect on the success of the devices in the mathematics classroom. Ifenthaler & Schweinbenz (2013) found that students' attitudes had the greatest effect on acceptance of new instructional technology, followed by facilitating conditions, performance expectancy ("the individual belief that using a specific technological innovation will help to improve job performance") and social norms.

In the U.S., many students report negative attitudes toward mathematics, despite the efforts of Science, Technology, Engineering and Mathematics (STEM) advocates to encourage student interest and performance in this area in recent decades (Greene, DeStefano, Burgon & Hall, 2006). However, this performance is typically measured by means of timed standardized tests. Student performance on these types of tests is influenced by "a wide variety of motivational and affective factors such as test anxiety, risk-taking preferences, cognitive style, and confidence in one's abilities" (Eccles & Jacobs, 1986). In a study by Eccles & Jacobs (1986) they found that "social and attitudinal factors" had a greater influence on junior and senior high school students' grades and enrollment in mathematics courses than differences in their mathematical aptitude.

Historically, another factor in play here is math anxiety, which can affect student performance and is very highly and negatively correlated with perceptions of math ability (Fennema & Sherman, 1976; Wigfield & Meece, 1988). Some researchers have even found that gender differences in mathematical achievement and attitudes can perhaps be attributed to gender differences in math anxiety (Eccles & Jacobs, 1986; Wigfield &

Meece, 1988). Math anxiety should be conceptually distinguished from mathematics ability. The components of math anxiety are similar in all age groups and genders. Two main components are negative affective reactions—such as fear, nervousness, and discomfort—and worry about doing well in mathematics. Wigfield & Meece (1988) found that while boys and girls did not differ in their reports of math worry (indicating they were equally concerned about doing well in mathematics), girls were much more likely to experience more "negative affective reactions to math class".

Further complicating matters, student attitudes toward mathematics are also formed by "the gender-stereotyped beliefs of parents," the value parents place on the subject, and their perception of the difficulty of mathematics. Parents' beliefs may even have a larger effect on students' mathematics grades than the students' attitudes (Eccles & Jacobs, 1986). All of these beliefs are influenced by media reports attributing gender gaps in mathematics to innate or biological factors.

One hope of supporters of digital technology integration is that these devices will have a positive effect on student attitudes and perhaps alleviate some of the components of math anxiety. Unfortunately, negative student attitudes toward mathematics are often well formed by the end of the early years of schooling (Larkin & Jorgensen, 2014). Some studies have found that technology can be used as a resource, motivator, and facilitator of communication. Such qualities can help support students with math anxiety and other emotion disturbances (Hak, 2014; Haydon et al., 2012; Larkin & Jorgensen, 2014). These types of emotional issues can often have a strongly negative effect on student performance in all subject areas, including mathematics (Haydon et al., 2012). Even if technology only provides teachers insight into student perceptions and feelings about a subject by means of providing a more private and intimate means of gathering student journals, the benefit to teacher understanding of student attitudes could help to improve the classroom experience (Larkin & Jorgensen, 2014).

Another concern, regarding student attitudes toward technology specifically, is that these attitudes may also be established at a young age. However, this may not necessarily be the case. For example, a recent study of university student attitudes toward digital textbooks on e-reader devices found that after a couple of years, students were growing used to digital textbooks. Even over the two years of the study, the researchers noted marked shifts in student attitudes toward the technology. The first students to use the devices generally felt that students were two generations away from readiness to use digital textbooks—that is, they envisioned it working for students currently in elementary school, but not for generations closer to their own age (Weisberg, 2011).

However, after only two years, in the new class of students, many preferred the e-textbook to a paper textbook. They found the ability to use the electronic reader wherever they were and easily carry it to be valuable. Of course, this group of students benefited from two years of technological advancements in the swiftly iterating market of e-readers, as well as decreases in the prices of the devices over that time. Weisberg (2011) found that the cost of the devices, the perceived impact of the devices on their learning, and whether they are assigned or recommended by the instructor were the major factors driving student acceptance of the devices. He also "demonstrated that there is no impact on the students' learning through the use of digital textbooks versus traditional textbooks; there is neither increased nor decreased learning of the course content"

(Weisberg, 2011).

Technology Use and the Teacher

However students may feel about technology, its success in the classroom is ultimately dependent on how it is implemented by the teacher. These concerns have been around since the first appearances of computers in classrooms. For example, over 40 years ago, chemistry educators were concerned that students would be able to collect data and use a computer to immediately obtain the slope and intercept from a linear regression without having to perform all the requisite calculations (Young, 1970). Young suggested "that neither the mindless nor the sadistic approach represents effective use of a computer" and that it is

> too easy to use computers to only evaluate simplistically correct answers, it is almost as easy to write routine intrinsic programmed instruction and call it computer-assisted instruction. Indeed, it is true that no professor can teach; that is the task we set to the student, each one, on his own. But we can help our students in their work best by working harder ourselves to put imagination as well as our own right answers into the computer for our students to use. Unless we supply our own version of imaginative utility, we cannot require the student to do the same, later. (p. 759)

His conclusion rings so true today that one wonders what progress has been made at all in implementing technology in the classroom. Specifically, it touches on the core issue of teacher preparation and use of technology. Simply using it to replace mechanical procedures or to check student work will change the learning experience, but not necessarily student understanding and comprehension (Wenglinsky, 1998). In order for this to occur, "imaginative utility" is required on the part of the educator to take students further than was previously possible.

Decades later, Warschauer & Matuchniak (2010) concluded that educators needed to focus more on the integration of technology and adopt a dual-approach pedagogy to teach both basic and advanced skills at the same time. In addition, assessments need to change to be less about basic skills and more about performance in 21st century applications based on the technology. All too often teachers feel they are forced to "teach to the test" as a result of time constraints, resulting in a lack of incentive to integrate technology more deeply into the curriculum (Warschauer & Matuchniak, 2010). In a study of grade 2-5 classes in New Zealand, Williamson-Leadley & Ingram (2013) found that the iPad app Educreations could be used to challenge traditional forms of assessment. Educreations is a "digital whiteboard" that supports multiple slides, making notes, and real-time sound recording integrated into the animation of the student's work. This study found that students were more engaged and motivated with the app versus traditional worksheets and that teachers could use the recorded assessment to promote dialogue by going back and forth through the student's thinking—rather than being confined to the single completed answer on a piece of paper (Williamson-Leadley & Ingram, 2013). This provided teachers with a more effective formative assessment option.

There is also hope that iPads and similar devices will contribute to the development of evidence based learning and teaching (Melhuish & Falloon, 2010). Scientifically based practice has been pushed to the forefront of the attention of the U.S.

educational system with the passage of the Elementary and Secondary Education Act (ESEA or No Child Left Behind) in 2001 (Slavin, 2002). According to Slavin, this legislation defines "'scientifically based research' as 'rigorous, systematic and objective procedures to obtain valid knowledge,' which includes research that 'is evaluated using experimental or quasi-experimental designs,' preferably with random assignment" (Slavin, 2002, p. 15). While this is perhaps more rigorous than some education research performed today, it is really only an extension of the best research being performed in the field.

More transformative however, is the subsequent movement toward true evidence based education. Evidence based education is an approach to all aspects of education—from policy-making to classroom practice—where the methods used are based on significant and reliable evidence derived from experiments (Petty, 2006). Properly implemented, it could bring about the sort of scientific revolution that has already occurred in industries such as medicine, agriculture, transportation and technology (Slavin, 2002).

Probably the easiest analogy to draw with evidence based education is with the current state of medicine in the U.S. In recent decades, modern medicine has "leapt forward" by moving from a field dominated by "eminence, charisma, and personal experience" to one in which randomized trials are employed to determine what treatments are the most effective (Goldacre, 2013). The essential idea is to randomly assign subjects to experimental or control groups, rather than have other external factors determine the groupings. The danger in doing so is that confounding variables such as socio-economic status, gender, attitude, age, illness, or any number of other factors, could play a role in the determination of the groupings and mask any effect of the treatment being tested (Goldacre, 2013). In fact, this has become so entrenched in modern medicine that most informed patients would be hesitant to undergo a treatment that had not been found effective though statistical analysis in controlled randomized experiments. However, this revolution in medicine almost entirely passed over mathematics education, and has left the field jumping from fad to fad over the years as political pressures shift and new standards are introduced to "fix" the system, with little to no scientific evidence to support the claims made their writers (Melhuish & Falloon, 2010; Slavin, 2002).

The randomized experiment is considered by many to be the defining quality of evidence based education. From a statistical standpoint, the ability to randomly assign students, classrooms, or schools to experimental groups helps to reduce error by reducing the effect of confounding variables. One could say it is a requisite quality of a study if one seeks to explore causation rather than correlation (Carnoy, Kilpatrick, Schmidt & Shavelson, 2007). However, there are ethical implications to consider when assigning students to different educational treatments—the idea of students somehow being treated unfairly and not receiving the same quality of education is unsettling to many parents and educators. It is a mistake to assume new treatments are always better; it is entirely possible the new program will be ineffective, perhaps even detrimental, with respect to student mathematical learning. From a scientific standpoint, this is a necessary risk to take for progress—certainly in the medical field this has proven to be entirely worthwhile.

A more ethically satisfying approach would be the use of natural experiments. A natural experiment is an empirical study where the participants are chosen by forces outside the observer's control, such as nature or some other authority, but the grouping reasonably approximates random assignment (Glymour, Kawachi, Jencks & Berkman, 2008; Rutter, 2007). Certainly an advantage of this type of natural experiment would be the likelihood of it occurring. For example, a researcher would be much more likely to be granted access to teachers who happened to be trying a new textbook than to be allowed to randomly assign students to an experimental class intended to test it.

A third option for experimental design that is similar to a natural experiment is an observational study. An observational study is also describing a situation where the treatment groups are determined outside the researcher's control, but without an assumption of randomization, natural or artificial. This is an extremely common type of study due to its less intrusive and more direct nature (Tashakkori & Teddlie, 2003, p. 315). An advantage to this design is that there are far fewer ethical issues, as the decisions were not made for experimental purposes but were implemented for reasons of productivity and student achievement. Obviously a disadvantage of this type of study for the purposes of evidence-based education is that there is no randomization of subjects between groups, so any analysis of gathered data may just as easily be revealing the effect of a lurking variable as it is studying the effect of the treatment (Melhuish & Falloon, 2010; Slavin, 2002).

Internet-connected devices such as iPads and tablets allow researchers to pursue all of these research designs in new ways. Many apps, such as Addimal Adventure or Splash Math 2nd Grade, offer backend services to teachers where student performance data in the app can be accessed via an online dashboard or reported by email (Carpenter, Pagar & Labrecque, 2013). This connectivity combined with automatic updating could allow for randomly assigned experimental groups to test different variations of app design for effects on mathematical performance. For years, this sort of A-B testing has occurred on websites to improve user experiences and website performance (Kohavi, Longbotham, Sommerfield & Henne, 2009). While natural experiments may still depend on naturally occurring groups, the ability to possibly gather data from many different classrooms across the country simultaneously opens up the possibility of larger sample sizes and comparisons that would have been difficult to draw otherwise. Observational studies can be improved due to the sheer amount of usage data that could be collected by iPads—student recordings, input logging in apps, and navigation patterns, among other signals (Dalton, N., Dalton, R., Hölscher & Kuhnmünch, 2012).

However, teacher use of educational technology is not simply determined by the presence of the technology—it is largely dependent on beliefs and attitudes toward it, as well as the technology training provided to the teachers. Attewell (2001) suggests that rather than treating teacher training as a “third digital divide,” it is perhaps better to consider it under the umbrella of the second digital divide of use. While Attewell (2001) discusses use more in terms of race and SES and how it interacts with home and school use, this is integrally tied to how the teacher uses technology in the classroom. However, this in turn is dependent upon the level of teacher knowledge, beliefs and attitudes regarding technology and mathematics.

Teacher Attitudes toward Mathematics and Technology

It is easy to overlook possible bias when describing teaching; in fact, one could argue this mistake is often made by school administrators, policymakers, politicians and researchers alike. This applies to new educational technology as much as it does to the subject matter of mathematics. If teachers see potential in new technology and have sufficient training and resources to implement it effectively, then it may benefit student learning and achievement. The results will be far different if they believe the technology to be an ineffective distraction and either barely use it or ignore it entirely (Vu et al., 2014). Any new technology initiative must address teacher beliefs regarding how it should be integrated into the curriculum (Ertmer, 2005). Previous research on teacher beliefs in general can provide a framework into which technology can be integrated.

Teacher beliefs are one of the hardest aspects of practice to change, yet we ask for this change with nearly every new set of standards or assessments that is thrust upon educators (Philipp, 2007). What the beliefs held by teachers are and how they align with the upcoming Common Core State Standards for Mathematics (CCSSM) will in large part determine the success of the initiative behind these new standards (Langton, 2014).

Of course, one must first make the case that teacher beliefs are important in educational practice. Many policymakers seem to view teaching like any other job—there are clear tasks to perform, standard operating procedures to follow in performing them, and desired outcomes that result from this work. Anyone who has taught knows the situation in the classroom is more fluid than this, and there are often a multitude of approaches to any particular topic. In the current “age of accountability”, teachers must avoid simplicity in their teaching (Cochran-Smith, 2003). That is, somehow educators must strike a balance between teaching material too simplistically—which may lead to higher standardized test scores—and focusing too much on certain areas of mathematics to the detriment of others—which may artificially deflate test scores. Of course, many have concluded that standardized tests are often a poor measure of mathematical aptitude, but in the current political environment they are unavoidable (Eccles & Jacobs, 1986; Cochran-Smith, 2003).

There are many types of teacher-assessment belief interactions, since teachers hold beliefs about many aspects of their craft. Without taking the time to examine each in depth, it is worth considering that a teacher likely holds beliefs about the importance or relevance of the material, the effectiveness of the textbook, the abilities of the students, pedagogical strategies, expectations of parents or administrators, and the quality or importance of the assessment (Fang, 1996). Due to the sheer number of possible individual types of beliefs, it is perhaps more efficient to consider how beliefs may be conceptualized and organized by different theoretical frameworks.

To illustrate some of the differences in these frameworks, one might compare and contrast the models proposed by Ernest (1989) and Copes (1982). Ernest's model for the teacher's mind has three major components: Knowledge, Beliefs, and Attitudes. Each is further subdivided into categories. A teacher's knowledge must encompass more than simply the mathematics being taught. According to Ernest (1989), an effective teacher must have knowledge of all the following areas:

- Mathematics
- Other subject matter
- Teaching mathematics
    - Mathematics Pedagogy
    - Mathematics Curriculum
- Classroom Organization and Management

- Context of Teaching Mathematics
    - School Context
    - Students Taught
- Education
    - Educational Psychology
    - Education
    - Mathematics Education

A teacher's beliefs are described as their conception of the nature of mathematics, models of teaching and learning mathematics, and principles of education (Ernest, 1989). A teacher's conception of the nature of mathematics is a belief system concerning the subject as a whole—Ernest describes three possible views

- Problem-solving view—mathematics as a dynamic, problem-driven subject
- Platonic view—mathematics as a static collection of structures and truths
- Instrumentalist view—mathematics as a useful but unrelated collection of facts, rules and skills

Ernest (1989) also describes the range of different models of teaching mathematics in a simplified form, noting that these are often of utmost importance in implementing curricular reforms:

- the pure investigational, problem posing and solving model
- the conceptual understanding enriched with problem-solving model
- the conceptual understanding model
- the mastery of skills and facts with conceptual understanding model
- the mastery of skills and facts model

- the day to day survival model

His range of models for learning mathematics is more focused on the learner, but from the point of view of the teacher's perception of the student:

- child's exploration and autonomous pursuit of own interests model
- child's constructed understanding and interest driven model
- child's constructed understanding driven model
- child's mastery of skills model
- child's linear progress through curricular scheme model
- child's complaint behavior model

Ernest's principles of education are quite general values held by the teacher, and are supported by their models of teaching and learning. Some examples might include

- a commitment to giving every child the experience of success and confidence in mathematics
- a commitment to the preparation of critical thinking and numerate citizens
- a belief that every child can be creative and original in mathematics
- a respect for each child's own mathematical knowledge

As Ernest notes, while a teacher's principles can have a powerful effect on their overall thought process, their level of integration with the whole of the models and beliefs determines how effectively those principles are enacted (1989). Ernest (1989) divides a teacher's attitudes into two main categories: their attitude to mathematics and their attitude to teaching mathematics.

An alternative approach to modeling teacher beliefs, attitudes and knowledge is presented by Copes (1982) and is based on Perry's stages of learning development. In this framework, all three are combined into the teacher's "approach"—perhaps more accurately, one might say it focuses on beliefs. Whereas Perry's theory had nine positions "from which persons view aspects of their worlds," Copes (1982) condenses them to four stages:

- *Dualism (or absolutism).* Every question has an answer—it is the authority's job to know it.
- *Multiplistic*. There are many views, all equally valid. This is similar to fin de siècle formalism.
- *Relativism*. Not all opinions are equally good. The judgment of quality is based on standards such as validity, internal and external consistency, and context.
- *Commitment (or dynamism).* Major life decisions "can be made only on the basis of uncertainty", "a person's knowledge is something that he or she must build alone" with all available sources of knowledge as guideposts (Copes, 1982).

These stages are intended to represent a student's transition through knowledge. The challenge to a teacher is to identify what stage a student is in and determine the best approach to move them to the next stage. As Copes notes, these stages mirror the historical development of a subject area, and the material in mathematics textbooks is often presented in the reverse order (Copes, 1982).

At first glance, these two models seem quite dissimilar—Ernest's model is much more focused on individual aspects of learning and teaching in the mind of the teacher, whereas Copes' model is built around responsiveness to student attitudes and perceptions of mathematics and encourages a pedagogy based on this information. However, Ernest's core conceptions of mathematics are quite similar to Copes' stages of development.

Following this lead and viewing the models as somewhat nested, the two are not so much competing models, as they are alternative approaches to describing the entire teacher-student belief interaction. Whereas Ernest seems more centered on the teachers' metacognition on mathematics instruction and how this might affect practice, Copes is more student-centric in the determination of a teaching strategy to move a student to the next developmental stage in the model. Copes' framework provides a goal toward which students can be moved, but is subject to the standard psychological critique that staged models are often overly simplistic. It is also possible that it underappreciates the sheer impact of the teacher's beliefs on the students' learning, in both cognitive and affective ways. As Ernest (1989) puts it, a student's learning experience can make the difference between "a student who is an interested, confident, skilled and autonomous problem-solver, at best, to one who is a disenchanted, non-numerate mathephobe, at worst" (p. 24).

It is important to understand teacher attitudes toward mathematics, as studies have shown that these attitudes can affect student performance in the subject. After all, elementary teachers were once students in mathematics courses, and their feelings toward the subject developed therein often persist in their teaching. In fact, many teachers may gravitate toward the early grades due to personal anxiety around mathematics (Beilock, Gunderson, Ramirez & Levine, 2010). In a 2010 study, Beilock et al. found that math anxiety in female teachers carried negative consequences for the math achievement of student students. This is particularly worrisome considering that early grades teachers in the U.S. are predominantly female, and the other issues of gender inequity in mathematics previous discussed. However, it should be noted that a teacher's attitudes toward mathematics can change over time. For example, Bonner (2006) found that teachers, who suffered from math anxiety and had begun to dislike teaching the subject, began to enjoy teaching it when using a new problem-solving based approach.

Missing in these frameworks is the specific role of technology in mathematics education and how its implementation is affected by teacher knowledge, beliefs and attitudes. The integration of technology often fails due to a lack of acceptance by its potential users. By better understanding the factors influencing its acceptance, one might improve the chances of "sustained integration" in education (Ifenthaler & Schweinbenz, 2013).

In the media, there are often reports of the positive impact of iPad usage on teaching and learning, but there are also failures. This has led to a debate about whether or not such devices will revolutionize mathematics education (Vu et al., 2014). In their study of teacher attitudes toward using the iPad in classrooms, Vu et al. (2014) mentions three distinct advantages of iPads:

- Providing teachers with opportunities to transition from long-term projects which incorporated software-specific projects with a steep learning curve to smaller scales, app-based learning tasks.
- Allowing teachers to test drive and learn about apps in just a day or so, as opposed to many days spent learning new software.

- Allowing for the portability and kinesthetic interactions that traditional desktop or laptop computers could not offer.

All of these advantages speak to the issues teachers found with implementing technology in the past, as discussed in the second digital divide above. Issues of complexity, inconvenience, flexibility, and student engagement are addressed by the new technology—although they are certainly far from being solved. With this in mind, Vu et al. (2014) also note a few disadvantages of iPads:

- The slow finger-typing actually made written course work more difficult.
- The tablets were great for enjoying media and allowed learners to share readings, but teachers could not use them to mark-up material on the fly and show changes to learners in response to their questions, a type of interactivity that was a major thrust in pedagogy.

It is yet unclear whether these advantages and disadvantages will be enough to change teacher beliefs and attitudes toward tablet technology. Researchers have found that technology has been accepted at varying levels in classrooms, but without "a clear understanding of how and why teachers accept or reject technology in classroom practice, the full integration of technology as advocated by constructivism" is difficult (Ifenthaler & Schweinbenz, 2013). It may be the technology is more often deployed to be a useful accommodation for students with disabilities. For example, pupils who couldn't hold a pen were able to use a keyboard to write (Ifenthaler & Schweinbenz, 2013).

Teacher attitudes toward technology can also be affected by the type of technology initiative under which they are working. In a 2014 study of teachers' attitudes toward using the iPad in the classroom, Vu et al. found that on average teachers thought the use of the iPad in the classroom was somewhat useful (2.75 out of 5.00). It should be noted that there were three different models of iPad implementation in this study. Some teachers had 1-1 device programs (each iPad to each learner), others had each iPad to each group in the classroom, and some had only the teacher with an iPad.

Despite this lukewarm evaluation of the iPads' usefulness, the teachers all indicated that they would recommend their colleagues use it in their classroom. Vu et al. (2014) explain this contradiction by noting that the teachers who rated iPads as the least useful were those who only had one iPad in the classroom. Perhaps they realized the device had promise if more were available, but as a standalone device being used only the teacher, it was not useful (Vu et al., 2014).

It is fair to say that most teachers are unsure about how effective mobile educational technology will be in the classroom. Even in cases where participants assume a positive impact, their opinions are based on assumptions rather than on secure knowledge and experience (Ifenthaler & Schweinbenz, 2013). What is clear is that in order to even attempt the successful integration of this technology, teachers require a smoothly running technical infrastructure and professional supports in the classroom (Ifenthaler & Schweinbenz, 2013; Vu et al., 2014).

Teachers and Technology Professional Development

While one aspect to consider in the use of technology in mathematics education is the availability and use of technology resources to schools, attention must also be paid to the quality of the equipment and the level of access teachers have to use those technology resources as a learning tool in their classrooms. Technology resources located in classrooms greatly increase student access to technology. When paired with teachers who are comfortable and competent with technology, there's an increase in student use of technology in education. Norris, Sullivan, Poirot and Soloway (2003) reported “a significant and substantive correlation between technology access and use, almost without exception, the strongest predictors of teachers' technology use were measures of technology access” (p. 16).

In this area, the situation has changed somewhat over the past few decades. It was once the case that computers were only available in computer labs—now, they are more often available in the classroom. However, it is still the case that many schools depend on computer labs, due to funding constraints. Removing technology from the classroom and placing the technology resources in laboratories seems to overwhelmingly decrease student use of those resources, as well as decrease the sophistication of education they receive when using the technology. Teachers who must take their students to computer labs in order to provide access to the technology resources present in the school are much less likely to use or require technology resources in lesson plans, classroom activities, or homework assignments (Smerdon et al., 2000). In one study at the fourth grade level, at least one third of the classroom use of technology was directly geared toward lower-order learning activities with 54.5% of fourth-grade teachers reporting learning games as the primary use; 35.9% reporting drill and practice; 7.5% reporting simulations and applications, and 2.1% reporting “introducing new topics” (Wenglinsky, 1998, p. 21).

However, there's possibly great disparity in the amount of higher-order activities in learning games compared to the traditional drill and practice of mathematical skills.

Wenglinsky (1998) saw a large portion of fourth grade mathematics as being structured toward lower-level learning. In fact, this even varied by region; Wenglinsky (1998) noted that students from the Northeast and West and from urban or rural areas were more likely to receive higher-order activities than students from Southeast or suburban areas. In the same study, at the eighth grade level over half of the classroom use of technology was directly geared toward lower-order learning activities. Drill and practice was most frequent (34.3%), playing learning games (29.2%) was followed closely by simulations and applications (27.2%), and only 9.2% of teachers reported that their primary use of technology was to introduce new topics (Wenglinsky, 1998). From these data, the eighth grade students appear to be receiving less higher-order instruction aided by technology than the fourth grade students. Similarly, the differences between geographic regions grow at the eighth grade level. Wenglinsky (1998) reports significant differences in the levels of higher-order activities across all areas (Central, Northeast, West and Southeast), as well as across suburban, urban, and rural areas.

A natural concern is that the fourth grade teachers in this study may lack the resources or training to be able to take the use of technology in mathematics beyond a game. Socioeconomically disadvantaged students may have teachers who are less skilled in the use of technology. Wenglinsky (1998) noted the 1996 NAEP results suggested "that disadvantaged groups, to some extent, receive less exposure to teachers well prepared in technology use than do other groups of students" (pp. 20-21).

The explanation as to why these teachers are less prepared in technology use likely has many facets. One reason could be that they are new educators who are already familiar with technology. After all, it is well known that low SES schools often have high turnover rates and this can lead to many new teachers in the classroom (Rumberger & Thomas, 2000). Perhaps, due to an overestimation of their own knowledge, they do not take advantage of professional development for technology. Another reason could be they are dissatisfied in their work environment and because of that are uninterested in pursuing more training (Little, 1990; Lieberman, 1995). Of course, the reason could also be that the training simply isn't offered by the school or district, or that it is so minimal as to have little effect on classroom practice.

After examining the quantity and quality of technology resources available to educators and their students, one must consider how teachers are instructed to use technology in their classrooms. Smerdon et al. (2000) report that "teachers' preparation and training to use education technology is a key factor to consider when examining their use of computers and the Internet for instructional purposes." Teacher preparedness has many layers, including professional development opportunities for teachers, the level of technical support within the school, and teacher attitudes and beliefs.

Ready access to quality professional development opportunities for teachers within their geographic region correlates to educators participating in the development opportunities (Smerdon et al., 2000). Clearly, providing teachers with accessible professional development training would increase the number of students who have teachers who have recently received training. However, the level of the course is important as well. Educators are more likely to have the opportunities to participate in introductory courses for professional development, but are less likely to locate or participate in more advanced courses (Smerdon et al., 2000).

When educators are able to utilize these professional development opportunities, they report that, following the professional development training, they feel ready to incorporate technology into their role as educators (Wenglinsky, 1998). From these observations, it might be concluded that by increasing teacher access to technology oriented professional development activities, classroom use of technology will subsequently increase. However, Becker (2007) states that “comfort with technology does not necessarily translate into the ability to integrate technology into the teaching and learning process” (p. 29). Even if this does not necessarily directly translate to an increase of integration of technology, it is only logical to suppose that more opportunities for professional development, coupled with a technology-related requirement for new educators, would benefit teachers as well as students.

The studies referenced above were focused primarily on desktop computer use in the classroom, and the issues of access observed throughout the 1990s and early 2000s. One hopes schools have learned from those examples and that these lessons will inform the implementation of iPad initiatives. However, in a 2014 study, Vu et al. interviewed an opportunistic sample of 21 teachers regarding iPad usage and the professional training they received:

> According to seven teachers in the same public school, except a formal training session provided by an Apple sales representative, they did not receive any formal training in iPad use. They had to resort to different sources to educate themselves about how to use the iPad in the classroom. Six other teachers at a private school reported that they did not have any training program or workshop before using it. They all did attend a "tech camp" in the summer to learn how to integrate a

> variety of technology into classroom. This "tech camp" did not cover the iPad use and it was before the iPad was introduced into their school, so according to these teachers, the "tech camp" was not considered as a formal iPad training. (Vu et al., 2014, p. 62)

This lack of professional development is a common refrain from teachers implementing iPads for the first time in the classroom and it can be detrimental to their success. In the same study, two teachers “even confessed that they did not have any plan to use the iPad in the classroom during the semester, but because we asked for voluntary research participation, they attempted doing so” (Vu et al., 2014, p. 67). This classroom technology training also seems to play a pivotal role in how students perceive and use technology (Disney et al., 2013).

Teachers benefit from professional development training activities by increasing their technology self-esteem. Educators that are unfamiliar with current technology and have very little professional development in the use of technology resources as an educational tool may avoid technology and effectively operate in a similar way to teachers without technology resources in the classroom (Disney et al., 2013). In the past, surveyed teachers who received professional development training in technology indicated they felt adequately prepared to use technology in the classroom for instructional activities (Smerdon et al., 2000). However, the implementation level comes down to the comfort level of the teacher with the technology. With recent technological advances in tablets, this comfort level can vary greatly depending on the teacher’s knowledge of such devices. In a study of the usefulness of iPads in teaching, teachers who already owned iPads often found it fun to find and implement new apps in their classrooms, while teachers who didn’t already own one often didn’t know what apps were available to them for specific lessons (Vu et al., 2014).

In a study of five inner-city Chicago Catholic schools, Gibbs et al. (2009) found that technology in-service trainings increased teacher understanding of specific technologies and resulted in increased student use of and skills in technology. However, they also stressed the importance of in-service tailored to different skill levels, as teachers with previously high levels of technological knowledge received little benefit from the in-service trainings (Gibbs et al., 2009). As teachers use technology they build a level of competence and comfort translating to a positive view toward the use of technology in the classroom. This is especially noticeable when the student achievement increases with the use of technology.

Producing teachers who are proficient with technology, are able to attend professional development activities, and are allowed or able to incorporate the technology resources in the school to provide students with higher-order learning activities was shown to significantly increase student performance in mathematics with desktops (Wenglinsky, 1998). However, this continues to be a challenge for mathematics education today, especially with changes to the technology and its capabilities.

Teacher Challenges with Technology

Vu et al. (2014) reported in their study that the data from classroom observations also indicated that “current teaching practice was largely a teacher-centered approach in which learners' roles were mainly information receivers, and the teacher's role was an information deliverer. This practice was different from what researchers and educators talked about as the complementary relationship between technology use in the classroom and constructivism" (p. 70). They further identified the challenges with technology that led to this implementation as

- lack of technology (many teachers in this study did not have the iPad in their school, so they did not want to use it)
- lack of access to technology (many teachers could not get access to the Apple store to download and install apps for their teaching)
- lack of technical support (teachers had to manage to handle the iPad themselves without any technical support from school)
- leadership (teachers at a private school used the iPad more often than their peers because they knew their school administrators' expectation) (Vu et al., 2014)

Integrating these findings with everything discussed so far, there are four main categories of teacher challenges when it comes to integrating technology into the classroom.

Time. Using technology in the classroom takes more time than simply writing notes on a board and lecturing to students. Between time spent on preparation before class, on setup at the beginning of class, dealing with technical issues and on transitioning to technological activities during the lesson, many hurried teachers resort to traditional lecture practices in the interest of moving forward in the material. Exploratory or discovery-based learning using technology is especially time consuming and many teachers may avoid it due to pressure to stick to a schedule.

Logistics. The simple reality of getting the technology and students together in the same moment can be challenging on its own. While classroom calculator sets have become commonplace, classroom computers are often limited or obsolete. Computer labs must often be scheduled and can disrupt the flow of a lesson. Implementations of tablets can vary from one device per student, one per group of students, or one per teacher. Internet connectivity can be an issue, especially in rural areas with low bandwidth or even urban areas where the usage is extremely heavy for the school's connection. This isn't even considering the coverage and quality of wireless internet in the school, which is a necessity for any new tablet technology. Combined with maintenance and repair of devices, there is significant logistical overhead in providing devices to as many students as possible.

Quality of Experience. As classroom instruction becomes increasingly internet-dependent, the infrastructure of a school and its impacts on connectivity and network speed begin to have dramatic effects on the quality of the learning experience for students. Excessive delays or lost work can damage the flow of a lesson, and shift the focus to technical problems and solutions rather than mathematical ones. The technology can become a distraction, rather than an aid.

The quality of the Graphical User Interface (GUI) is also of utmost importance, especially for students with disabilities or disorders (Cumming, Strnadová & Singh, 2014). A quality interface should provide full functionality and be as cognitively transparent as possible. A perfect example is the telephone; when speaking on the telephone, it is very easy to forget the phone is there and to be speaking directly "at" the person on the other end. As touch and voice interfaces improve and evolve over the next decade, more intuitive and anticipatory interfaces will allow devices to get out of the way and mathematical content to take a more prominent role in any application.

Student familiarity and equity. Students arrive in the classroom with many different levels of technological knowledge and background. A legitimate concern is that students with better knowledge of a device will get more out of instructional applications on implemented on it. Unfortunately, if this is the case, it is connected to issues of equity and access, as higher SES students are more likely to have exposure to technology at home and students with no familiarity with the technology may not be able to progress as far in the material as others.

Summary

In this chapter, many aspects of the successful integration of educational technology into the classroom were discussed. All the challenges aside, it would appear that technology presence in the classroom does in fact have a positive impact on learning—at least in the context of computer based learning. However, a healthy dose of skepticism is probably useful as well. Computers and tablets can be valuable tools for practicing skills, but there are many limitations to their effectiveness. While many excellent apps have been developed, many are little more than digitized flash cards, drill and practice, or excerpts from a textbook haphazardly attached to a game. Also of concern are student attitudes toward technology and mathematics, the corresponding beliefs and attitudes of teachers, and professional development around technology. These factors will determine the likelihood of successful and sustainable integration of technology into classrooms. In the next chapters, attempts to measure many of these qualities in the elementary classroom are described and reported. These results will provide interesting comparisons and contrasts to those presented above from established literature.

Chapter 3: Methodology

In this chapter, the research questions are discussed and the design of the study is described to answer these questions in second grade classrooms at an elementary school with a one-to-one iPad initiative. The study population and background of the initiative are described as well. Quantitative techniques are used to measure student app performance and iPad usage, and qualitative interviews are used to assess student and teacher attitudes toward mathematics and technology. The basic mechanics and design of two of the apps examined are described and discussed.

Purpose

The nature of this study was primarily observational. Given the unique technological environment of and the lack of research in connected classrooms with one-to-one device initiatives, it is useful to learn more about students and teachers involved in such initiatives and establish a "baseline" measure for further research. By capturing a picture of an active program to use as a reference point, the information gathered serves as a source for further questions that may be better answered by experimenting with different treatments. Of course, one must consider that "prior conceptual structure composed of theory and method provides the starting point for all observations" and no observational study can be performed without a certain amount of theoretical bias present in the researcher (Creswell, 2013, p. 66).

As mentioned in Chapter 1, the research questions being investigated are:

1. How does iPad or other technology usage affect student and teacher attitudes towards mathematics?
2. How does student performance in an app environment translate to mathematics performance in more traditional forms of assessment?
3. How much time is spent using iPads in the classroom and for what instructional purposes are they used?
4. What issues are involved in implementation of the technology?

Overall, this study makes use of quantitative and qualitative components. Qualitative methods, primarily interviews, were used to answer Questions 1 and 4, to obtain a more personal, rich, and detailed qualitative understanding of student and teacher attitudes (Creswell, 2013, p. 4; Tashakorri & Teddlie, 2010, x). Questions 2 was answered using a quantitative description and analysis of student performance in mathematics and iPad usage, as this is typically how performance is measured on standardized mathematics assessments. Question 4 was addressed using quantitative methods, as its goal was simply to gather usage data for reference.

Population Background

This study took place at an urban K-5 elementary school in Montana over a four month period from October 2014 to February 2015. “Urban” in this case is based on recent U.S. Census data and the classifications described by the Rural Health Research Center (Rural, n.d.). The school reported 82% of second graders as at or above average on the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) assessment for the 2013-2014 academic year. No student achievement assessments in mathematics were reported. The district's 2013-2014 socioeconomic data show that 51% of the school population was from low income families. The student body at this school year was reported as being 83.7% White (Non-Hispanic), 9.9% American Indian, 2.1% Hispanic, 2.1% Asian, 1.9% Black or African American, and 0.2% Native Hawaiian or other Pacific Islander. This mirrored the race/ethnicity mixture in the classroom population studied.

In the fall of 2012, this school launched a one-to-one iPad initiative. This program, primarily targeting students in grades 2 and 5, was made possible by the support of an anonymous donor who was "interested in integrating real-world technology into classrooms." Approximately 150 iPad 2 tablets were supplied, along with Apple TVs and charging stations for each classroom, a management cart and Macbook Air for device administration, and Speck protective cases. The students were assigned iPads for use in the classroom and allowed to take them home as well, for a $40 fee per student per year. These fees were used to purchase apps and pay for repairs and replacements. The donation did not cover network upgrades, wireless access points, app costs, or maintenance costs.

The study population consisted of two classrooms (approx. 40 students) of second-grade students (aged 6-7) and two teachers. These teachers were implementing a "Walk to Math" program. During the daily, one hour math instruction period students requiring Intensive & Strategic intervention (approx. 15 students) gathered in one classroom, while the rest at or near Benchmark understanding (approx. 25 students) gathered in the other. These numbers are approximate since students could not only move between levels of Walk to Math, but transfers often occurred between schools as a result of families moving. Students who had to change classrooms carried iPads and mathematics materials such as workbooks or pencils with them during the transition.

Data Collection

The researcher spent an average of four days each week volunteering in the classrooms during daily, one hour mathematics lessons. Time was divided equally, with two days spent in each of the two classrooms each week. In the final month of the study, visits were restricted to two days per week (one in each classroom) due to scheduling constraints.

This volunteering had several purposes. One was to become familiar with the students and allow them to be more comfortable and forthcoming in the interview sessions. Establishing good rapport with the students and teachers is important and might help to minimize possible reactive effects (Tashakorri & Teddlie, 2010, p. 306). This allowed the researcher to get much deeper responses to interview questions, as well as possibly encouraged students to discuss weaknesses in math that they might not with an unfamiliar adult. Working as a volunteer also helped to cultivate a symbiotic relationship with the teachers. This provided compensation for the time and effort they expended to accommodate the study and make the research possible.

While the researcher primarily worked with students individually or in small groups, it was also possible to gather iPad usage data each day. The number of minutes the class used the iPad each day was recorded, as well as the nature of the activity. The apps in use, or made available for use by the teacher, were also recorded. This time each day also allowed for the collection of student artifacts when possible from work on iPads.

This generally took the form of screenshots of work or recordings of student problem solving.

The primary qualitative component consisted of interviews with students and teachers. Interviews were chosen over surveys of attitudes due to the depth of information available from an interview (Creswell, 2013, p. 190). Also, given the student population was composed of second graders, it was determined that surveys—especially written ones—would depend too much on language comprehension abilities. Children of this age tend to have a short attention span, can easily lose interest, and are more likely to use "satisfying" approaches and response sets when they are not concerned or interested in a topic (Borgers, De Leeuw & Hox, 2000). In an interview setting, these tendencies are more easily recognized. Of course, children of this age also commonly engage in "pleasing" behavior and can be very suggestible, so these factors were considered in the interview process (Borgers et al., 2000; Brady, Poole, Warren & Jones, 1999). However, prolonged time spent in the field helps to mitigate this effect, as the researcher becomes more familiar with the classroom environment and can identify and explore inconsistencies. Creswell (2013) points out that "the more experience that a researcher has with participants in their settings, the more accurate or valid will be the findings" (p. 202).

Interviews were conducted with six students and two teachers after the first and fourth months of the research period. Three students were chosen from each Walk to Math classroom. From the Intensive & Strategic group, one female and two male students were chosen. From the Benchmark group, one male and two females were chosen. All students were chosen based upon teacher recommendations of students who were more prone to be talkative or expressive, as well as the level of familiarity and comfort with the researcher.

Student interviews took place in the school library, away from teachers and other students. The interviews were limited to 10-15 minutes each. Interview responses were recorded and transcribed. Recordings were audio only to avoid the distraction of video (Schuck & Kearney, 2006). The recordings were destroyed following transcription and student names changed in order to ensure student privacy. The interview questions were based on a scale for monitoring students' attitudes to learning mathematics with technology described by Pierce et al. (2007). After initial factor analysis and reliability analysis, Pierce et al. (2007) trimmed their survey down to five factors, with four questions each.

Their scale for mathematics and technology attitudes is built around five affective variables relevant to learning mathematics with technology: Mathematics Confidence (MC), Technological Confidence (TC), Attitude toward learning Mathematics with Technology (MT), Affective Engagement (AE), and Behavioral Engagement (BE). Subsequent factor and reliability analysis found the five factors explained 65% of the variance in their data, and yielded satisfactory Cronbach alpha values for each subscale (MC, .87; MT, .89; TC, .79; BE, .72 and AE, .65) (Pierce et al., 2007). As a value of 0.70 is generally considered sufficient for most social science applications, these indicate a "strong or acceptable degree of internal consistency in each subscale" (Pierce et al., 2007, p. 294; UCLA, n.d.). Their survey instrument, initially designed for middle secondary students, was adapted for use with elementary students and teachers (Appendix 3). This adapted survey instrument was then used to rate the responses of the students for analysis and comparison. The student interview questions were based on the five factors of the rating instrument and are included below.

Student Interview Questions

1. Do you like math class? Do you feel like you're good at math? Are there other subjects that you're better at? Worse at?
2. Do you feel like you're good at using your iPad? What about computers? What other electronics are you good at using? (Example: DVDs, mobile phones, MP3 players)
3. Do you like using your iPad for math? How do you use it for math? Do you ever do math without it? Which do you like better? Why?
4. Do you think math is fun? Interesting? Satisfying? Why?
5. Do you work hard in math class? How do you answer a hard question?

Teacher interviews took place in the classroom during instructional downtime or lunch periods and were limited to 15-20 minutes each. The previously discussed adapted scale from Pierce et al. (2007) was used to rate the responses for analysis and comparison (Appendix 3). The teacher interview instrument is included below.

Teacher Interview Questions

1. How long have you been teaching math? How confident with math do you feel? Do you feel as confident teaching it? Are there subjects you are better at or worse at?

2. How confident are using technology at home? In the classroom? What sort of technology do you use on a regular basis?
3. Do you like using iPads in math class? How do you think it affects your teaching? How do the students feel about it?
4. Did you find math interesting as a student? Do you find it interesting as a teacher? Is it satisfying? Fun?
5. Do you find yourself putting more time into mathematics lessons as compared to other subjects? How do you refresh yourself on the material, or do you often need to?

As these were qualitative interviews, the dense and rich responses were “winnowed” for the sections that pertained to the research questions above. The transcriptions were coded based on these research questions as well to facilitate analysis (Creswell, 2013, p. 199). The last research question pertaining to challenges with implementing this new technology was primarily addressed in the teacher interviews.

To answer the question of how student performance in an app environment translates to mathematics performance in more traditional forms of assessment, students completed worksheet quizzes using exactly the same (or very similar) problems that appeared in the apps. These paper results were then compared with logged app performance and examined for any discrepancies or correlations in performance.

Addimal Adventure

Two apps were examined in this manner—Addimal Adventure and Splash Math 2nd Grade. Addimal Adventure is a game designed by Teachley to teach single-digit addition for grades K-2 (Teachley, n.d., Figure 2). The game is based on two types of gameplay: the Tool round (Figure 3) and the "Speed round" (Figure 6). The "Speed round" is not explicitly named in the game, but is the term used here to describe the second, faster style of game play required to display mastery of addition facts.

In the Tool round, rather than relying on "digital flashcards and worksheets", this game allows students to use four basic strategies to solve single-digit addition problems: "count all", "count on", "doubles", and "tens" (Teachley, n.d.). The "count all" strategy is simply counting all blocks from one to the total. "Count on" is described as holding the larger number in one's head, then counting on from it using the other addend (Figure 3). "Doubles" relies on students tendency to remember and recognize doubles—for example, solving $6 + 7$ by noting that it is $(6 + 6) + 1$, or one more than the double, 12 (Figure 4). "Tens" is a method based on regrouping the two addends into tens and then counting the left over ones. Each method is associated with a corresponding Addimal character that performs the animated actions of the operation as the student is manipulating the blocks. A fifth method is memorization—however, this is only introduced as an option once the student has utilized the other methods and even then it is not always an available strategy to explicitly select.

In the Tool round, the problems are read aloud by voice actors as they are presented, without time limitations (although certain solution options, such as memorization, may disappear after a few seconds). Answers to problems are input by dragging a slider on a number line. In the Speed round, the problem is not read aloud by the app and the student must answer the addition problem in three seconds in order to receive full points. There is not a timer for this—the time is determined by the animated

Figure 2. Addimal Adventure Home Screen.

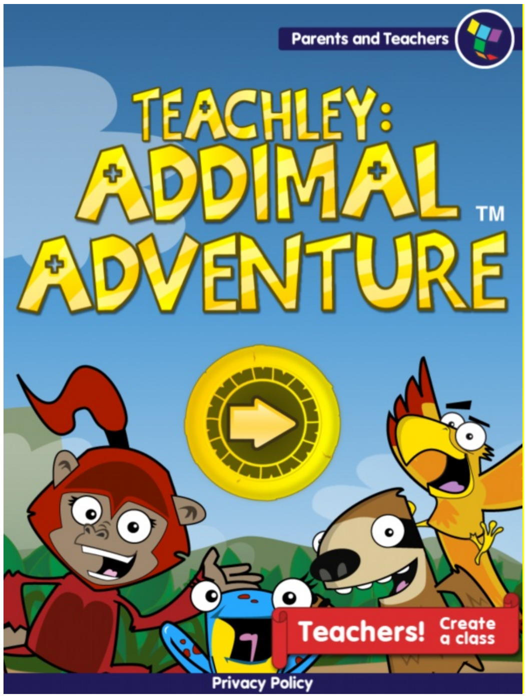


Figure 3. Addimal Adventure Tool Round (Count On Strategy).

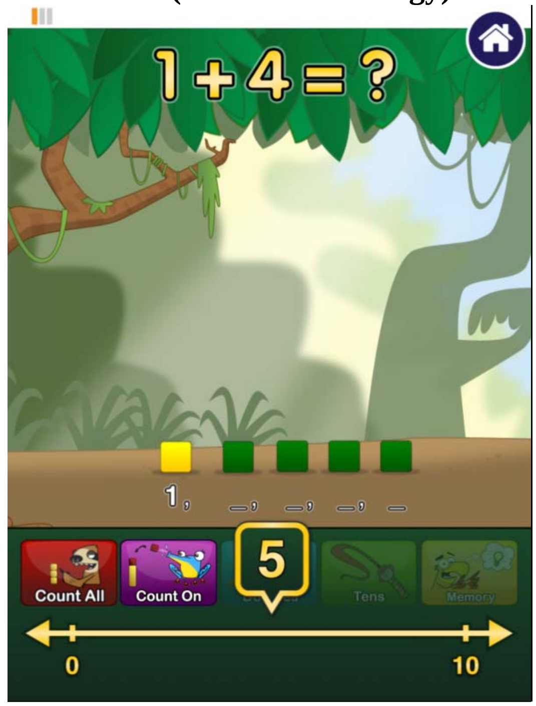


Figure 4. Addimal Adventure Tool Round (Doubles strategy).

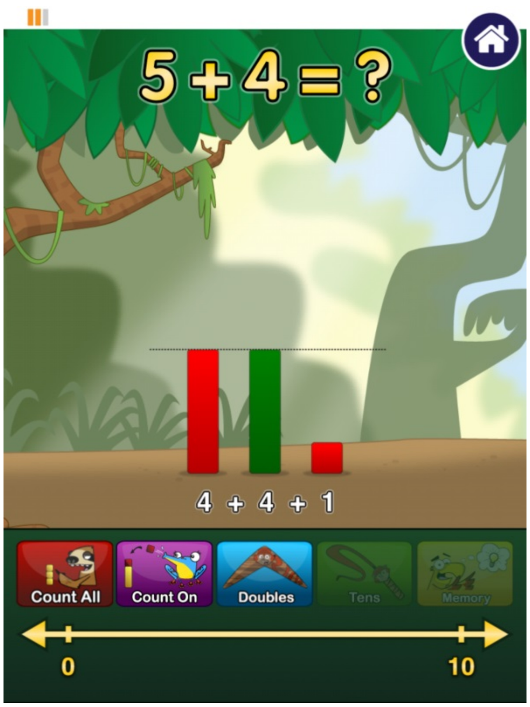


Figure 5. Addimal Adventure Story and round transition animation.

Figure 6. Addimal Adventure Speed Round initial scenario.

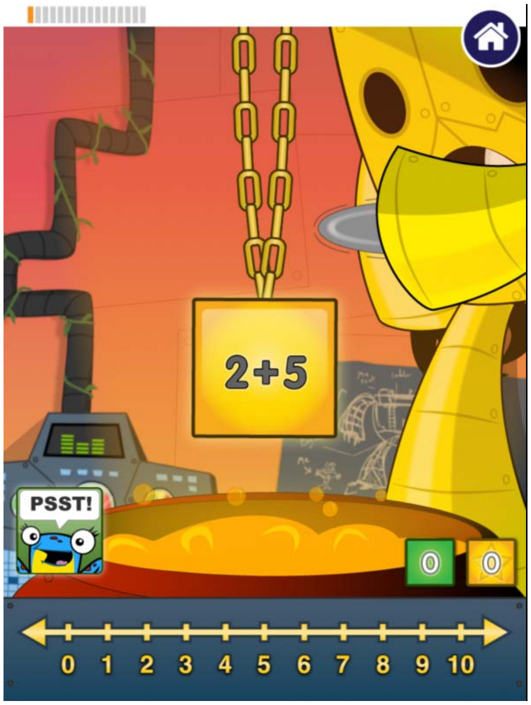


Figure 7. Addimal Adventure Speed Round, displaying hint.

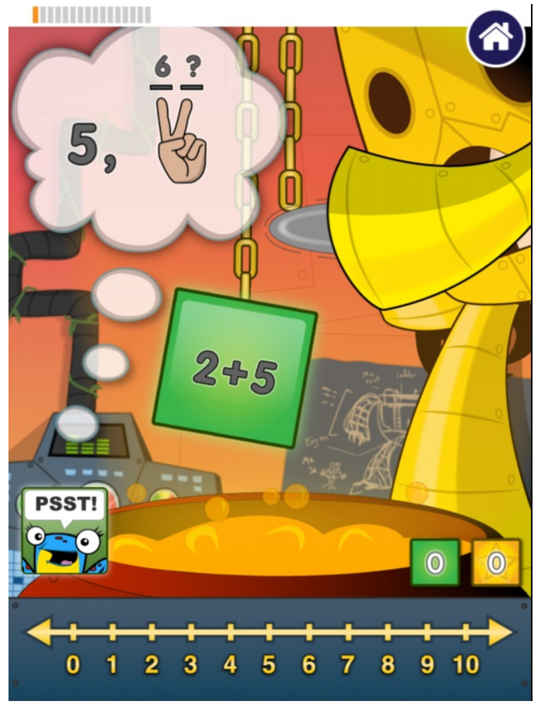


Figure 8. Addimal Adventure Mastery grid of addition facts.

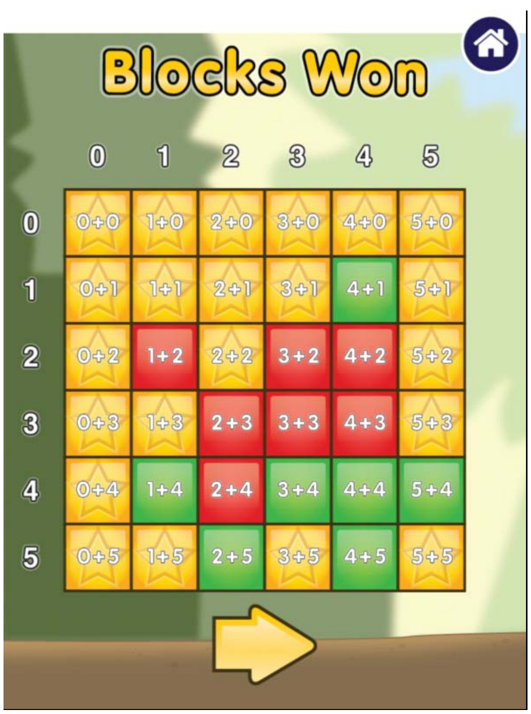
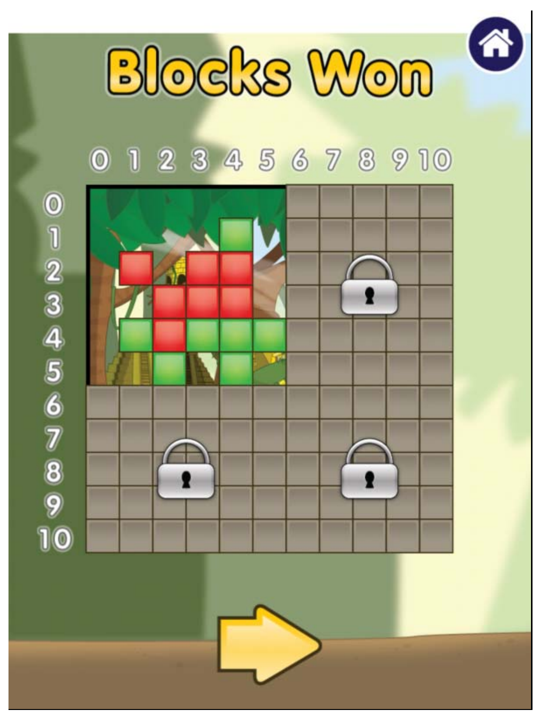


Figure 9. Addimal Adventure Mastery grid in context.



saw about to cut the chains holding the block (Figure 6). The student can select a help option from one of the Addimals, but doing so penalizes them. Likewise, missing the problem on the first attempt penalizes them, and after two attempts a new problem is introduced (Figure 7). This round is framed as a competition against the antagonist of the app's story (Figure 8). Successfully solved problems uncover tiles in a picture that represents the reclamation of a city from the villain, and fully revealing the picture (i.e. demonstrating mastery of all single-digit addition facts) is the only way to complete the game (Figure 8, 9).

As the only way to beat this game is to be able to solve single-digit addition problems in three seconds, student performance outside the app was examined using a timed 30 second quiz with a selection of addition problems. The ten problems given were based on five addition problems that were repeated with the addends commuted. This technique is commonly used in the app (Figure 8), so the assessment instrument (Figure 10) was similarly designed.

These data were compared with the student progress gathered within the Addimal Adventure app. Teachley, the company behind the app, offers a paid back-end service to teachers with an online interface providing analytics of student progress and strategy preference in the game. However, not having the funds or necessary training, the teachers had not been utilizing this service. For this reason, student progress in the app was measured by recording the state of the mastery grid (Figure 9).

Figure 10. Addimal Adventure single-digit addition skills assessment.

Name ____________________

$3 + 8 =$ _____	$9 + 0 =$ _____
$7 + 8 =$ _____	$10 + 6 =$ _____
$6 + 2 =$ _____	$8 + 7 =$ _____
$6 + 10 =$ _____	$8 + 3 =$ _____
$0 + 9 =$ _____	$2 + 6 =$ _____

Splash Math 2nd Grade

The second app examined, Splash Math 2nd Grade, covers a wide variety of topics in the second grade curriculum: place value, counting and number patterns, one digit addition, two digit addition, one digit subtraction, two digit subtraction, time, measurement, geometry, data, money, three digit addition, and three digit subtraction (Figure 12).

Figure 11. Splash Math 2nd Grade home screen.

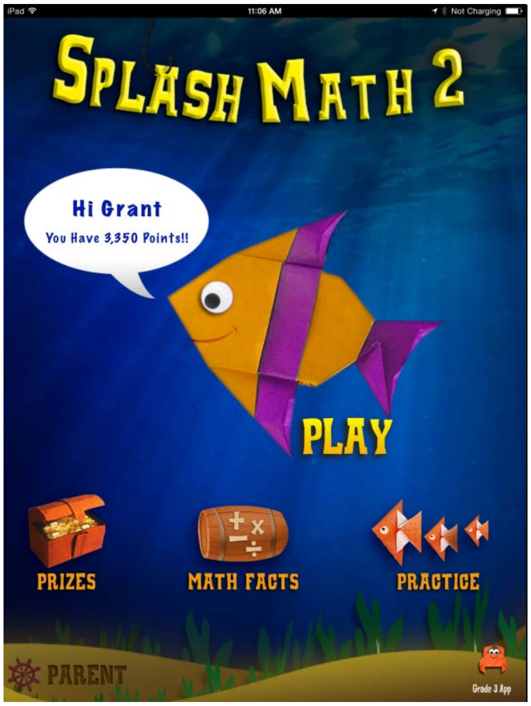


Figure 12. Splash Math Practice mode topic options.

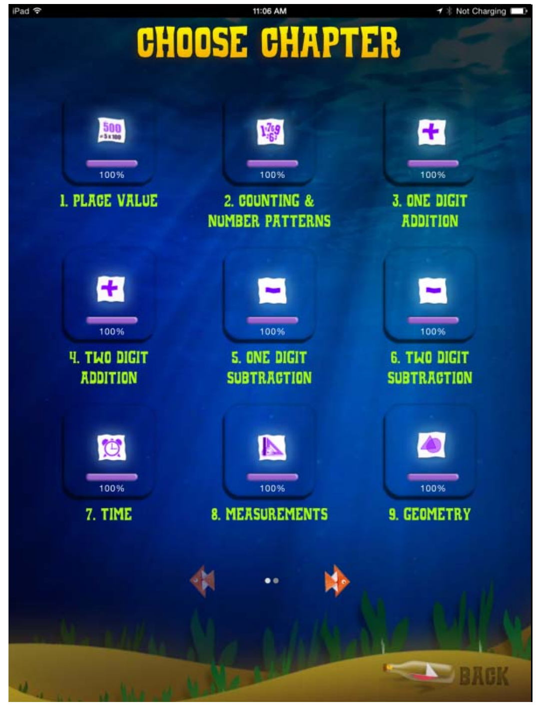


Figure 13. Example Splash Math single-digit addition problem.

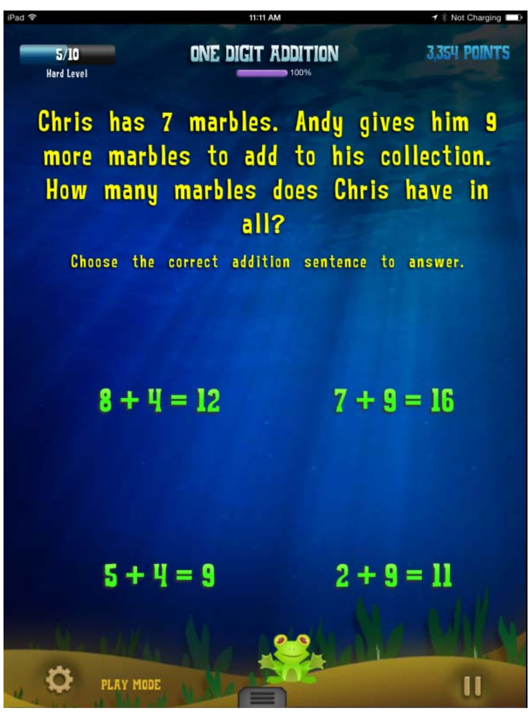


Figure 14. Example Splash Math counting/number patterns problem.

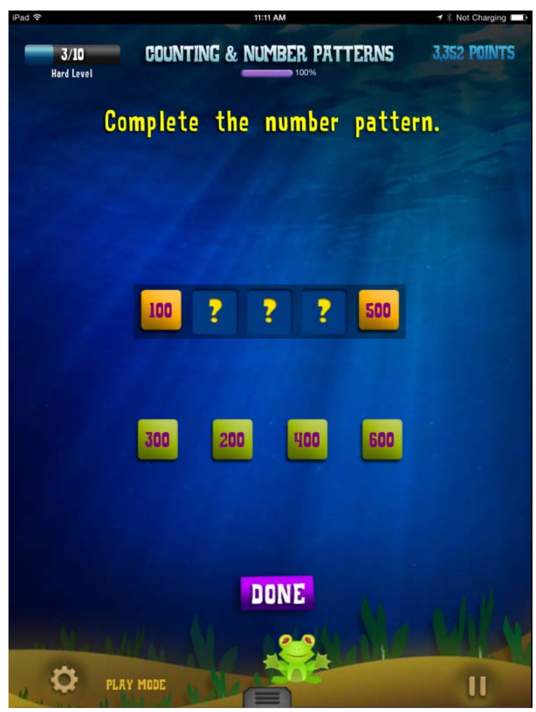


Figure 15. Example Splash Math place value problem.

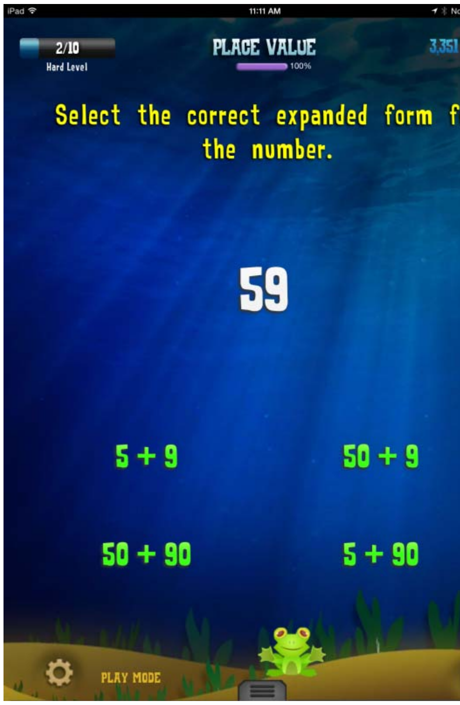
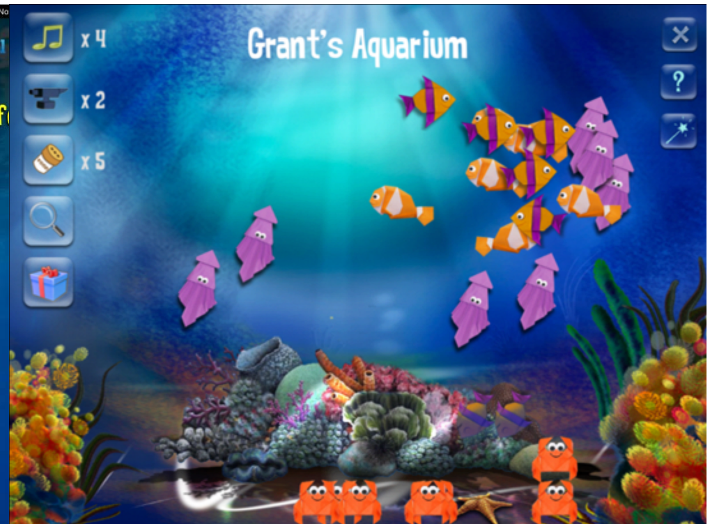


Figure 16. Splash Math student aquarium with prizes and aquatic life.



Students can operate in one of two modes: Practice and Play (Figure 11). In Practice mode, students practice in a subject area of their choosing and are presented problems solely from that area. Alternatively, students can have a mix of problems presented from all subject areas in Play mode. Progress is displayed as a percentage and progress bar visible on each subject area’s tile, with various rewards available with further progress (Figure 12). These rewards typically take the form of equipment and toys in the student’s virtual aquarium, where they can play with collected aquatic life and prizes (Figure 16). While this environment is not directly related to mathematics, it provides an incentive to work on the mathematics topics in order to gather more supplies for the aquarium.

Problems in this game are presented in a traditional multiple choice format. There is no introduction or training available, although problems do progress in difficulty. The problem is read aloud to the student using a digitized screen reader voice, as well as presented visually. The student can then select the correct answer from the four options typically presented, and the number of correct answers so far is tracked at the top of the student's interface (Figure 13, 14, 15).

Student progress in this app was measured by examining student iPads. The progress percentage for each topic in the app was recorded. These data were compared to student performance on worksheets composed of ten problems taken directly from the Splash Math 2nd Grade app, as they were presented in Play mode (Appendix 1). Problems chosen were limited to the categories to which a majority of the students had been exposed during lessons involving the app. As this app is not timed, the worksheet was not timed either and students were given as long as needed to complete working on it.

Student scores on chapter tests in mathematics were also collected throughout the research period. These data were used as a covariate in the analysis of student scores in apps and on the assessment instruments.

Summary

In this chapter, the research design, population, and measurement instruments of the study were described. The data gathered took the form of qualitative interviews, classroom observations of the time and nature of iPad usage, and student performance comparisons between skills in apps and on more traditional worksheets. Also provided was a brief description of two apps—Addimal Adventure and Splash Math 2^{nd} Grade—from which app data was gathered. These descriptions will help to make results discussed in the next chapter more meaningful, especially as students and teachers describe app interactions in interviews.

Chapter 4: Results

In this chapter, quantitative results for iPad usage, app and quiz performance for Splash Math 2nd Grade and Addimal Adventure, and mathematics and technology attitudes ratings for student and teacher interviews are presented. Exploratory and comparative analysis is performed as well. Results are given for Intensive & Strategic and Benchmark levels of Walk to Math classes, as well as the combined group, for all areas.

Overall iPad Usage Frequency and Type

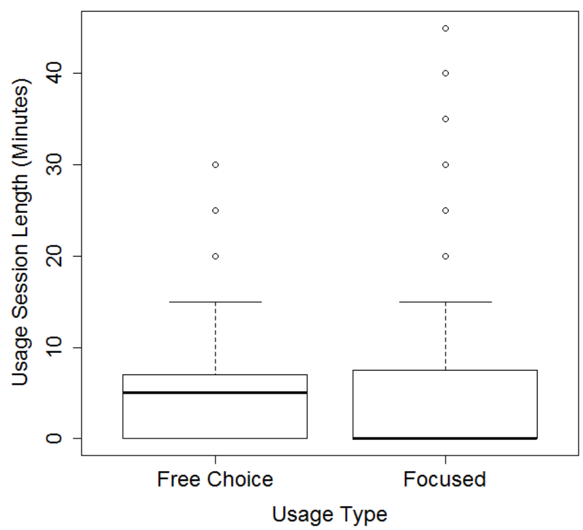
Usage data was gathered for 43 lessons, with 22 observations for the Intensive & Strategic Walk to Math group, and 21 observations for the Benchmark group. The number of minutes of iPad use in the lesson was recorded, as well as the type of instruction. Two types of instructional usage were observed: “Free Choice” and “Focused”. In free choice activities, students were allowed to select from a teacher determined list of mathematics apps and play them individually for a certain amount of time. In focused lessons, students were all working in the same app, typically as a class or in small groups. The availability of apps for these lesson types was recorded as well (Table 9).

Table 1 presents summary statistics for usage type for all observed lessons in both Walk to Math groups combined. Overall, free choice lessons lasted an average of 5.74 minutes and ranged from 0 minutes (when no lesson took place) to 30 minutes in length. Focused lessons lasted an average of 6.74 minutes, and ranged from 0 minutes to 45 minutes in length (Table 1). These data are also displayed in Figure 17. There were 28 free choice lessons observed, totaling 247 minutes and 13 focused lessons observed, totaling 290 minutes (Table 2). It is clear that free choice lessons occurred more frequently than focused lessons overall, but that focused lessons often occurred for longer periods of time than free choice lessons.

Table 1. Walk to Math – Combined Groups Usage Summary (minutes).

Usage Type	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
Free Choice	0.00	0.00	5.00	5.74	7.00	30.00	n = 43
Focused	0.00	0.00	0.00	6.74	7.50	45.00	n = 43

Figure 17. Combined Groups iPad Usage Minutes by Usage Type.



To determine whether this was the case for both levels of Walk to Math, a similar analysis was conducted for each usage type over these groups. In the Intensive & Strategic class, 19 free choice lessons were observed, totaling 131 minutes and 6 focused lessons were observed, totaling 100 minutes. In the Benchmark class, 9 free choice lessons were observed, totaling 116 minutes, and 7 focused lessons were observed, totaling 190 minutes. These totals are presented in Table 2.

Table 2. Usage Types for Walk to Math Groups (minutes).

	Free Choice		Focused		Total	
Walk to Math Level	# of Lessons	Total Length	# of Lessons	Total Length	# of Lessons	Total Length
Intensive & Strategic	19	131	6	100	25	231
Benchmark	9	116	7	190	16	306
Total	28	247	13	290	41	537

Table 3. Usage Frequency for Walk to Math Groups (Daily).

	Days of Usage Type				
Walk to Math Level	Neither	Free Choice Only	Focused Only	Both	Total
Intensive & Strategic	3	13	0	6	22
Benchmark	8	6	4	3	21
Total	11	19	4	9	43

Table 3 presents daily iPad activity numbers for both classes. Overall, iPads were not used 11 times, used only for free choice 19 times, used only for focused lessons 4 times, and used for both types of lessons 9 times. The Intensive & Strategic class used the iPad 19 out of 22 days, but mostly for free choice only lessons. The Benchmark class used the iPad 13 out of 21 days, but for less free choice only lessons.

Table 4 presents summary statistics of minutes of free choice usage in the Intensive & Strategic and Benchmark groups. The Intensive & Strategic group saw a mean usage of 5.96 minutes of free choice, and ranged from 0 to 20 minutes. The

Benchmark group saw a mean usage of 5.52 minutes, and ranged from 0 to 30 minutes per free choice activity.

Table 4. Free Choice Usage Summary for Walk to Math Groups (minutes).

Walk to Math Level	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
Intensive & Strategic	0.00	4.25	5.00	5.96	6.75	20.00	n = 22
Benchmark	0.00	0.00	0.00	5.52	7.00	30.00	n = 22

Similarly, Table 5 presents summary statistics of minutes of focused usage in the Intensive & Strategic and Benchmark groups. The Intensive & Strategic group saw a mean usage of 4.55 minutes per focused lesson, and ranged from 0 to 40 minutes. The Benchmark group saw a mean usage of 9.05 minutes, and ranged from 0 to 45 minutes

Table 5. Focused Usage Summary for Walk to Math Groups (minutes).

Walk to Math Level	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
Intensive & Strategic	0.00	0.00	0.00	4.55	3.75	40.00	n = 22
Benchmark	0.00	0.00	0.00	9.05	15.0	45.00	n = 22

per free choice activity. These data are also presented in Figures 18 and 19 below comparing the minutes of each usage type over Walk to Math groups.

Figure 18. Free Choice iPad Usage Minutes by Walk to Math Group.

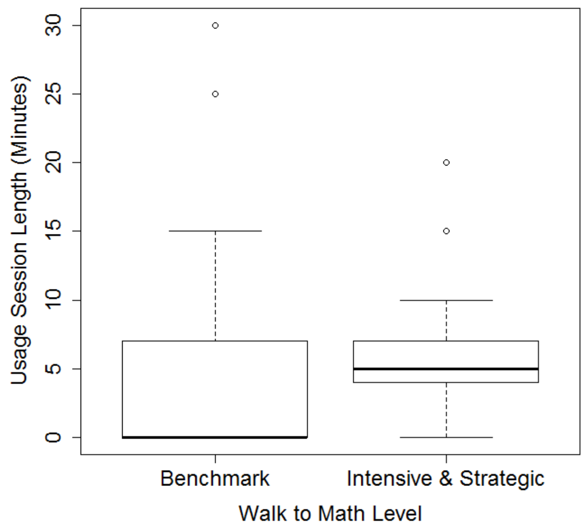
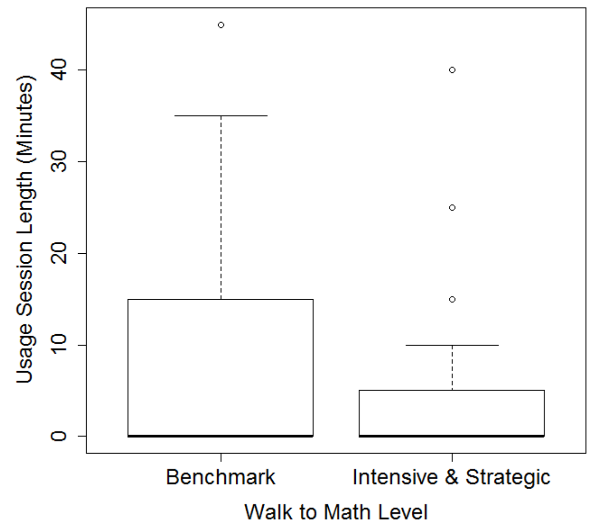


Figure 19. Focused iPad Usage Minutes by Walk to Math Group.



Active iPad Usage and Frequency

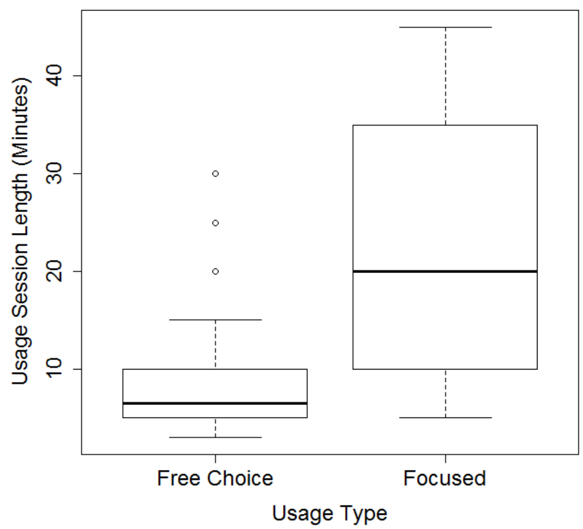
While both teachers in this study frequently used iPads in their lessons, it was not always the case that it was the appropriate tool. For this reason, it is of interest to compare usage types only on days when iPads were in use. In the following analysis, all recordings of 0 minutes were dropped (when the type of usage did not occur). It should be noted that this decreased the sample size for each usage type to n = 28 for free choice and n = 13 for focused (Table 6).

Table 6 presents summary statistics for usage type in both Walk to Math groups combined, but only for lessons in which iPads were in active use. Overall, free choice lessons lasted an average of 8.82 minutes and ranged from 3 minutes to 30 minutes in length. Focused lessons lasted an average of 22.31 minutes and ranged from 5 minutes to 45 minutes in length (Table 6).

Table 6. Walk to Math – Combined Groups Active Usage Summary (minutes).

Usage Type	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
Free Choice	3.00	5.00	6.50	8.82	10.0	30.00	n = 28
Focused	5.00	10.0	20.00	22.31	35.0	45.00	n = 13

Figure 20. Combined Groups iPad Usage Minutes by Usage Type (Active Sessions Only).



These data are also displayed in Figure 20. It is now clear that, while free choice lessons occurred more frequently than focused lessons overall, when they occurred, focused lessons lasted much longer.

Breaking this down further to analyze active usage differences between the Walk to Math groups, Table 7 presents summary statistics of minutes of active free choice usage in the Intensive & Strategic and Benchmark groups. When free choice lessons were used, the Intensive & Strategic group saw a mean lesson length of 6.90 minutes of free choice and ranged from 3 to 20 minutes. The Benchmark group saw a mean length of 12.89 minutes and ranged from 5 to 30 minutes per free choice activity. It should again be noted that the sample sizes are decreased to n = 19 and n = 9 for Intensive & Strategic and Benchmark groups, respectively (Table 7).

Table 7. Active Free Choice Usage Summary for Walk to Math Groups (minutes).

Walk to Math Level	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
Intensive & Strategic	3.00	5.00	5.00	6.90	7.50	20.00	n = 19
Benchmark	5.00	7.00	10.00	12.89	15.0	30.00	n = 9

Similarly, Table 8 presents summary statistics of minutes of active focused usage in the Intensive & Strategic and Benchmark groups. When focused lessons were used, the Intensive & Strategic group saw a mean lesson length of 16.67 minutes of focused use and ranged from 5 to 40 minutes. The Benchmark group saw a mean length of 27.14 minutes and ranged from 10 to 45

Table 8. Active Focused Usage Summary for Walk to Math Groups (minutes).

Walk to Math Level	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
Intensive & Strategic	5.00	6.25	12.50	16.67	22.5	40.00	n = 6
Benchmark	10.0	17.5	30.00	27.14	35.0	45.00	n = 7

minutes per free choice activity. Sample sizes are 6 and 7 for Intensive & Strategic and Benchmark groups, respectively (Table 8). These data are also presented in Figures 21 and 22.

Figure 21. Free Choice iPad Usage Minutes by Walk to Math Group (Active Sessions Only).

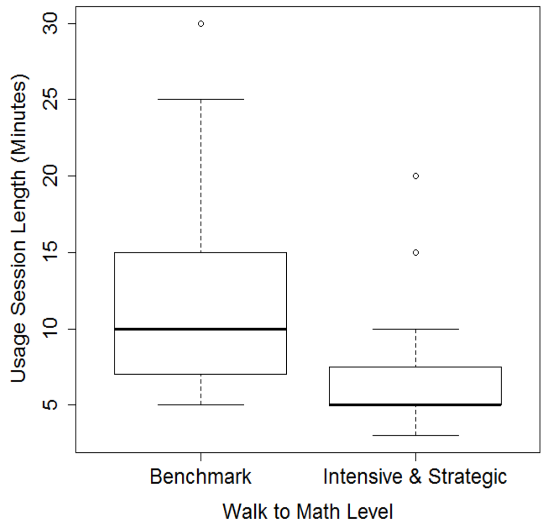
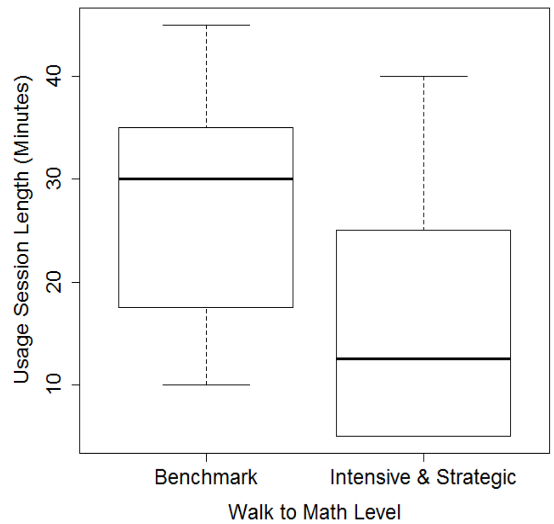


Figure 22. Focused iPad Usage Minutes by Walk to Math Group (Active Sessions Only).



App Availability

Student iPad usage in all lessons and activities was controlled in that students were only allowed to work on apps the teacher made available. Available in this case refers to teacher permitted use, not technological availability of the app; that is, all apps were always available on the iPads. The following apps were made available at some point throughout the observation period:

- Educreations Interactive Whiteboard (Educreations, Inc.). An interactive whiteboard app with recording and playback capability, as well as photo integration.
- Addimal Adventure (Teachley). A game for learning single digit addition facts. For more details, see Chapter 3.
- Splash Math 2nd Grade (StudyPad, Inc.). A workbook based game for all mathematics topics in 2nd Grade. For more details, see Chapter 3.

- Wings (Motion Math). A game for mastering multiplication skills that makes use of the accelerometer in the iPad to detect tilting in order to steer the character to the larger value.
- Sail Through Math (McGraw-Hill). A game for practicing math skills in addition, subtraction, multiplication, division, as well as more advanced topics.
- Sushi Monster (Scholastic). A game for practicing and building fact fluency in addition and multiplication.
- Counting Money (King's Apps). A game designed for all ages to learn how to count money of all denominations.
- Tell Time (Horizon Business, Inc.). A game for practicing telling time on a traditional circular clock face.

Table 9 reports the total instructional minutes for which each app was made available over all 43 observed lessons. Overall, the most frequently used apps were Splash Math 2nd Grade and Addimal Adventure. The least frequently used were Tell

Table 9. Walk to Math – Combined Groups App Availability.

App	Free Choice Availability (in minutes)	Focused Availability (in minutes)	Overall Availability (in minutes)
Splash Math 2nd	221	65	286
Addimal Adventure	196	40	236
Educreations	0	185	185
Math Bingo	114	5	119
Wings	70	25	95
Sail Through Math	44	0	44
Sushi Monster	27	0	27
Counting Money	20	0	20
Tell Time	17	0	17

Time and Counting Money. Along with Sail Through Math and Sushi Monster, these two apps were only used in free choice lessons. Educreations Interactive Whiteboard was unique in that it was the only app to be exclusively used in focused lessons.

Table 10. Walk to Math – Intensive & Strategic Group App Availability.

App	Free Choice Availability (in minutes)	Focused Availability (in minutes)	Overall Availability (in minutes)
Addimal Adventure	100	40	140
Splash Math 2^{nd}	105	5	110
Math Bingo	70	5	75
Educreations	0	55	55
Wings	36	0	36
Counting Money	20	0	20
Sushi Monster	20	0	20
Sail Through Math	0	0	0
Tell Time	0	0	0

Tables 10 and 11 report the total instructional minutes for which each app was made available to Intensive & Strategic and Benchmark levels of Walk to Math, respectively. In the Intensive & Strategic Walk to Math class, Addimal Adventure and Splash Math 2^{nd} Grade were the most frequently used apps. Sail Through Math and Tell Time were not observed in use. In the Benchmark class, Splash Math 2^{nd} Grade and Educreations Interactive Whiteboard were the most frequently used, with Tell Time and Sushi Monster being the least used. Math Bingo was used more frequently in the Intensive & Strategic class (75 minutes vs. 44 minutes in Benchmark), whereas Educreations was used much more frequently in the Benchmark class (130 minutes vs. 55 minutes).

Table 11. Walk to Math – Benchmark Group App Availability.

App	Free Choice Availability (in minutes)	Focused Availability (in minutes)	Overall Availability (in minutes)
Splash Math 2nd Grade	116	60	176
Educreations	0	130	130
Addimal Adventure	96	0	96
Wings	34	25	59
Math Bingo	44	0	44
Sail Through Math	44	0	44
Tell Time	17	0	17
Sushi Monster	7	0	7
Counting Money	0	0	0

App Progress and Quiz Score Analysis – Splash Math 2nd Grade

Student progress percentages in the Splash Math 2nd Grade app were recorded for eight of the thirteen categories discussed in Chapter 3: place value, counting and number patterns, two digit addition, one digit subtraction, two digit subtraction, measurements, geometry, and data. As each category records its progress as a percentage, the total "app score" possible was considered to be 800 points. Also recorded were student scores on the 10 question Splash Math 2nd Grade assessment quiz (Appendix 1). For ease of comparison, both have been converted to percent scale. Due to transferred students, app data was captured from iPads from three students who were not able to take the quiz. Table 12 presents summary statistics for these two datasets for both Walk to Math groups. Over all Walk to Math groups, the mean app progress was 30.60%, with scores ranging from 0% to 80%. The quiz scores had a much higher mean of 77.14% and ranged from 0% to 100%. These data are also portrayed in Figures 23 and 24.

Table 12. Walk to Math – Combined Groups Splash Math 2nd Grade app progress and worksheet scores (%).

Splash Math 2nd	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
App Progress Total (%)	0.00	17.72	25.38	30.60	43.28	80.00	n = 38
Quiz Total (%)	0.00	70.00	80.00	77.14	90.00	100.0	n = 35

Figure 23. Combined Groups Splash Math App Progress.

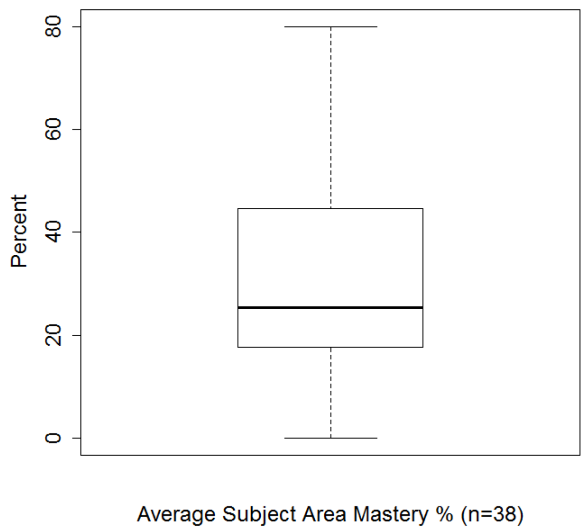


Figure 24. Combined Groups Splash Math Quiz Scores.

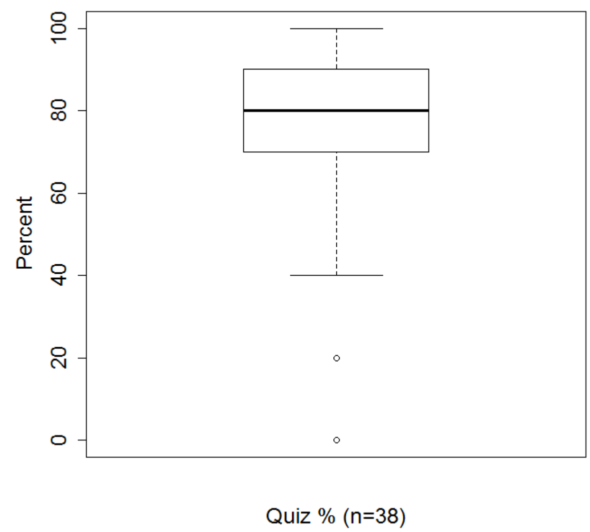
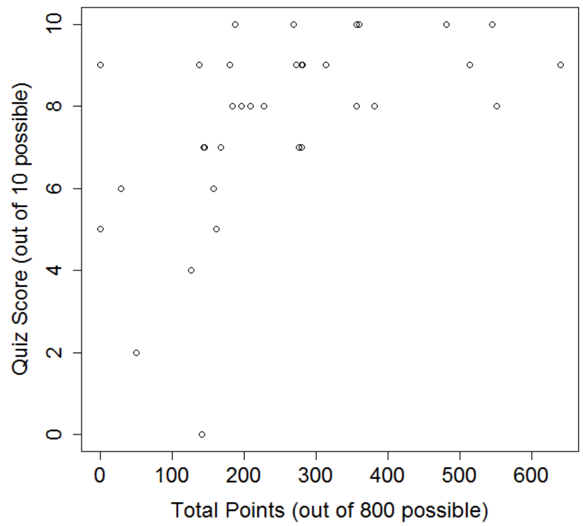


Figure 25 is a scatterplot of quiz scores against app progress. This shows a moderately positive relationship (Pearson's $r = 0.52$) between the two scores.

While the app and quiz scores are positively correlated, it is informative to control for other factors which may be affecting quiz performance. For this reason, student scores on three unit tests (Appendix 2) were gathered as well. These results were used as covariates to test the effect of app progress on quiz scores. Two linear models were produced: Table 13 presents coefficients and standard errors from a model using only

Figure 25. Combined Groups Splash Math Quiz Score vs. App Progress.



app progress as a predictor, while Table 14 presents the full model using app progress and unit test scores. As these results are intended to be purely descriptive, and the sample sizes are too small in most cases for statistically valid inference, no residual analysis or extensive model comparisons are presented.

In the first model, app progress would appear to have significant explanatory power in describing quiz scores ($p = 0.0012$). However, from the second model it is clear that Test 1 scores explain much more of the variation in quiz scores than app progress. Of course, this analysis is on the combined population of both classes, and it is worth noting that high numbers of transfer students resulted in missing scores for several unit tests. For this reason, five students are omitted from the second model (Table 14).

To further explore this relationship in regards to the different levels of Walk to Math, a similar analysis was conducted on the two student groups. Table 15 presents app progress and quiz score summary statistics for the Benchmark group. These students had

Table 13. Coefficients and standard errors from a linear regression of combined groups Splash Math 2nd Grade quiz scores on app progress. Residual standard error 1.992 on 33 degrees of freedom (n = 35). $R^2 = 0.28$. Adjusted $R^2 = 0.255$.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	5.73	0.65	8.82	< 0.0001
App Progress	0.0077	0.0022	3.56	0.0012

Table 14. Coefficients and standard errors from a linear regression of combined groups Splash Math 2nd Grade quiz scores on app progress and unit tests 1, 2, and 3. Residual standard error 1.636 on 25 degrees of freedom (n = 30). $R^2 = 0.59$. Adjusted $R^2 = 0.519$.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	-7.515	6.042	-1.24	0.23
App Progress	0.002	0.002	0.75	0.46
Test 1	0.049	0.019	2.56	0.02
Test 2	-0.013	0.077	-0.17	0.86
Test 3	0.134	0.072	1.85	0.08

a mean app progress of 41.05% and ranged from 0% to 80% completion. Their quiz scores were higher, with a mean of 88.57% and scores ranging from 60% to 100%. These data are displayed in Figures 26 and 27 as well.

Table 15. Walk to Math – Benchmark Group Splash Math 2nd Grade app progress and worksheet scores (%).

Splash Math 2^{nd}	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
App Progress Total (%)	0.00	33.62	39.25	41.05	47.75	80.00	n = 21
Quiz Total (%)	60.0	80.00	90.00	88.57	100.0	100.0	n = 21

Figure 26. Splash Math App Progress by Walk to Math Group.

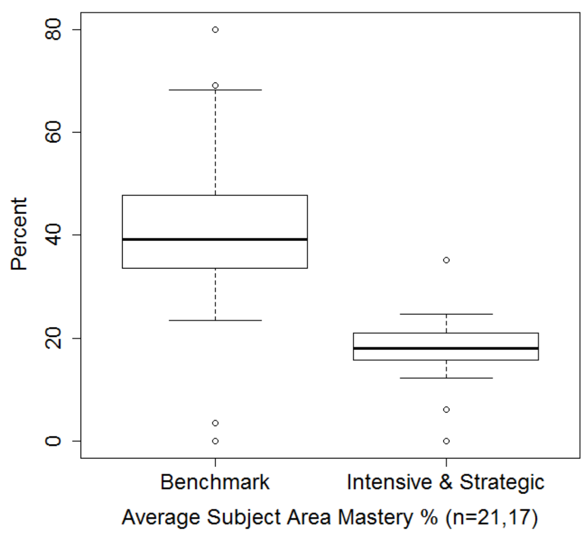


Figure 27. Splash Math Quiz Scores by Walk to Math Group.

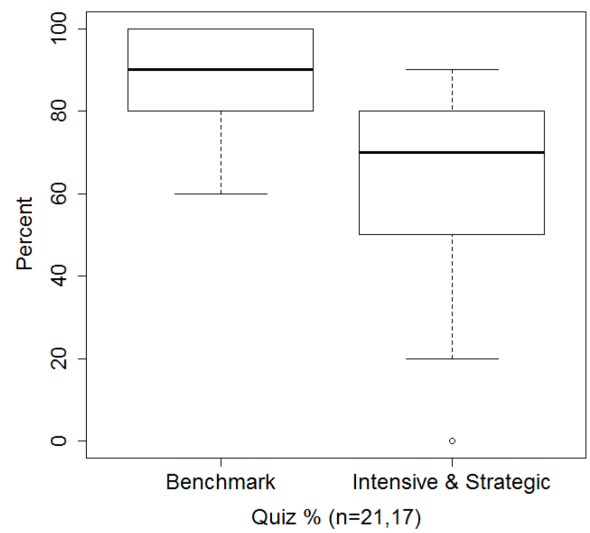


Figure 28. Benchmark Group Splash Math Quiz Score vs. App Progress.

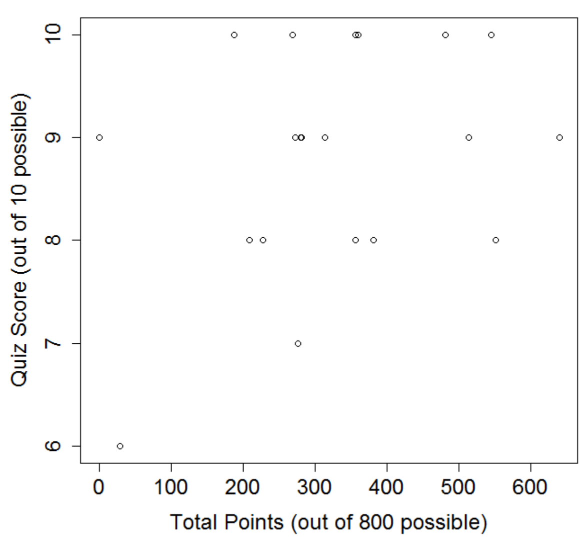


Figure 29. Intensive & Strategic Group Splash Math Quiz Score vs. App Progress.

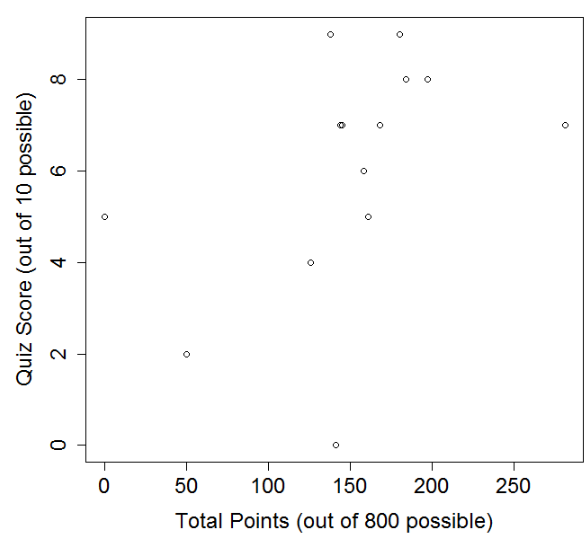


Figure 28 is a scatterplot of quiz scores against app progress for the Benchmark group. This shows a weakly positive relationship (Pearson's $r = 0.33$) between the two scores.

For the Benchmark group, test scores were again used as covariates to test the effect of app progress on quiz scores. Two linear models were produced: Table 16 presents results from a model using only app progress as a predictor, while Table 17 presents the full model using app progress and unit test scores. In the first model, app progress does not have significant explanatory power in describing quiz scores (p = 0.142). However, in the second model, none

Table 16. Coefficients and standard errors from a linear regression of Benchmark student Splash Math 2nd Grade quiz scores on app progress. Residual standard error 1.073 on 19 degrees of freedom (n = 21). $R^2 = 0.110$. Adjusted $R^2 = 0.063$.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	8.105	0.544	14.89	< 0.0001
App Progress	0.0023	0.0015	1.53	0.142

Table 17. Coefficients and standard errors from a linear regression of Benchmark student Splash Math 2nd Grade quiz scores on app progress and unit tests 1, 2, and 3. Residual standard error 1.077 on 16 degrees of freedom (n = 21). $R^2 = 0.245$. Adjusted $R^2 = 0.056$.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	0.213	6.616	0.03	0.98
App Progress	0.002	0.002	0.98	0.34
Test 1	-0.020	0.086	-0.23	0.82
Test 2	0.065	0.121	0.54	0.60
Test 3	0.042	0.095	0.44	0.67

of the test scores are more significant than app progress, although the model explains little of the variation in quiz scores ($R^2 = 0.245$).   Also, this analysis is only on 21 students. It is worth noting that in the Benchmark group, there were no transfer students causing omitted results in the full model.

Similarly, for the Intensive & Strategic group, Table 18 presents app progress and quiz score summary statistics. These students had a mean app progress of 17.70% and ranged from 0% to 35.12% completion. Their quiz scores were higher, with a mean of 60% and scores ranging from 0% to 90%. These data are displayed in Figures 26 and 27 as well.

Table 18. Walk to Math – Intensive & Strategic Group Splash Math 2nd Grade app progress and worksheet scores (%).

Splash Math 2nd Grade	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
App Progress Total (%)	0.00	15.75	18.00	17.70	21.00	35.12	n = 17
Quiz Total (%)	0.0	50.0	70.0	60.0	77.5	90.0	n = 14

Figure 29 is a scatterplot of quiz scores against app progress for the Intensive & Strategic group. This shows a weakly positive relationship (Pearson's $r = 0.45$) between the two scores.

For the Intensive & Strategic group, test scores were again used as covariates to test the effect of app progress on quiz scores. Two linear models were produced: Table 19 presents results from a model using only app progress as a predictor, while Table 20 presents the full model using app progress and unit test scores. In the first model, app progress appears to have moderately significant explanatory power in describing quiz

Table 19. Coefficients and standard errors from a linear regression of Intensive & Strategic student Splash Math 2nd Grade quiz scores on app progress. Residual standard error 2.417 on 12 degrees of freedom (n = 14). R^2 = 0.204. Adjusted R^2 = 0.137.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	3.33	1.65	2.02	0.067
App Progress	0.02	0.01	1.75	0.105

Table 20. Coefficients and standard errors from a linear regression of Benchmark student Splash Math 2nd Grade quiz scores on app progress and unit tests 1, 2, and 3. Residual standard error 3.213 on 4 degrees of freedom (n = 9). R^2 = 0.395. Adjusted R^2 = 0.210.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	-8.860	21.657	-0.41	0.70
App Progress	0.015	0.023	0.62	0.57
Test 1	0.029	0.088	0.34	0.75
Test 2	-0.057	0.232	-0.24	0.82
Test 3	0.187	0.184	1.02	0.37

scores (p = 0.105). However, this variable is not significant in the second model (p = 0.57). It is worth noting that in the Intensive & Strategic group, transfer students caused omitted results in the full model, resulting in five students being dropped from the analysis.

An item analysis of quiz problems was conducted to explore relationships between quiz and app performance in different subject areas. Student quiz scores for each problem were averaged and compared to the class average for the corresponding subject area in the Splash Math 2nd Grade app. Six subject areas were represented by a single item each on the quiz, and two areas were represented by two items each (place value and counting and number patterns) (Table 21). Table 21 also reports these class averages, which are depicted in Figure 30. The overall class quiz and app averages for each subject area are highly correlated (Pearson's r = 0.85).

Figure 30. Combined Groups Splash Math Subject Area Quiz Average vs App Average.

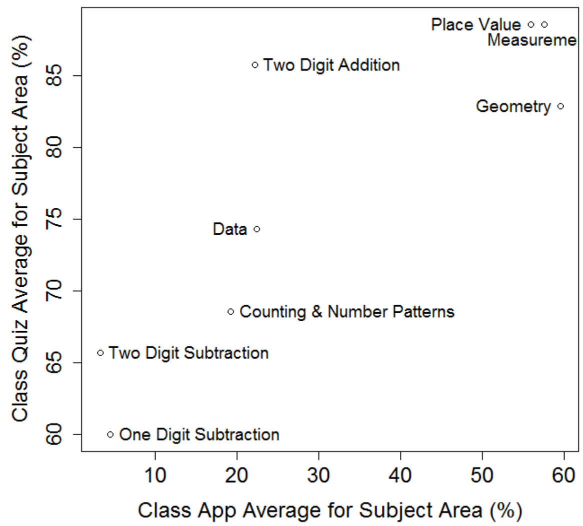


Table 21. Walk to Math – Combined Groups Quiz and App Average for each Subject Area.

Subject Area	Quiz Item Number	Class Average App Progress (%)	Class Average Quiz Score (%)
Place Value	1,9	56	89
Counting & Number Patterns	2,10	19	69
Two Digit Addition	6	22	66
One Digit Subtraction	5	5	83
Two Digit Subtraction	3	3	60
Measurements	8	58	86
Geometry	4	60	74
Data	7	22	89

A similar item analysis was performed for each Walk to Math grouping. Tables 22 and 23 present the app and quiz average for the two Walk to Math classes. These data are depicted in Figures 31 and 32. These plots show a stronger correlation in the Intensive & Strategic group (Pearson's r = 0.62) than in the Benchmark group (Pearson's r = 0.49) for class average quiz and app scores for each subject area.

Table 22. Walk to Math – Intensive & Strategic Group Quiz and App Average for each Subject Area.

Subject Area	Class Average App Progress (%)	Class Average Quiz Score (%)
Place Value	48	79
Counting & Number Patterns	12	54
Two Digit Addition	2	36
One Digit Subtraction	1	71
Two Digit Subtraction	0	14
Measurements	55	79
Geometry	22	57
Data	94	79

Table 23. Walk to Math – Benchmark Group Quiz and App Average for each Subject Area.

Subject Area	Class Average App Progress (%)	Class Average Quiz Score (%)
Place Value	63	95
Counting & Number Patterns	25	79
Two Digit Addition	38	86
One Digit Subtraction	7	90
Two Digit Subtraction	6	90
Measurements	59	90
Geometry	90	86
Data	40	95

Figure 31. Benchmark Group Splash Math Subject Area Quiz Average vs. App Average.

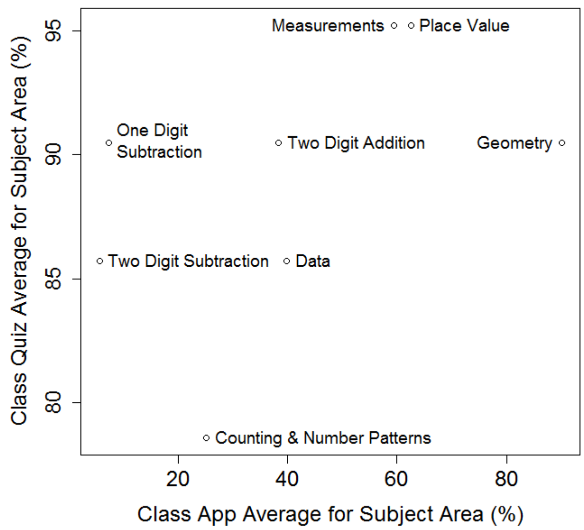
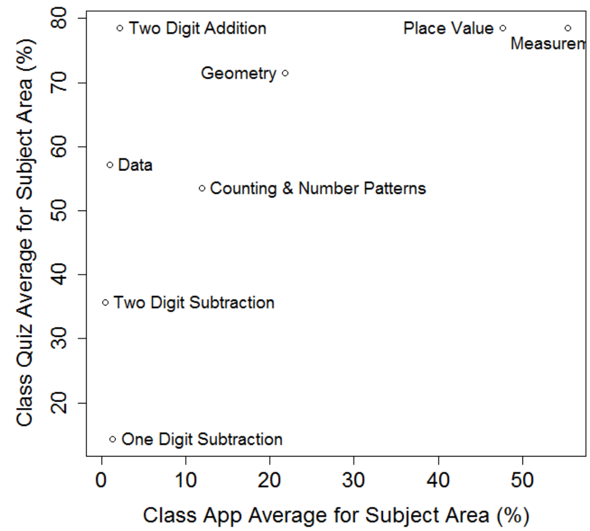


Figure 32. Intensive & Strategic Group Splash Math Subject Area Quiz Average vs. App Average.



App Progress and Quiz Score Analysis – Addimal Adventure

Student progress in the Addimal Adventure app was recorded based on the percentage of the picture that had been uncovered (Figure 9). Full completion of the game requires uncovering 121 blocks and obtaining gold on all the corresponding addition facts (Figures 8, 9). Student scores on the timed addition facts quiz (Figure 10) were captured for comparison. This quiz consisted of 10 questions; the scores are reported as percentages in Table 24, along with summary statistics of app progress.

Table 24. Walk to Math – Combined Groups Addimal Adventure app progress and worksheet scores (%).

Addimal Adventure	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
App Progress (%)	21.49	35.33	68.18	63.96	85.33	100.0	n = 36
Quiz Score (%)	10.0	60.0	100.0	80.0	100.0	100.0	n = 35

Figure 33. Combined Groups Addimal Adventure App Progress.

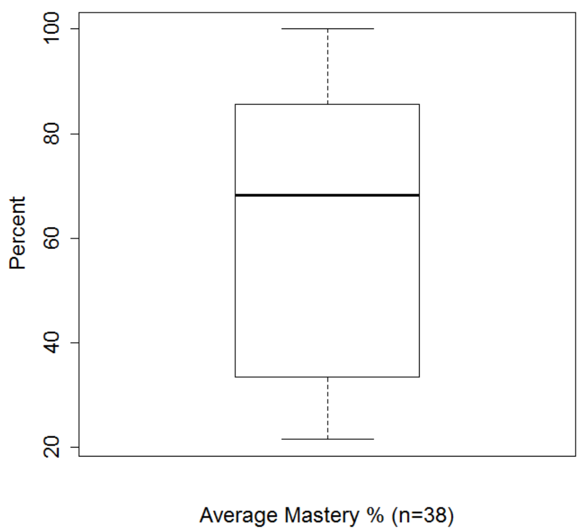


Figure 34. Combined Groups Addimal Adventure Quiz Scores.

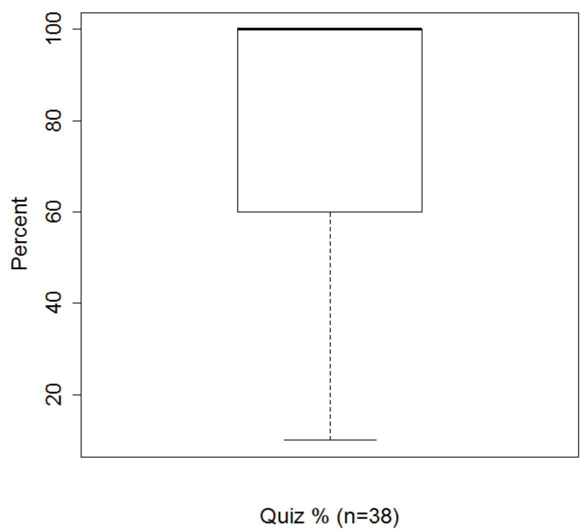
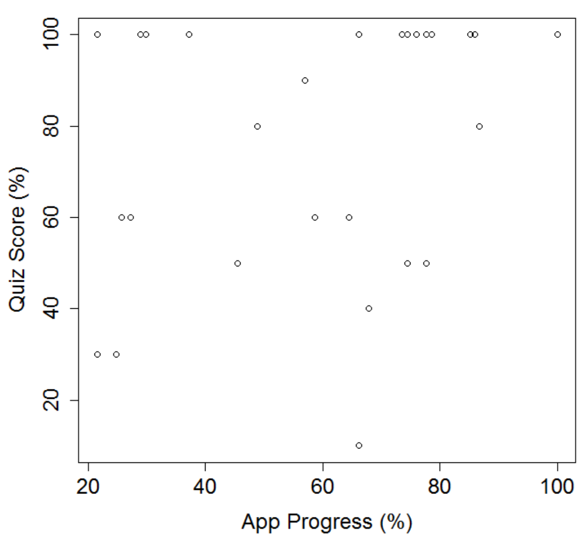


Figure 35. Combined Groups Addimal Adventure Quiz Score vs. App Progress.



Overall, students had a mean progress of 63.96% in the app, with a range of 21.49% to 100%. Quiz scores had mean of 80% and ranged from 10% to 100%. These data are displayed in Figures 33 and 34. Figure 35 is a scatterplot of quiz scores against app progress for both Walk to Math groups. This shows a weakly positive relationship (Pearson's $r = 0.41$) between the two scores.

Unit test scores were used as covariates to test the effect of Addimal Adventure progress on quiz scores. Two linear models were produced: Table 25 presents results from a model using only app progress as a predictor, while Table 26 presents the full model using app progress and unit test scores. In the first model, app progress appears to be significant in describing quiz scores ($p = 0.019$). However, in the second model the test scores explain more of the variation in quiz scores, especially Test 1 ($p = 0.001$), and

Table 25. Coefficients and standard errors from a linear regression of combined student Addimal Adventure quiz scores on app progress. Residual standard error 25.15 on 31 degrees of freedom (n = 33). $R^2 = 0.166$. Adjusted $R^2 = 0.139$.

	Estimate	SE	t	Pr(> |t|)
Intercept	53.21	11.76	4.53	< 0.0001
App Progress	0.41	0.17	2.48	0.019

Table 26. Coefficients and standard errors from a linear regression of combined groups student Addimal Adventure quiz scores on app progress and unit test 1, 2, and 3 scores. Residual standard error 18.96 on 25 degrees of freedom (n = 30). $R^2 = 0.515$. Adjusted $R^2 = 0.4369$.

	Estimate	SE	t	Pr(> |t|)
Intercept	22.37	78.58	0.29	0.78
App Progress	0.23	0.17	1.40	0.18
Test 1	0.85	0.22	3.92	0.001
Test 2	0.95	0.92	1.03	0.31
Test 3	-1.22	0.90	-1.35	0.19

app progress is no longer significant (*p* = 0.18). Again, transfer students had missing test scores, resulting in three students being dropped from the analysis in the full model.

A similar analysis of Walk to Math groupings shows that Intensive & Strategic students had mean progress of 54.66% in the app, with a range of 21.49% to 85.95%. Quiz scores had mean of 61.43% and ranged from 10% to 100%. These data are reported in Table 27 and displayed in Figures 36 and 37. Figure 39 is a scatterplot of quiz scores

Table 27. Walk to Math – Intensive & Strategic Group Addimal Adventure app progress and worksheet scores (%).

Addimal Adventure	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
App Progress (%)	21.49	35.95	64.46	54.66	68.18	85.95	n = 15
Quiz Score (%)	10.00	42.50	60.00	61.43	80.00	100.0	n = 14

Figure 36. Addimal Adventure App Progress by Walk to Math Group.

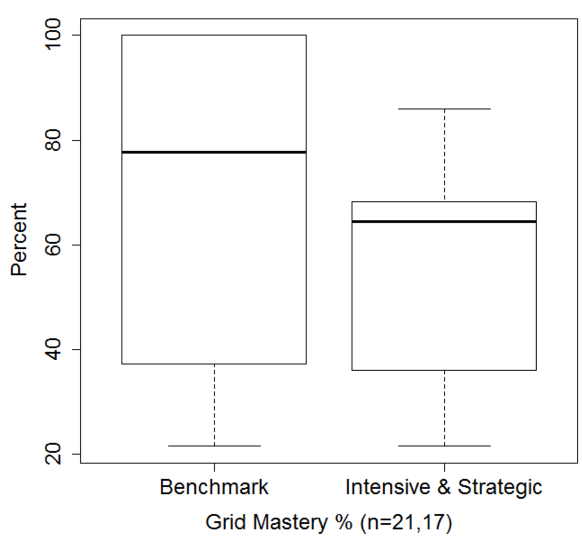


Figure 37. Addimal Adventure Quiz Scores by Walk to Math Group.

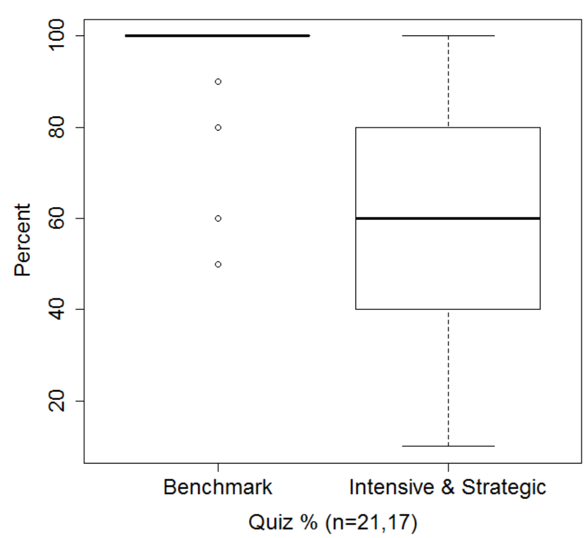


Figure 38. Addimal Adventure Quiz Score vs. App Progress – Benchmark Group.

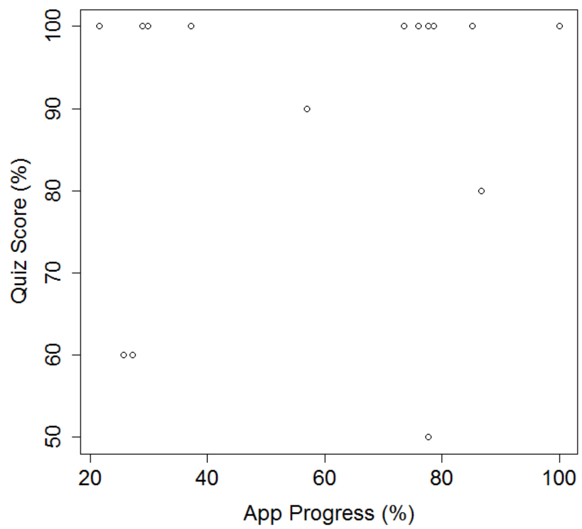
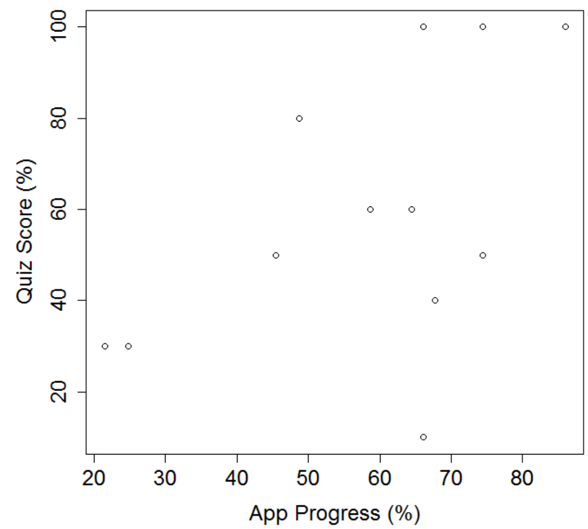


Figure 39. Addimal Adventure Quiz Score vs. App Progress – Intensive & Strategic Group.



against app progress for Intensive & Strategic students. This shows a moderately positive relationship (Pearson's r = 0.51) between the two scores.

Unit test scores were again used as covariates to test the effect of Addimal Adventure progress on quiz scores. Two linear models were produced: Table 28 presents results from a model using only app progress as a predictor, while Table 29 presents the full model using app progress and unit test scores. In the first model, app progress appears to be somewhat significant in describing quiz scores (p = 0.09). However, in the second model the test scores again explain more of the variation in quiz scores and app progress is no longer significant (p = 0.85). Transfer students in this class had missing test scores, resulting in three students being dropped from the analysis in the full model.

Table 28. Coefficients and standard errors from a linear regression of Intensive & Strategic student Addimal Adventure quiz scores on app progress. Residual standard error 27.26 on 10 degrees of freedom (n =12). $R^2 = 0.2634$. Adjusted $R^2 = 0.1897$.

	Estimate	SE	t	Pr(> |t|)
Intercept	13.23	25.54	0.52	0.62
App Progress	0.79	0.42	1.89	0.09

Table 29. Coefficients and standard errors from a linear regression of Intensive & Strategic student Addimal Adventure quiz scores on app progress and unit test 1, 2, and 3 scores. Residual standard error 31.68 on 4 degrees of freedom (n = 9). $R^2 = 0.5344$. Adjusted $R^2 = 0.06879$.

	Estimate	SE	t	Pr(> |t|)
Intercept	-234.85	382.71	-0.61	0.57
App Progress	-0.32	1.60	-0.20	0.85
Test 1	1.61	1.04	1.56	0.20
Test 2	2.79	3.13	0.89	0.42
Test 3	-0.17	2.81	-0.06	0.95

The analysis of Benchmark students shows a mean progress of 70.60% in the app, with a range of 21.49% to 100%. Quiz scores had mean of 92.38% and ranged from 50% to 100%. These data are reported in Table 30 and displayed in Figures 36 and 37.

Table 30. Walk to Math – Benchmark Group Addimal Adventure app progress and worksheet scores (%).

Addimal Adventure	Min.	Q1	Median	Mean	Q3	Max.	Sample Size
App Progress (%)	21.49	37.19	77.60	70.60	100.0	100.0	n = 21
Quiz Score (%)	50.00	100.0	100.00	92.38	100.0	100.0	n = 21

Figure 38 is a scatterplot of quiz scores against app progress for Benchmark students. This shows a weakly positive relationship (Pearson's r = 0.32) between the two scores.

Unit test scores were again used as covariates to test the effect of Addimal Adventure progress on quiz scores. Two linear models were produced: Table 31 presents results from a model using only app progress as a predictor, while Table 32 presents the full model using app progress and unit test scores. In the first model, app progress is not significant in describing quiz scores (p = 0.16). However, in the second

Table 31. Coefficients and standard errors from a linear regression of Benchmark student Addimal Adventure quiz scores on app progress. Residual standard error 15.35 on 19 degrees of freedom (n = 21). R^2 = 0.1012. Adjusted R^2 = 0.05389.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	80.48	8.80	9.15	< 0.0001
App Progress	0.17	0.12	1.46	0.16

Table 32. Coefficients and standard errors from a linear regression of Benchmark student Addimal Adventure quiz scores on app progress and unit test 1, 2, and 3 scores. Residual standard error 13.93 on 16 degrees of freedom (n = 21). R^2 = 0.3766. Adjusted R^2 = 0.2207.

	Estimate	SE	*t*	Pr(> |*t*|)
Intercept	7.42	88.30	0.08	0.93
App Progress	0.27	0.13	2.04	0.06
Test 1	2.56	1.13	2.26	0.04
Test 2	-0.92	1.61	-0.57	0.57
Test 3	-0.94	1.21	-0.78	0.45

model, not only is Test 1 significant in explaining the variation in quiz scores (p = 0.04), but app progress is moderately significant as well (p = 0.06). However, it is worth noting that the second model still explains little of the overall variation in quiz scores (R^2 =

0.3766), although it does explain more than the first model (adjusted R^2 = 0.2207 (Table 32) vs 0.053 (Table 31).

Interview Ratings

Student and teacher interviews were conducted after the first month and at the end of the study. Three students from each Walk to Math cohort were interviewed. For the purposes of analysis, random names have been assigned to the students to preserve anonymity. However, the gender of the names has been maintained. From the Intensive & Strategic class, one female and two males were interviewed: Emma, Aiden, and Jackson, respectively. From the Benchmark class, one male and two females were interviewed: Ethan, Sophia, and Isabella, respectively. Jackson transferred to a different school between interviews, so for the second interview he was replaced by Noah, a new student who had just transferred into the Intensive & Strategic class. Each of the two teachers was interviewed as well.

All interviews were analyzed using the framework described in Pierce et al. (2007). As mentioned in Chapter 3, their scale for mathematics and technology attitudes is built around five affective variables relevant to learning mathematics with technology: Mathematics Confidence (MC), Technological Confidence (TC), Attitude toward learning Mathematics with Technology (MT), Affective Engagement (AE), and Behavioral Engagement (BE). Their measurement instrument was adapted for use with iPads and teachers, for the sake of consistency; it is available in Appendix 3. This allows for a Likert-type scoring format for each of the five variables (Pierce et al., 2007). That is, each statement on the measurement instrument has a score from ranging from 1 to 5, with 5 being the highest agreement or frequency.

Student and teacher interviews were coded based on the research questions and these five affective variables (Appendix 3). As the interviews were open-ended, not all items of the questionnaire were addressed. These items received no score. For this reason, an average rating for each category was computed. Each rating had a maximum score of 5 and a minimum score of 1. As a consistency check, a second coder examined a sample of 5 of the 16 total interviews (approximately 31%). This coding agreed with the researcher's interview coding 73% of the time on average, and assigned ratings differed from the researcher's ratings by 0.66 points on average. Tables 33, 34 and 35 present the researcher's average ratings for all students and teachers for both interview sessions.

For Interview 1, on average Intensive & Strategic students appear to have roughly similar ratings to the Benchmark students. In fact, Intensive & Strategic students have higher mean ratings in every variable except mathematical technology. For Interview 2, Intensive & Strategic students had higher mean ratings in all categories than Benchmark students. Between Interviews 1 and 2, Intensive & Strategic students saw a decrease in ratings for behavioral engagement, mathematical confidence, and affective engagement. However, they saw an increase in ratings for technological confidence and mathematical technology. Between Interviews 1 and 2, Benchmark students saw a decrease in ratings for affective engagement, mathematical confidence, and mathematical technology. However, they saw an increase in ratings for technological confidence and behavioral engagement.

Table 33. Student Interview 1 Mean Ratings.

Interview 1		Mean Rating				
Intensive & Strategic		BE	TC	MC	AE	MT
Emma		4.5	3.7	5.0	4.8	2.3
Aiden		4.7	3.3	4.7	4.7	2.3
Jackson		4.5	5.0	3.0	4.3	4.0
	Mean	**4.425**	**4.000**	**4.425**	**4.575**	**3.350**
Benchmark		BE	TC	MC	AE	MT
Ethan		3.3	4.7	4.8	4.8	2.0
Sophia		2.7	2.7	4.3	4.0	3.3
Isabella		3.0	4.5	4.7	3.7	4.3
	Mean	**3.325**	**3.725**	**4.200**	**4.375**	**3.475**

Table 34. Student Interview 2 Mean Ratings.

Interview 2		Mean Rating				
Intensive & Strategic		BE	TC	MC	AE	MT
Emma		4.8	3.8	4.7	4.7	3.3
Aiden		3.7	4.8	4.0	4.7	3.5
Noah		3.0	4.3	3.5	4.0	4.0
	Mean	**3.950**	**4.225**	**4.300**	**4.425**	**3.950**
Benchmark		BE	TC	MC	AE	MT
Ethan		4.3	4.7	5.0	3.3	1.7
Sophia		3.3	4.0	3.3	4.5	3.0
Isabella		3.0	4.0	4.0	3.0	4.0
	Mean	**3.850**	**4.125**	**3.775**	**3.700**	**3.300**

In both Interviews 1 and 2, the teachers appear to have somewhat different ratings—mostly in the categories of mathematical confidence and technological confidence. For Interview 1, the Intensive & Strategic teacher had higher ratings in every variable except behavioral engagement and affective engagement. For Interview 2, the Intensive & Strategic teacher had higher ratings in all categories except behavioral engagement. Between Interviews 1 and 2, the Intensive & Strategic teacher saw a decrease in ratings for affective engagement and an increase in ratings for behavioral engagement and mathematical technology. Between Interviews 1 and 2, the Benchmark teacher saw a decrease in ratings for affective engagement, mathematical confidence, and mathematical technology. However, the teacher saw an increase in ratings for technological confidence and behavioral engagement. This is exactly the same pattern of changes observed between interviews in the Benchmark students. However, given the extremely small number of students, teachers, and interviews, the results do not admit a valid statistical comparison to draw firm conclusions about differences or similarities in ratings between groups.

Table 35. Teacher Interviews 1 & 2 Mean Ratings.

		Mean Rating				
Intensive & Strategic	Interview	BE	TC	MC	AE	MT
Teacher	1	4.0	4.0	5.0	4.5	4.8
	2	4.3	4.0	5.0	4.3	5.0
Benchmark	Interview	BE	TC	MC	AE	MT
Teacher	1	4.3	3.0	3.0	5.0	4.3
	2	4.8	3.8	2.8	4.0	4.5

Individual interview responses and codings are not reported in this chapter, but are available in Appendix 4. These responses will be used in the discussion of the results in the next chapter to provide background and qualitative explanations for observed relationships in iPad usage, app progress and quiz scores, and interview ratings of mathematical and technological attitudes.

Summary

In this chapter, an exploratory analysis was presented of results gathered from iPad usage recordings, student app progress and quiz scores for both Splash Math 2nd Grade and Addimal Adventure, and interview ratings of several affective variables describing student and teacher attitudes toward mathematics and technology. All of these results will be discussed in the next chapter. Relevant excerpts from interviews will be included there as well, to provide a qualitative explanation for, or counterpoint to, any observations.

Chapter 5: Discussion

In this chapter, the results presented in Chapter 4 are discussed. First, iPad usage frequency and type is described and relevant excerpts from student and teacher interviews are used to provide adequate background to explain the observed usage. Student and teacher attitudes toward mathematics and technology are also discussed. Technological issues that arose, as well as possible improvements which could lead to better differentiated instruction, are gleaned from the interviews. Student app and quiz performance for Splash Math 2nd Grade and Addimal Adventure is discussed and conclusions are drawn.

iPad Usage Frequency and Type

Two types of iPad use were observed in this study—free choice and focused lessons. Looking at both sections of Walk to Math combined, the two usage types occurred for similar total amounts of time (Table 2). However, their distributions are quite different (Figure 17). Overall, free choice lessons occurred almost twice as frequently as focused lessons and typically lasted an average of 8.82 minutes (Table 6), as opposed to 22.31 minutes for focused lessons. Also focused activities were rarely the only iPad use in a mathematics lesson. More often they were used in conjunction with free choice activities (Table 3). However, it should also be noted that roughly 25% of lessons were conducted without any iPad use at all (Table 3).

When usage over the different sections of Walk to Math is examined, stark differences are evident between the groups. Benchmark students used iPads 32% more minutes in total than Intensive & Strategic students and spent 90% more time in focused lessons. However, it is not simply the case that the Benchmark class used the iPad more often. Over the research period, the Benchmark class didn't make any use of the iPad during mathematics for 8 lessons, compared to 3 lessons where they weren't used in the Intensive & Strategic class. However, free choice lessons were much more common in the Intensive & Strategic group, occurring roughly twice as often as in the Benchmark group (Table 7).

An explanation for this discrepancy can be found in the interviews conducted with teachers. The Intensive & Strategic teacher liked using iPads as a focusing tool for students transitioning to math class:

Teacher: It's a great tool for early finishers. That they've always got something that they're really engaged in and they can be independent at. And I think that's huge. We use it a lot in here for a warmup.

Researcher: I've noticed that.

Teacher: So when the kids kind of flow in at different times, rather than just waiting or getting off task they can go back to it. I think it's great.

The first several minutes of class were often used to get students on task more efficiently by having students immediately put on headphones and open up one of the available free choice math apps listed on the whiteboard. This was often observed to be an effective technique for avoiding distractions. On several occasions, a disruptive student would attempt to distract a student working on their iPad, but the student working with headphones on was unable to hear them and remained engaged in the game.

In the Benchmark class, students were more often gathering at the whiteboard for daily instructions at the beginning of Walk to Math. This typically involved the discussion of the goal for the day, instructions for activities, when iPad usage would occur, and what apps they would be using to supplement the lesson. The type of iPad use was split fairly evenly between free choice and focused when this scenario occurred (Table 3). The distributions show focused lessons were generally longer in the Benchmark class. However, focused lessons occurred roughly the same number of times over the study period in both groups (Table 8).

App Availability

Teachers found it effective to limit student access to apps in free choice lessons. This kept students on task and challenged, as they were encouraged to work on more difficult apps, rather than replay games they had already mastered. This also allowed students to have some freedom to choose their difficulty for the day, while still working in apps relevant to the lesson.

Overall, the apps Splash Math 2nd Grade and Addimal Adventure were available for the most time (Table 9). However, in the Intensive & Strategic class Addimal Adventure was available more than Splash Math 2nd Grade, and in the Benchmark class Educreations Interactive Whiteboard app was used more than Addimal Adventure (Tables 10, 11). Educreations Interactive Whiteboard was also the only app to be exclusively used in focused lessons, so its high availability in the Benchmark class is a result of the higher frequency of focused lessons in that Walk to Math group.

Several different interactions seemed to be occurring between student performance, app choice, and app difficulty as well. For example, while the multiplication concepts of Wings were difficult for many students, it was a popular app due to the kinesthetic gameplay. Students enjoyed tilting the iPad and flying through numbers, even if they were somewhat confused by the problems at times. Several students admitted to being very confused by multiplication, but were willing to work at the concept because they enjoyed the game. On the other hand, Math Bingo is a game that focuses on basic addition and subtraction fact fluency—however, the game is beatable by tapping and guessing. For this reason teachers often discouraged it, but students enjoyed the game and would often still choose to play it. It is likely the easiness of it that attracted students.

Apps that concerned specific skills, such as Tell Time and Counting Money, were the least used. This was likely due to their specific nature; once the subject had been covered, the apps were no longer used. In interviews, the Benchmark teacher especially expressed a desire for more focused apps on particular skills:

Teacher: I want more specific, pinpointed apps that I feel like, it's just another second chance for them to apply what they know, or learn while they're moving along. But we just don't have the…

Researcher: You guys are just sort of getting them set up in the summer or something and pretty much what you roll out then is what you use for the rest of the semester, then?

Teacher: Yes, and there's not funding to allow for additional—most of those would be paid that are so specific.

The limited budget of the school for purchasing apps forces them to predominantly use free apps. Free apps however, unless produced by a non-profit company, governmental agency, or large company with other revenue streams, are primarily supported by advertisements (Tongaonkar, Dai, Nucci & Song, 2013). In fact, this was a concern among teachers and parents when the iPads were first being deployed. However, students didn't seem to be distracted by the ads and remained focused:

Teacher: […] we also have some apps that have, they're free, so they have some commercials on it.

Researcher: Ads and commercials.

Teacher: Yes, and that bugged me at first, a lot. And I thought we'd have a lot more parents that would be uptight about it, and we do have some, which I understand. But for the most part, the kids don't even notice them. They're really in tune with what they're doing on them.

The competitive market of apps and the tendency for apps to be priced cheaply, despite high development costs, impacts the type and quality of apps available for mathematics education. An app that is too specific, however well designed, may be purchased less frequently, making it difficult for app developers to justify committing resources to the project. On the other hand, more focused apps also have less content to cover; to some extent, this lessens the work of development. App maintenance and design is not an easy task however, and both of the more specific apps used in this school suffered from multiple design flaws and bugs.

For example, Counting Money was quite hard and often did not provide a low enough entry point for many students. Tell Time was effective, but quite procedural and the app design felt outdated. Of course, design is an ever changing target in the app world, and this rapid evolution makes it difficult for small developers to keep up. All of these factors make it difficult for developers to devote the time and resources necessary for a quality app, while still making the app broad enough to encourage purchases and maintain a sustainable business model.

Student Attitudes toward Mathematics on iPads

A large part of effective game design is difficulty and how it scales over the course of the gameplay. Despite the popularity of Math Bingo, not all students responded well to a game being easy. For many, especially higher performing students, the difficulty of the task made it more challenging and fun. In the interviews with Benchmark student Ethan, he expressed boredom and frustration with mathematics games on the iPad:

Researcher: Do you feel like you're pretty good at using your iPad?

Ethan: [hesitantly] I am, but I get bored of the games.

Researcher: Oh, ok. So what games do you play on there?

Ethan: My old favorite was Splash Math but now I'm kind of forced to do it, because I'm done with Addimals.

[…]

Ethan: I really like Wings, but everybody in the class has to be done with Addimals before we get to do that.

[…]

Researcher: Do you like using the iPad for math?

Ethan: Right now, because the two apps that they have I'm bored of, so not really now.

Researcher: Sure. When you first started using those apps did you like them?

Ethan: I loved them. Then I stopped liking them.

Clearly, Ethan's boredom with the apps was affecting his affective engagement with the subject. However, most students seemed content with the difficulty of the gameplay in mathematics apps. For example, several experienced speed difficulties in Addimal Adventure. In order to obtain the gold square and complete the puzzle, students had to solve addition problems within 3 seconds. For students using the various methods in the app—counting on, doubles, or making tens—this was often not quite enough time to solve the problem. If they didn't have the fact somewhat memorized, it was a race against time to get the answer. In one interview in the Intensive & Strategic group, Aiden discussed his frustration with Addimal Adventure at times:

Aiden: Because there's this evil guy, you have to remove the blocks, find out the answer, but he has his little robot that has this chainsaw that cuts metal.

Researcher: I've seen that, he's coming across, so you have to be really quick about it.

Aiden: Yeah, you have to think quickly. So I don't really do that one because it's much more harder. But I'm almost finished with the puzzle.

Researcher: I see. Because on the iPad you're using your fingers, so you have to do it all in your head. But on a picture and paper, you can draw a picture or put your pencil and down and use your fingers.

Aiden: Yeah [nodding]. But if he cuts one chain, then there's only one hanging on and then a little bubble comes up and it takes a break and tells you something. That's when I actually use my fingers.

Researcher: I see.

Aiden: I don't always make it do that, because, one thing you wouldn't really get any gold. Because you need the gold to show the picture.

Researcher: Sure. Do you feel like you're getting faster at those?

Aiden: Yes.

Researcher: So you're able to get the pictures a little bit better?

Aiden: Especially, there's this, if you don't get it by the time it cuts each chain, it shows a red block and it falls and it will cover up that answer on your puzzle, so it won't show that half that you just got wrong. If you got green, you can only see the green, and once you got it gold, you can actually see it.

[…]

Aiden: So this, like, math line, with numbers. I'm up to fifteens, so you have to hurry up and get it. […] a kid in our class, she goes "1, 2, 3, 4, 5" and then swipes, but I think it's easier to just tap and then lift because then you have more time instead of just going.

Researcher: I see. So when you're figuring out the answer, do you just know it in your head, or do you have to solve it very quickly?

Aiden: You have to solve it really quick. I sometimes have to use my fingers and I make it in time barely […] you have to work, because on the iPad you really gotta work fast.

The speed requirement for success in Addimal Adventure not only encouraged students to discuss strategies for the app, but to search for ways around the difficulty as well. In fact, in a later interview, Aiden confessed that he sometimes resorted to using a "cheat sheet" in the Speed round:

Aiden: I keep a lot of problems in my head, and then if I want to finish a story on something I have to put it in my head or put it on the paper. Or sometimes I just put it on a sheet of paper, the answers on Addimals, because you have to work fast.

Researcher: So that way, you can have your paper and use it?

Aiden: And to actually put the same answers that you're just working on practicing. But it's kind of like cheating.

Researcher:	I see, because you've got it beside you when you're playing it.
Aiden:	I'll either just do one problem, I only do one because otherwise it's cheating, the whole game.
Researcher:	I see, that makes sense.
Aiden:	Then you don't want to cheat, because you don't really get your math done.

Clearly, he was somewhat conflicted, since he considered this method as not really doing his math. However, it is an understandable reaction for a student who is confident in his ability to solve the mathematics problems in the app, but is simply not able to do it within the required time limit.

Of course, this was not the only approach observed. The speed difficulty of Addimal Adventure actually encouraged some students to stick with the app. One student in particular, Jessica, who was much less proficient at addition than Aiden, was observed simply tapping answers on the number line before the teacher came near and the student began to focus on the game. Later, in a one-on-one help session with the researcher, the student confessed to being frustrated with the difficulty of the app—she had been stuck on the first quadrant for some time and could simply not seem to get the last few blocks in time.

As Aiden mentions briefly above, missing an answer causes one to lose progress in the app ("it shows a red block and it falls and it will cover up that answer on your puzzle […] If you got green, you can only see the green"). For every step forward in the app, Jessica felt she was falling back two. For example, given sufficient time, she was consistently able to find that 7 + 8 is 15. Her preferred method appeared to be "counting on", and in the heat of the moment, she would often make a counting error, resulting in an answer of 14 or 13. She would immediately recognize her error and repeat the correct answer, but she had already lost a block nonetheless.

However, despite this tendency, after enough attempts Jessica finally started to see the result without counting on each time. She eventually found that she simply "knew" the answer to certain addition facts. She often expressed surprise at this memorization; as she said on one such successful answer, "I don't know where that came from." After enough time, her practice and dedication paid off. The student was ecstatic when she completed quadrant one and unlocked the next two. Rather than rest on her laurels, she immediately ploughed into them, and while she wasn't immediately successful, she was visibly proud of her accomplishment and for every new block gained.

While Jessica might have simply been experiencing the memorization of addition facts, the researcher doubts the student would have stuck with a worksheet or flash card on her own as long as she did with the app. Her engagement with the game gave her the drive to keep working on the problems, rather than submit to frustration and drift off task. The researcher had never witnessed this student have such a positive reaction to any other problem in mathematics. Admittedly, this is but a single anecdotal description, but if students are to be resilient in mathematics, they need these sorts of positive experiences to provide the incentive to struggle through difficulties (Aiken, 1976; Habgood & Ainsworth, 2011; Kim & Chang, 2010).

This level of engagement with the iPad was not uncommon, as the teachers reported in their interviews. The Intensive & Strategic teacher mentioned this as being particularly important for her students:

Teacher: [Our apps] are typically all the lite version, because they're free. But I think it gives the kids great practice, I think they're totally engaged, and that's huge and I think it's awesome, I can't imagine not having them.

[…]

Teacher: I think the kids are so engaged and they can work at their own pace. I think, yeah, it's great. I can't imagine not having them now. […] they're so savvy with them, too. […] Use a touch screen, figure out how games work, find out if there's little twists or turns or challenges that they need to meet in order to like build their nest, they totally figure it out.

The Benchmark teacher found that it helped her students spend more time on task as well, and that apps gave her the opportunity to expose students to concepts they'd learned in task, but in a slightly different form. This allowed students to gain more flexibility with mathematical concepts:

Teacher: If I had to take them away, I'd be really sad, because I do think it adds an element of, it just sparks their interest so they stay a little more focused and you can adapt it and, like you've seen, you can reapply what you already know, but in a different fashion so you're….I guess the time on task is much more focused, I think.

Of course, there are other ways to foster student engagement with mathematics than using iPads. One interesting possibility is the interactive whiteboard, but not for the possibilities it gives the educator. The Intensive & Strategic teacher observed that her students were more engaged by the interactive whiteboard, partially due to its similarity to a screen:

Teacher: [We use the] Interwrite board all the time, yeah. I like that, I think it's captivating. […] I think it's bigger, I think it's almost like a movie screen for them. And I don't know if the light plays into that as well and I think […] it does seem to be much more captivating and attention grabbing. Maybe it's this generation, they're screened.

While further research would be required to determine how much the "screen" factor plays into student engagement with whiteboards, the comment should give researchers pause. When adults assume they know why students engage with certain technological devices, they run the risk of imposing their perceptions on children. Researchers must take to care to discuss technological interactions with students lest development resources are devoted to aspects of devices with which students are not concerned.

For example, despite the student engagement with the iPad observed by teachers and the researcher, when questioned in the interviews, two of the Benchmark students (Ethan and Sophia) and one of the Intensive & Strategic students (Aiden) expressed a preference for doing math with a pencil and paper. As Ethan put it when asked which he preferred,

Ethan: Yeah, pencil and paper, I use pretty much anything that I can use for math, I would use. Like if I was in the street now and I was bored, I would pull out my homework and do it. […] I like doing it with pencil and paper.

Researcher: I see. Ok. And why do you like that better?

Ethan: Um, it's because I really just, I want to work on my writing, so that's pretty much the reason, and that was the first way I learned.

This is perhaps a convincing reason to have students continue working on paper, especially those who have trouble with writing. In fact, writing was also a factor for other students who preferred the iPad:

Researcher: Do you think it's more fun doing [math] on the iPad?

Isabella: Yeah, and also you don't have to write the numbers.

Researcher: Oh, so you don't…

Isabella: It's already written and you just have to pick which one fits with the equation.

[…]

Isabella: Because, sometimes when I write with the pencil, it gives me blisters.

Researcher: I see. So you get blisters when you write with the pencil too much, but the iPad screen, you can just…

Isabella: Touch on it.

Jackson: Because you don't have to use your strength, you have to just touch it.

While Isabella and Jackson chose the iPad in an effort to avoid writing, Emma preferred a whiteboard and marker specifically because the iPad and pencil limited her ability to write:

Emma: I like using…well the iPads are a little hard to write with, it's just, I had an iPad thing [stylus] so I could just write it. Because it's hard to draw on the iPad. Because it might mess up…

[…]

Emma: Yeah. It's kind of hard with the pencil, so it's kind of hard to draw circles. Because when you use a marker, you can just put a dot, dot, dot. Yeah, you don't have to like, circle, circle, circle, but on our pencils, we have to. Because you don't have to have a pencil and write on it. So you don't have to do that and you can just tap on it.

However, Aiden's reason as to why he preferred doing math with a pencil and paper had more to do with the way in which the iPad affected and limited his ability to do mathematics:

Aiden:	Because, when you're on the iPad, it just like says… you can't read it by your own self. And it doesn't have, because you can't use your fingers, and it says problems that you don't even know.
Researcher:	Ok, so I think I see what you mean. Let me see if I understand you there. So you like it on pencil and paper more because…
Aiden:	You can actually read, use your fingers, where the iPad on Addimals, you can't really use your fingers.

Given his earlier concerns over the speed of Addimal Adventure, it is not surprising that Aiden preferred the freedom to solve problems at his own pace without being pressured by a timer in an app.

Student preference for doing mathematics with a pencil and paper, a whiteboard, or an iPad has much to do with their conceptions of the nature of mathematics and what forms it takes in each medium. For example, when asked how they did mathematics on the iPad, over half of the students interviewed referred to games first:

Researcher:	Do you like using your iPad for math?
Isabella:	Yeah.
Researcher:	Do you ever use it for math at home?
Isabella:	I don't have any math games on it.
Researcher:	Ok, I see. So is that how you use your iPad for math, math games?
Isabella:	[nods yes]

Aiden: Yeah, this one app is called Splash Math Chapter 1 that we can do yet and Chapter 2, and it helps you with math, it helps you with reading, and it has a lot of stuff.

Researcher: Wow, that's cool. I didn't realize it helped you with reading also.

Aiden: Yeah, because it has problems that you need to read.

Noah: We usually just use like math games or books…

Some, however, thought of Educreations interactive whiteboard first. In the first round of interviews, Emma was the only student to immediately think of mathematics on the iPad as being Educreations:

Emma: Yeah, we use iPads. Sometimes we go to Educreations. So if we were doing a problem, we would just go there and then you pick your color to write with and some people go on the board and write.

In the second round of interviews, this was the case for Isabella, but Emma's mind now went to games first:

Isabella: Uh, we use Educreations to do math problems and it's fun to me to also go on math apps. […] I think the fun part is that you get to use your iPad and you get to color with it.

Emma: Yeah. I've learned some new apps, like my friend showed me and, it's about this game that you, you're supposed to count.

Of course, this doesn't reveal exactly how the students conceptualize mathematics, but it does provide an idea of what sort of activity on the iPad they associate with doing math.

One should also be careful when discussing a second grader's conception of mathematics as a whole. At this developmental stage, they are still discovering the nature of the subject and are operating at a relatively concrete level. For example, when asked if she felt she was good at math, Emma replied "Yeah, I feel like I'm really good at math. […] I'm really good at making one hundred boxes and ten sticks and circles." This concrete conception of the subject was also reflected in student responses when they were asked to imagine solving a hard math problem. Several examples presented themselves in interviews:

> Ethan: I remember them in my mind, after I figure them out. […] I usually use other ones I have in my mind, like easy ones? And I put those together and use those to get up to that other number and then I can actually use those to…like if I already know 8+8, 9+9, I know my doubles really well. So if I just, if I see a double anywhere in a problem, I do that after I do the other things. And when I get that, I just know it like, click, in my mind.
>
> […]
>
> Researcher: Is that pretty much what you normally do when you have a hard question, do you think?
>
> Ethan: Yeah. So how I like to do it is I like to memorize every single problem I do.
>
> Researcher: Oh, wow.
>
> Ethan: I try to, at least. And I keep them in my brain and then I can use them for other times.

> Sophia: 9 times 3. […] I'd draw it out.

> Researcher: Can you think of a hard question you had to answer in math lately?
>
> Isabella: Yeah, but it was like one thousand, three hundred and ninety nine, but I don't remember what the numbers were.
>
> Researcher: Of course, I don't blame you. That's a big number. So that was a hard question it sounds like. How do you normally solve a hard question?

Isabella: I add the ones, then the tens and if there's hundreds I add those.

[…]

Isabella: Uh, I draw it out. Like, if it was subtraction, I'd try and subtract it without messing up.

Emma: I like when we just do math problems, hard math problems I don't know. Like if we do a new math problem we've never done before, I would just get going and if I'm confused I just draw a one hundred box and do the thing.

[…]

Emma: Yeah, because when you become a little bit better at math you just forget the number, what one you were doing, before it was really hard for you, now it's not. […] Well, how I figure it out is like, I like doing proof drawings […]

Aiden: I use my pencil and like, if it's a one hundred, I make a one hundred, then like, one hundred fifty I make five lines, and then I can just see the answer. I can count up.

[…]

Aiden: Yeah, I use my fingers sometimes, proof drawings sometimes, but on the iPad you have to think it in your head.

Researcher: Think it in your head, ok. And when you're solving that and figuring it out…

Aiden: Sometimes on Wings I just hit pause, and then I can actually think.

Jackson: I just use my fingers or just go to our free choice and grab a couple blocks and put those together and do that.

[…]

Jackson: I ask the teacher if I can use some blocks.

Researcher: Oh, ok. So you use the blocks to answer a hard question? I see. Why does that make it easier, do you think?

Jackson: Um, it's pretty much blocks, that, if you have a whole bucket of blocks and you're doing your math, you can put them all on here and just count.

In all of these examples, the students do not seem to be thinking of mathematics as an abstract field, but as calculation—specifically, addition, subtraction or multiplication. Some even try to memorize every problem they've ever done. Difficulty has more to do with the size of the numbers than the question. Only Jackson referred to the use of manipulatives, but several students described using their fingers to calculate. None of the students referred to the difficulty of reading and interpreting word problems or spoke of problem solving in the abstract.

While this should not be surprising given their age and exposure to mathematics, one should be mindful of this tendency when discussing mathematics with and designing mathematical apps for elementary students. Apps should take care to adapt mathematical language and presentation of material to the appropriate age level. While students may be able to figure out and play a game without fully understanding the rules or material, this is not a productive use of time. Teachers must also keep in mind that student progress in a game may not always equate to understanding of the mathematics. This should constantly be evaluated by other forms of formative assessment, and conversations should be encouraged between students and teachers about the mathematics. After all, while incorporating iPads in the classroom provides a new source of instruction for students, teachers shouldn't rely entirely on the devices to assess student understanding—especially to the detriment of the qualitative assessment that can be gathered by having students explain their thinking.

Student Attitudes toward Mathematics

As students discussed how and why they work hard in mathematics, it was interesting to observe how much their parent's attitude toward the subject appeared to influence their own (Disney et al., 2013; Eccles & Jacobs, 1986; Giacquinta et al. 1993). Sometimes this took the form of behaviors in mathematics:

Emma: Also, sometimes I go on PBS Kids and I go on math problems […] and when I get one wrong I have to do it again. […] I do that on my mom's computer. Sometimes I have to do that so I get math stuck in my head.

Aiden: Because you get to learn a lot about, what's that and what's that. […] And you know, then when somebody asks you, "I forgot, can you help me with this answer", you can show them a proof drawing, you can help them, you can say "24, I've had this problem in my class, so I can help a lot". But then when they say, and they could also say "hey dad, is this right" and you'll have to check it.

[…]

Aiden: I don't really care if I get it right, but our mom wants my brother and me to get A pluses a lot, so yeah.

In Aiden's case, this also took the form of not immediately reaching for the calculator when trying to solve a mathematics problem:

Researcher: Great. So you guys don't only do math on the iPad, right?

Aiden: No, so we can do it at home. I don't use my dad's phone because if you like, do a problem and then hit equal, it just shows the answer.

Researcher: Sure, it just has a calculator.

Aiden: Yeah, and if you use your dad's phone and then hit equal and it just shows, that would be not really doing your homework.

[…]

Aiden: Learn a lot and you don't have to actually go online and look up the answer.

Researcher: You don't have to look it up, you know how to do it yourself?

Aiden: Yeah, you just know how to do it.

Also of interest was how students were already developing attitudes toward intelligence and mathematics ability. These attitudes can affect student performance in mathematics at all ages, as students begin to take on high or low status in math (Crespo & Featherstone, 2012). When asked why they enjoyed mathematics, students often associated being good at math with being smart. Some examples from the interviews are:

Aiden: Because you learn a lot. And it gets you smarter.

Jackson: You get to think a lot and use equations and stuff, like in your mind, and it helps you get smarter and when you get to college, you can go to college.

Ethan: Uh, I was born with a math minded brain, because my Papa was a teacher and really good at math, and my grandma was a teacher, she was really good at math.

Clearly, attitudes regarding innate mathematics ability and intelligence are already beginning to form at this age, even if we are perhaps simply hearing the voices of parents reflected in the student responses. However, given the timed nature of many iPad apps, it is not uncommon for students to begin to associate speed with success in mathematics and intelligence. Educators and app designers must take care to not encourage such attitudes to the future detriment of students who are not as fast in solving mathematics problems. This could be accomplished by designing games and activities that focus more on creative problem solving and cooperative progress throughout a subject area than on speed and competition.

Student Technological Confidence

Generally, students did not seem to express enthusiasm for the iPad—they simply spoke of it as part of class. However, they did express frustrations with the device and apps at times. For example, in reference to Educreations interactive whiteboard, students were often annoyed that their saved drawings and work would periodically be deleted:

> Ethan: Oh yeah, used to like it, but then they took away all my pictures that I made.
>
> Isabella: Ugh, if you don't go on it every day then it erases it.

Surprisingly, only Sophia made mention of a Splash Math 2nd Grade error where the app will often display overlapping text in the answer section (discussed in more detail later in this chapter, see Figures 39, 40):

> Sophia: Well, sometimes. One time my iPad glitched a little bit.
>
> Researcher: What did you have to do to fix it?
>
> Sophia: I had to turn it off.
>
> Researcher: Ok.
>
> Sophia: Except it still doesn't work, so I can't go on that anymore.

Even in her discussion of this issue, Sophia expressed confidence in how to deal with it, despite the problem not being entirely fixed.

Generally, students were observed to be quite savvy in figuring out the devices and learning how to deal with common issues. When apps would crash, they were frequently observed opening the active apps menu and closing multiple apps that were running to reset them. Student interview responses also revealed confidence in figuring out apps and games, despite sometimes lacking the vocabulary to precisely describe them:

Ethan: Yeah. I'm good at using practically any electronics.

Aiden: I know games, everywhere, then if somebody needs help I can just show them, or if they can't find it, I just swipe two fingers down it, and then it's just like that.

Researcher: Ok, so you can swipe down two fingers and find the app?

Aiden: Yeah, it just shows a search, so you just type in one letter and it will show some games, so you have to keep searching until you find.

Ethan: […] I can pretty much if you give me a game, I can figure it out how to do the rules.

Emma: And if it says to the two hundred, you're supposed to do that and it goes to the two hundreds? [gestures a pinch]

Researcher: So you pull your fingers together?

Emma: Yeah. So I have to go really fast.

Teacher Attitudes toward Mathematics and Technology

These students' attitudes toward mathematics were also affected by the attitudes of their teachers toward the subject (Larkin & Jorgensen, 2014). The interviews revealed a stark difference between the teachers in this study in regard to mathematics confidence. While the Intensive & Strategic teacher was confident and successful in mathematics as a student, the Benchmark teacher primarily recalled struggling with the subject. She reported a lack of confidence and success in mathematics as a student, but described a growing appreciation of the subject as she taught it more:

Teacher: Math was not my forte. And I did not feel strong in it. I felt much better with language arts and things like that. But as a teacher, math is actually my favorite thing to teach, right now.

Researcher: Really? Why?

Teacher: Yeah, out of everything. I don't know, I guess I really enjoy the talk of math, I like to see the ah-ha's, I like to see success and I think with this program and with the way I teach now, I think there's a lot of success and I just really thrive on it.

[…]

Teacher: Kind of unpleasant. Yeah. Because when I was taught, I basically was just told what to do to get through the problem, but didn't try to apply it to something that would link me in personally or to make it relatable to our own world. Really, not good.

Researcher: So it became more interesting then as you started to try to teach it to students?

Teacher: Yes. I loved it. All of a sudden my eyes were just opening. And even in college, I didn't like the way they taught us our math for elementary at all.

Researcher: Was it very rote?

Teacher: Yes. Again, it was just algorithms.

[…]

Teacher: I feel a lot more confident now that I'm more mature and have taught math many years. And I have the foundational, honestly, the skills, because I think we were just rushed through math so quickly. And taught how to do the math without the knowledge of the basics of it. You know, kind of like the algorithms, specifically. So, I think the kids who were lower, like me, I didn't think I was a great math student at all, were just kind of pushed through and rushed through and not given the necessary time to build that benchmark base….

[…]

Teacher: Barely holding on, but not given the extra time or made to feel like "you're fine, you've got it" just provide some more practice, you know, modelling—no, never.

The Intensive & Strategic teacher, on the other hand, enjoyed learning mathematics as a student and teaching it:

Teacher: And I love math, math has always my favorite. It was my favorite subject as a kid.

However, the Benchmark teacher actually felt her negative experiences in mathematics as a student helped her to better identify with her students and their difficulties:

Teacher: I think even at the beginning of my teaching career I felt fine because I was teaching the lower levels, but I think I'm much more methodical and I think I have much more background knowledge to share with them now that I totally understand. And I remember how I thought—actually sometimes I think it helps me that I was a struggling mathematician because now I can identify more with them.

Clearly, even poor experiences in mathematics as a student do not preclude a teacher from being effective at and enjoying teaching mathematics.

Another factor influencing student attitudes toward mathematics in this study may have been the curriculum and textbook the school was using, the Common Core aligned Houghton-Mifflin *Math Expressions*. Both teachers reported significant changes in the curriculum since the beginning of their teaching careers roughly two decades ago. Teachers felt the new methods and materials supported different types of student problem solving and encouraged the knowledge of multiple algorithms:

Teacher: Well, I think now, from the beginning there's just so many strategies offered and kind of a more open ended way to solve, whereas before we just kind of pigeon-holed and showed kids just the rote ways to do things, but now we're doing the explaining and the understanding and "show me how you understand" and I just think it's so much more successful.

Researcher: So as far as the algorithm of "stack it," or "put the 1 on top or the bottom," before did you pretty much go from basic addition facts to "here's how you add?"

Teacher: Yeah, maybe manipulatives. And then it went straight to "carry your ten." And that's it, instead of quick draws and all the other methods or even combining them together. And even just the things like kids don't know that they do, but making it apparent to them, like our anchor numbers of tens—all the tens. Our anchor of fives—fives are beautiful for kids to anchor to. Understanding doubles, doubles plus one, it just helps them to maneuver around those numbers much more quickly.

Teacher: Yeah. Well, the vocabulary is different than when I first started teaching 2nd grade. And actually, the whole, quick draws, showing your work, all of those things, there's a much higher expectation for that, making sure that kids really understand what they're doing. We've really gotten away from just learning the algorithm and really moved more toward "show me that you know." Really, there's a huge expectation for kids to be able to explain their thinking, and I think that's great.

[…]

Teacher: And I think with the new curriculum, I think it's easier to teach than the old way where we just, kids were kind of taught there was one way to do things, I think with Math Expressions and you teach the kids a number of strategies and then they choose the one that works best for them, I really like that. I do wonder a little bit about Math Expressions and how developmentally appropriate some of it is. I think the pacing might be a bit much for some 7 and 8 year olds, and that worries me a bit.

[…]

Teacher: I notice a difference with the Common Core aligned Math Expressions that it's amped up a lot, and what's really got me thinking about that is, because I work with the strategic and intensive math students and I know what the third grade curriculum looks like, and it worries me for them because they just need more repetition and a little slower pace. And so many of them have really gained confidence as mathematicians, and I worry that that's going to change. I know, gosh, years ago I taught 4th grade, and some of the stuff we teach in 4th grade is now taught in 2nd. And I really do wonder about the development aspect of all of that.

It is worth noting that both teachers expressed positive opinions of Addimal Adventure specifically based on its use of multiple models for addition, many of which were represented in the textbook as well.

There were concerns over the new curriculum as well. Foremost among these was a worry over possibly increasing gaps between higher and lower performing students as a result of the increased difficulty of the curriculum. This was the reasoning behind their decision to implement a Walk to Math program this school year. As the Intensive & Strategic teacher mentioned in both her interviews:

Teacher: This year was a little more challenging with having so many intensive and strategic kids in our math class. I think it's amazing that we can have a smaller strategic intensive group, but the kids learn at such a slower rate. So that's kind of a challenge.

Teacher: But it is really interesting, from 4th grade in the early 90s, to 2nd grade in 2014, many second graders are learning what we used to teach in 4th grade. […] I'm sure there were a lot of second graders that were probably bored in math because the pace was pretty slow and they were probably ready for more. But I think the kids that were struggling didn't fall as far behind, because the pace was slower.

[…]

Teacher: So it's amazing how much quicker acquisition is expected and most kids are up for it, so it's super cool. But I think that we're seeing the gap get wider as the curriculum gets more rigorous. I think that the kids that have the basic skills are zooming and that the kids that don't have the basic skills are struggling because of the pace. […] It's a challenge, and really, mastery is the goal for everybody in math.

[…]

Teacher: […] particularly with the learners at the intensive and strategic level, they really need more one-on-one or small group, and most of them are non-readers. So that is really a disability for them, so it's just awesome and powerful. And I think that hour flies for them because they're so engaged. And I think that […] making the decision to do Walk to Math, [the Benchmark teacher's] willingness to take on a bigger group and all that has really been amazing for the kids because if most of these kids were in a regular math class, I think they'd be really, really struggling.

Certainly this teacher recognized the different needs of individual students in her class and was attempting to meet them all. The decision to implement a Walk to Math program was the best way the teachers saw to get students with intensive and strategic needs into a smaller classroom where they could receive effective and productive mathematics instruction. As in the example of Jessica, this led to more successful and positive experiences with mathematics than they might have otherwise experienced.

However, the teachers were not blind to the possible downsides of this sort of ability grouping. There were concerns over missing role models of higher achieving students, as well as how the students in the Intensive & Strategic group would fare when they entered an integrated mathematics classroom the next year.

> Teacher: I really am torn about it too and I think one of the things the intensive and strategic kids miss is that modeling by benchmark and benchmark plus kids. I really feel it's tough and I know a lot of schools are moving towards clustering, which really is tracking. And philosophically, I'm really torn.
>
> […]
>
> Teacher: Anyway, I think that, I think with Common Core probably what we've seen too is that the gap has become wider. Those students that are proficient and strong in math, they're just flying, they're sailing, doing awesome. And the kids who need more repetition, and who have some holes, they are, it's much more difficult for them to keep up the pace.
>
> […]
>
> Teacher: This year, we're particularly having a group that is strategic and intensive learners. I've really had to take a look at how I teach and maybe scaling back the number of strategies that I'm teaching to kids, so they're not overwhelmed. And then constantly staying current with assessment on what they know and filling that in. And then this group has been particularly challenging because we've had so many kids move in and out. And so many of the new kids haven't had Math Expressions or are significantly behind in math too, and so just trying to figure out where their holes are and catching them up as best we can has been, you know, a challenge and takes assessing and just finding out how you're going to reach those kids.

The last quote brings up another issue complicating matters this year, which was the high number of students transferring in and out of the school due to families moving. Changing schools is a difficult transition for any student, but may be especially difficult for a struggling one (Kerbow, 1996; Rumberger, 2003). In this situation, the differences in the instructional environment may have been compounded by the presence of a one-to-one iPad initiative. The transition between classrooms with and without such devices might significantly affect a student's mathematical attitudes, especially if their primary mode of success in the subject was on the iPad.

One possible method of bridging the widening gap between higher and lower achieving students would be the differentiation of instruction using more specific and focused apps. The Benchmark teacher envisioned this as a possible means to provide custom, individualized mathematics education to her students.

> Teacher: But that's what's good about the iPads, if we could have a little bit more funding and a little bit easier downloading of these apps, it really could be very individualistic. Super individualized.
>
> Researcher: So you're imagining a different payload for each student.
>
> Teacher: Exactly. So, the kids that are with you, over in [the Intensive & Strategic] class, they'd be working on Splash Math 1st grade. And then we'd move them into 2nd grade when they're ready. These guys, 2nd grade, we'll move them into 3rd grade.

The Intensive & Strategic teacher saw a similar advantage in differentiation, but focused on the assessment possibilities it might bring.

> Teacher: I think it's super cool how engaged the kids are when they are on an iPad, and I think it's differentiation, right there. Some apps are better than others. And because our budget is really low, primarily we're using all free apps. So, the assessment tool is not as good as it would be if you were buying the paid version.
>
> […]

Teacher: I really don’t use those as an assessment tool. […] I think that one of the things I do have as a goal is to use some of the iPad apps more as an assessment tool. You know, just not there yet.

The possibility of using iPads as assessment tools was appealing to teachers, but had not yet been implemented. Partly this was due to the need for full versions of apps, which were limited by the budget. However, the lack of technological support and training in this area was also a factor.

Of course, as both teachers mention, such differentiation in instruction requires technical support and funding to make it successful. This school deployed apps to the students’ iPads only once per year. Over the summer, iPads were repaired, replaced, wiped, and configured. Using a Mac Mini and the Apple Configurator software, all of the apps for all subjects for each grade were installed on the iPads. As the students did not have administrator access, these could not be updated without reconnecting them to the administrative computer. However, this was a time consuming and technical task. While most of the technical hurdles they originally experienced—too little storage space for the iPad images on a Macbook Air, confusing instructions and workarounds from technical support—had been solved over time, the inconvenience still resulted in iPads only being updated once per year. In order for individualized instruction to become a reality on the iPad, the devices would need to be updated more frequently to address software errors and change app “payloads” for each student based on their progress.

Even without being able implement such differentiated iPad use, both teachers reported that having iPads in the classroom significantly changed the way they taught mathematics. In response to questions about whether the devices had affected her teaching, the Benchmark teacher mentioned they forced her to be more "progressive" in her teaching and expressed her initial concern with the program:

> Teacher: Yes, I really do like it. It's more progressive, it makes me feel like I need to be more progressive in terms of how I teach. So I try to be cognizant of how could I make this more adaptable or more current to what kids want to see, or how they learn, or whatever. So yes, it does add a little spark. I liked it.
>
> Researcher: Ok. And you think the kids like them?
>
> Teacher: Yeah, they love them. […] They do. Although, Ethan, he prefers to do paper/pencil stuff.
>
> […]
>
> Teacher: Well, from the beginning at first, I was really nervous using them, because I always thought there's going to be a malfunction, and it's going to have downtime, the kids are going to go crazy, what do you do? And I just didn't want to go there at first. But then as soon as you move through those and, you know, you have good classroom discipline, and you become more competent, then I really have them incorporated every day, in terms of thinking what I'm going to do with them, how is that going to impact what we'll do, how much time am I going to allow. So it does, it really…I don't know, it makes me think about how I'm going to integrate them, and if it's acceptable for that day, or not, or whatever.

The Intensive & Strategic teacher didn't comment on any worries or concerns she had over the technology when the devices were first implemented. Rather, she focused on how the devices improved the student transition to Walk to Math class and provided ways to keep students independently on task:

> Teacher: I think it makes it more fun actually. I think it's, I think to have that go-to piece, you know just for example, I often use it first thing on some days, as the kids are streaming in, and then they're all getting here at different times, I give them five or ten minutes to warm up. And I think it encourages kids to hustle over and get to math, get seated, get rocking and rolling. And then I also think, for

early finishers, it's great because they have something super engaging math-wise to do, that they enjoy. So yeah, I think it's great. I think it makes management really good, easier.

However, despite the positive effects on instruction reflected in the teacher interviews, the integration of iPads into lessons was not always straightforward. Teachers reported more work at the beginning of the iPad program. Integrating the devices into the classroom was a labor intensive and challenging task. The Benchmark teacher again focused on the initial technical difficulties,

Teacher: At first it was, because I didn't want them to be on things that weren't appropriate and a waste of time. But now that we have most of the programs that we like downloaded, and they are working, for the most part. Like you saw with Splash Math, with the double screen (Figures 39, 40).

Researcher: Sure, having that graphic problem.

Teacher: There's always that stuff that just bugs you. So yeah, prep time has been more, but in the last year, it hasn't been. […] Yes, the frontloading paid off. I think there's definitely a learning curve, and also finding out which programs serve you the best. Or the apps, I guess I want to say.

The Intensive & Strategic teacher seemed to feel that, while it was hard work getting the devices initially rolled out and set up, implementation had gotten easier with time:

Teacher: It's become easier as we've become more familiar with the apps, yeah.

In fact, both teachers reported that they had to spend more time on reading lessons than mathematics lessons, due to the many levels at which students were reading. While this study didn't explore the use of iPads in reading, teachers had several apps they used for the subject. The increased workload of differentiated instruction makes it difficult to implement effectively in multiple subjects. Perhaps, iPads may present a means for doing this more efficiently, especially as the teachers overcome the technical hurdles involved in customizing the devices for each student.

Despite three years of experience, there were still technical issues reported with apps and devices, although teachers reported they had become less frequent. Both teachers reported very high confidence in using the technology in their classrooms—iPads, document cameras, interactive whiteboards, projectors, and computers. However, the Benchmark teacher was less confident using technology at home, while the Intensive & Strategic teacher was not confident at all. She explained this dichotomy as being the result of the practice she received in the classroom by using the technology every day. This lack of confidence with technology was possibly related to the concerns the Benchmark teacher had about how the iPads would be used when they were first being integrated in the classrooms:

Teacher: […] it was daunting and I just didn't know how we were going to manage all of them. And I was just worried, as a mini-computer, how were those going to be handled by students. But all my worries were really put to rest rather fast. Except for as you see, at the beginning of the year, when we're downloading all the apps back onto the iPads and trying to manage those, it's tough.

Researcher: So, the management end of them is hard, but as far as the way that the students are using it…

Teacher: Lovely.

Researcher: What were some of the fears that you had? Were you afraid they were going to break them?

Teacher: Break them for one thing. Be in areas, like having access to internet, where they shouldn't. But that hasn't been really a

> problem. We've had a couple of kids that have perused around, but they're savvy because they do it at home. […] But our district's pretty good now with all the blocking, so I feel a little bit better.

This last issue of access to the open internet is a difficult problem to solve as well. As long as the students have access to the web browser on the iPad, they can navigate to any website. However, blocking the app can not only cause connectivity issues with other apps, but might prevent teachers from making use of helpful websites and other web-based apps. The school district for this school made use of modern web domain filtering techniques to prevent student access to inappropriate or objectionable content online.

However, the web browser is not the only point of access to the internet from an iPad. Exposure to the wider internet was also a concern from advertisements that supported many of the free apps being used on the iPads. Previously these were discussed as a possible source of distraction, but since the advertisements are often hosted by third-parties and contain links to webpages, it is common for them to inadvertently serve inappropriate content (Tongaonkar et al., 2013). Without effective filtering, this provides another vector for web access from the device.

Given the complexity of iPads, it is unreasonable to expect teachers to maintain and be prepared for possible security loopholes such as these. Perhaps not surprisingly, teachers expressed the need for more technical support and training in the use of iPads in the classroom. In regards to technology training, they responded:

> Teacher: We need funding, we need more time, we need someone to help...
>
> Researcher: To roll those out to the iPads and to manage them.

Teacher: Yeah, to support us. I think they will be, in time, hugely supportive. And I do think that they are supportive, but I just want it to be a little bit more focused. Very focused.

[…]

Teacher: [Training was] horrible. I mean there were a few trainings, like on the whiteboards. We've had no official, when we first got our iPads, a little bit of setup training and how to do it, but that's it. And I think that because it was so new for us to have all and we were kind of…it's silly to say, but paving the way with those iPads, because they were figuring out at Apple too when everybody was trying to do all the iPads under one Apple book or whatever.

[…]

Teacher: So, I think just to address, first of all for the technology support, it's really not existent in our city.

Given that this school received iPads from a donation, rather than as part of a coordinated district-wide initiative, it was not surprising that a well-designed and funded technical support program did not accompany them. Clearly, teachers felt there was much more work to be done on this front. Indeed, the same concerns were expressed in the USDE's report on the problematic iPad program in the L.A. Unified district (Blume, 2015). Some progress had been made—for example, bandwidth for the school had improved and wireless connection issues had become less common. However, the problem still existed, and caused frustrations for students and teachers:

Teacher: Yes, our Wi-Fi is better than last year, which is better from the previous year. But it'll drop right in the middle too and it's frustrating for the kids.

Interview Ratings

While students in the Intensive & Strategic group often had higher ratings than Benchmark students in the interviews, it is difficult to draw any firm comparisons between the two groups. Not only is the sample size too small for statistical inference, but the students were not randomly sampled. Since they were chosen based on their propensity and ability to speak about their thinking in mathematics, it is likely this influenced the types of students interviewed. Also, the interviews were conducted in an open-ended fashion to allow for more comments from the students, rather than in the format of filling out a questionnaire. In addition, verification coding performed by a second coder revealed enough variation in ratings for concern. In a larger study with enough interviews to provide a training set, coding training would need to be performed in order to make interview ratings more reliable and consistent.

However, even given all of these caveats, it was pleasantly surprising that student attitudes toward mathematics in the Intensive & Strategic group were quite positive. These students were just as confident in mathematics as the Benchmark students seemed to be. Teacher interview ratings were quite similar to each other and between interviews. The most noticeable difference was that the Benchmark teacher scored lower in technological and mathematical confidence. This is evident in the interview responses as well.

App Progress and Quiz Score Analysis – Splash Math 2nd Grade

Despite the frequent availability of the Splash Math 2nd Grade app, student progress in the eight sections covered on the quiz had a mean of 41% in the Benchmark group and 18% in the Intensive & Strategic group (Tables 15, 18). Boxplots of the data reveal relatively symmetric distributions for both groups' app progress, and only two students overall who had more than 70% progress (Figure 26). Similarly, there were few outliers on the low end—only two students had not attempted or made any progress in the app. These situations could have been due to software errors on the iPads as well. The vast majority of students had worked in the app, but had not made much progress.

This could have been due to a number of factors. A relatively recent update to the iPad had caused graphics issues in Splash Math 2nd Grade, resulting in overlapping text in the answer section (Figures 39, 40). This made it very difficult to read the possible

Figure 40. Splash Math 2nd Grade graphics overlay error in answers.

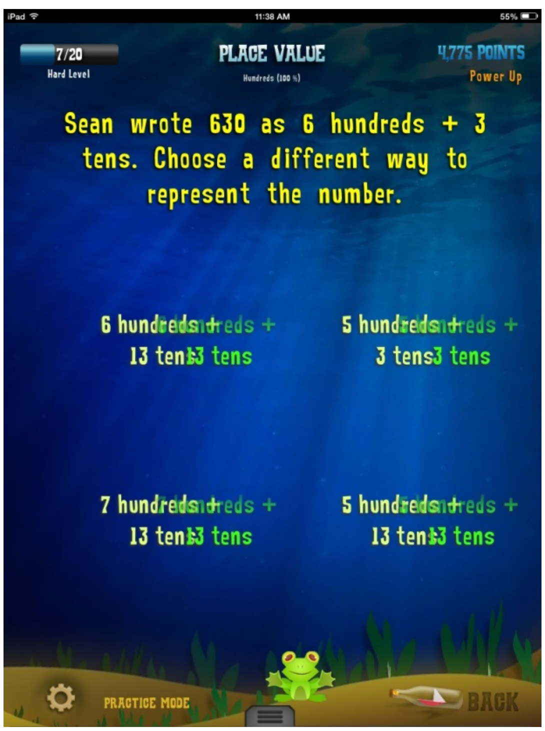
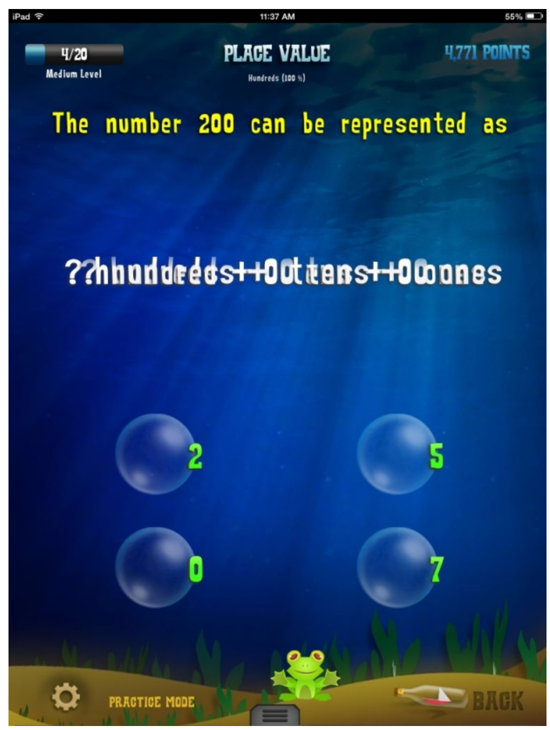


Figure 41. Splash Math 2nd Grade graphics overlay error in problem statement.



answers. Teachers even had to resort to having the students focus on a particular color when reading in order to be able to see the text in the overlap. Obviously, for students who were not strong readers, this was a very difficult task.

The lack of recorded progress was compounded by the fact that Splash Math allows for unlimited guesses on all problems. Since all problems are multiple choice, and there appears to be no penalty for guessing, students were often observed simply tapping answers until it was correct. It was unclear whether they were even actually reading the problem statement. While this sort of behavior was discouraged when it was noticed, it was nonetheless frequently observed, especially among students who were lower performing in mathematics. This also revealed a lack of engagement in the game. Students enjoyed playing with their aquariums, but the rewards therein depended on performance in the practice portion of the app. It may be the case that these rewards were too separated from the work of mathematics, and did not provide enough of an incentive for students to engage and work hard within the mathematical environment of the app.

While Splash Math 2nd Grade scores were positively correlated with quiz scores, the correlations were weak for both classes combined and analyzed separately (Figures 25, 28, 29). Linear models controlling for unit test scores in both groups also showed that app progress had no significant explanatory power in describing the variation in quiz scores. Students performed much better on the quiz, averaging 60% in the Intensive & Strategic group and 89% in the Benchmark group. This was interesting, considering that the quiz problems were taken directly from the Splash Math 2nd Grade app. The disparity in scores was perhaps due to a lack of engagement and effort in the app, while more serious attention was given when the problems were presented in a test or quiz format.

The teachers also presented the assessment item as a “challenge” from the researcher, so this may have encouraged students to really work hard and show off their knowledge as well. However, from these results, there was no evidence that app performance in Splash Math 2nd Grade explained the variation in individual student quiz scores.

An analysis of Splash Math 2nd Grade app and quiz performance in each subject area revealed a much stronger correlation, however. When data for both Walk to Math groups was combined, class averages on quiz questions had a strong positive relationship with class averages for the corresponding subject area in the Splash Math 2nd Grade app (Figure 30). It is interesting to note that students performed well on the measurement item, despite that the fact that the Splash Math 2nd Grade app contained an error in this section, and said the answer was 9 inches.

This strong relationship would seem to imply a connection between a class spending more time in the app and better performance on the quiz. However, this correlation was not as strong when the Benchmark and Intensive & Strategic groups were analyzed separately (Figures 31, 32). Of course, the sample size was decreased in both of these cases. Even if the strong correlation was not simply an artifact of the data, it doesn’t imply that increased Splash Math usage led to higher quiz scores. It is likely both of these variables are strongly correlated with the amount of instructional time spent on each subject in class. This would influence student performance, as well as the amount of time each student was instructed to work on each particular subject area in Splash Math 2nd Grade. It is also possible this analysis falls victim to the ecological fallacy—when inferences from group statistics do not extend to the individual (Schwartz, 1994).

Individual performance in subject areas would need to be measured and analyzed using more quiz items for each topic in order to rule out this possibility.

App Progress and Quiz Score Analysis – Addimal Adventure

Student progress in Addimal Adventure was better on average than Splash Math 2nd Grade progress for both groups. The Intensive & Strategic students had completed an average of 55% of the puzzle and had a mean quiz score of 61%. The Benchmark group had an app average of 70% and a mean quiz score of 92%. However, there was only a weak positive relationship between individual app scores and quiz scores in both Walk to Math groups (Pearson's r = 0.51 and 0.32, respectively). The linear models presented also support this conclusion, as Addimal Adventure progress was not significant in any of the full models controlling for the unit test scores.

There are several possible explanations for the disparity in scores. Firstly, the assessment instrument may be to blame—the addition facts chosen may have been too easy. Also related to the difficulty, students took the quizzes after they had been working in Addimal Adventure for a few weeks. In this time, they were also exposed to many other activities in class to bolster their addition skills. It is likely this additional practice clouded the separate influence of the app. Secondly, several students reported that they had been much further in Addimal Adventure, but that after some time of disuse, the app deleted their progress. While this app behavior was not observed by the researcher, it may be that several students had to start over in the app, which would have deflated app progress scores.

Summary

In this chapter, student and teacher attitudes toward mathematics and technology were discussed and excerpts from interviews to provide background were presented. Also discussed were several points of concern for teachers, regarding technology issues, app behavior, and limitations of their iPad implementation that prevented them from making the program more individualized. A short discussion of the results from Splash Math 2nd Grade and Addimal Adventure concluded there was no evidence performance in the apps significantly explained quiz scores. In the next and final chapter, conclusions are presented summarizing these points and possible directions for future research based on these findings are discussed.

Chapter 6: Conclusions

From the preceding analysis and discussion, the research questions presented in Chapter 1 can begin to be answered. A discussion of the limitations of the study, directions for further research, and considerations for schools seeking to implement similar technology in the classroom will be presented as well.

Research Questions

- How does iPad or other technology usage affect student and teacher attitudes toward mathematics?

It was previously hypothesized that students would have positive views of mathematics apps on the iPad, but express worry about mathematics in general. This was not upheld by the results. On the contrary, none of the students interviewed expressed worry about mathematics. Also, their views toward the iPad were not entirely positive. While students generally reported they enjoyed doing mathematics on the iPad, half of those interviewed preferred doing the work with a paper and pencil. One factor was the difficulty level in the mathematics games discussed. Some students found the games required too quick a solution; others thought the games were too easy.

Another factor was that writing on the iPad could be more difficult than on paper. Half of students interviewed found this to be annoying and preferred the creativity of pencil and paper or a whiteboard. However, the other half of the students preferred doing mathematics on the iPad.   These students preferred the iPad specifically because they didn’t have to write with a pencil. Reasons given for this preference were very concrete, such as avoiding getting blisters on fingers from writing with pencils and using only one’s fingers requiring less effort.

It was not clear that student attitudes toward mathematics were less procedural or algorithmic than might otherwise be expected. In fact, student descriptions of mathematics were generally limited to concrete examples of addition, subtraction and occasionally multiplication. Students thought of “doing math” as solving these problems. However, they were all quite process focused. A solution was always accompanied by a method, and students were familiar with a number of strategies for solving these problems. This approach cannot be attributed to the iPad apps however. These multiple strategies were encouraged by the textbook the school was using and by the teachers. They were, however, supplemented by at least one of the mathematics apps, Addimal Adventure, which explicitly incorporated multiple strategies for solving addition problems.

Teachers expressed positive views of teaching mathematics with technology and enjoyed teaching mathematics in general. However, while one teacher enjoyed mathematics as a student and always had success in the subject, the other struggled throughout her student career in mathematics and had mostly negative experiences with the subject until she began to appreciate it through teaching. Both teachers believed iPads helped students stay engaged in mathematics longer and resulted in more time spent on task. Teachers felt the devices allowed them to more effectively differentiate their instruction based on student needs and believed this helped them get more students to benchmark level in mathematics.

- How does student performance in an app environment translate to mathematics performance in more traditional forms of assessment?

The prediction that students would perform worse on paper based assessments than inside mathematics apps was also not supported by the results. In fact, students performed better on quizzes for both Addimal Adventure and Splash Math 2nd Grade than they had in either app environment. While the scores were positively correlated with varying degrees of strength, no evidence was found that app progress significantly explained student quiz scores.

- How much time is spent using iPads in the classroom and for what instructional purposes are they used?

This study found that iPads were being used in two different modes of instruction: free choice and focused. In free choice lessons, students were given a number of mathematics apps from which to choose and allowed to work independently. In focused lessons, students were typically working as a class or in small groups on the same app. The free choice lessons took the form of playing games, while the focused lessons often involved the use of an interactive whiteboard app. In this mode, the iPad was used more as a digital tablet, rather than an interactive gaming device. It is worth noting that iPads were not used at all for a quarter of the lessons observed, and use typically didn't last more than 5-10 minutes in free choice mode, while it might last the entire lesson in focused mode.

This study also found differences in usage between different levels of Walk to Math. Benchmark students were more often using the iPad in focused lessons, while Intensive & Strategic students more often used the iPad for free choice lessons. This trend needs to be carefully monitored in future research to ensure such usage differences do not exacerbate issues of equity between the two groups.

- What issues are involved in implementation of the technology?

The issues that emerged in the interviews were typically of two types: technical and pedagogical. Technical issues included errors and delays around device operating system and app updates, software bugs in apps, device management and administration, and internet connectivity. Pedagogical issues involved classroom discipline around the devices, budgetary restrictions, and the need for training on apps, how to use the devices effectively in lessons, and how to administrate them. All of these issues provide direction for researchers to provide support to teachers. Researchers should focus on learning best practices from teachers in the field and disseminating these to others by means of support materials and program design assistance.

Teachers also expressed the need for more specific, pinpointed apps for students on a variety of subjects. Mathematics education researchers should also focus on helping to develop such free apps for teachers. This can be accomplished by working with app developers to limit the scope of apps, while providing them with effective strategies and models known from the research. In addition, researchers should encourage open and anonymous availability of student data from apps so that apps can be improved based on usage and performance. Data mining of results would provide more information on how students interact with the apps and could lead to more effective and strategic app updates incorporating changes to pedagogy.

Limitations of the Study

As this study employed an observational design, rather than experimental, definitive and statistically defensible conclusions in regards to the effects of app use on student mathematical understanding cannot be formed. The small sample size of this study also precludes reasonable extrapolation to the larger student population. These limitations suggest an experimental design for a future study that might answer such questions.

In order to isolate the effect of app use on student understanding, a controlled experiment could be conducted in which similar classes with one-to-one device programs were examined, some of which were exposed to the app. It would be especially interesting to study Addimal Adventure in this manner, due to the additional information available using a properly configured teacher account through Teachley. These accounts are how the company monetizes the app and is able to provide it for free. However, to properly record all student activity, the accounts must be configured before iPad deployment. In this study, the use of Teachley analytics was not possible, since this was the first year teachers had tried the app in their classroom and students were not playing under logged-in accounts. If accounts are activated for students prior to deployment, the teacher account will not only have access to student progress in the app, but to more detailed information on preferred student strategies and recommendations for intervention as well.

The small number of students interviewed also limited inferences regarding student attitudes toward mathematics and technology. This sample was intentionally limited due to the amount of time required for interviews and the fact that the researcher was working alone. While surveys would have reached a larger number of students, it was determined the deeper insights gained from interviews would be more valuable. Also, the researcher was suspicious of the validity and consistency of survey responses from second graders.

Yet another factor was the familiarity of the researcher with the students and teachers interviewed. This was intended to encourage students to express themselves, but it introduces the possibility of observer bias. However, armed with the lessons learned from the interviews, survey instruments could be designed specifically for this age group that would be more reliable. This would allow for the collection of attitude data from more students—not just those who were selected due to their willingness and ability to discuss mathematics. The larger sample would allow stronger conclusions regarding these attitudes.

An unexpected complication in this research was the number of students who moved or changed schools over the course of the study. Unfortunately, one of the students interviewed, Jackson, moved before the second round of interviews and was replaced by a new student, Noah. In fact, Emma also unexpectedly moved away the week after her last interview. The incomplete records of transferring students also made data analysis difficult, a problem compounded by the small sample size of this study. A larger experimental study would be more resilient to transferring students and missing data, but this factor should be considered in any analysis.

Further Research

While several suggestions for further research are discussed above, many others present themselves. One avenue of research would be to compare student performance in classes equipped with iPads to those without any sort of one-to-one program. Such a study would need to control for possible SES differences between schools, as these could influence student attitudes and performance and would likely correlate with the presence of a one-to-one program. Ideally, this would involve a large enough sample of schools to provide statistically significant results. Using the observations and lessons learned from the reported study, such a large scale research project could be conducted more efficiently. This efficiency would be especially important, since the project would likely require several active field researchers. Pitfalls such as not accounting for the type of iPad use, app errors, or connectivity issues could be avoided.

Longitudinal studies of student attitudes toward mathematics and technology would be productive as well. As this generation doesn’t know a classroom without these devices, their perspectives will provide unique and interesting comparisons to past cohorts. Of course, their performance in mathematics will be interesting to monitor as well, as our educational system attempts to determine whether one-to-one device programs, such as this one, are worth the expense.

Following the progress and development of interviewed students through later grades would be informative also. This would allow comparisons to similar students who did not rise through schools using tablet technology in the classroom in the early years. In addition, at a smaller scale, it would be interesting to gather data regarding the behavior of students first using the iPad in the second grade. This study did not collect data in this period due to scheduling limitations and concerns of overloading teachers in the busy first weeks. However, in retrospect, it would be useful to know how students changed over time, especially in regards to students transferring to and from classes with and without such technology.

iPad Program Implementation Advice

This study illuminates several benefits of and issues with teaching mathematics using iPads. These are important discussion points for schools or districts considering implementing iPads or other tablets in the classroom. These devices can increase student engagement and time on task in mathematics, as well as provide motivation to students who respond well to goal-based games. They also allow for differentiated instruction using customized apps for students at various levels in different areas of mathematics. Properly managed, this can help a teacher make more efficient use of classroom time and give more students the individual attention they require. Improperly managed, the devices may not work or will be used for unproductive tasks. The result will depend on the learning environment established around the devices.

However, this learning environment needs many supports to exist. Any school considering implementing a one-to-one device initiative should first provide teachers and administrators a forum in which to discuss the technology and its use in the classroom. Are the benefits previously mentioned worth the extra effort of integrating tablets into the existing curriculum? If teachers are not fully onboard with the program, it will fail. While no teacher would turn down the devices if given them, they may feel there are more immediate problems to address in the school. Although iPads may provide more opportunities for students to engage in mathematics, they are simply another tool in a teacher's toolbox. They will not fix systemic classroom issues or improve student performance in mathematics without effort. Before incurring the expense of a one-to-one initiative, a school needs to be clear and honest about why the devices are appropriate and have realistic goals and expectations for student learning. Once these goals are in place, the teachers must be properly supported in the classroom. There are two main areas of support needed: technological and pedagogical.

Technological. Schools must be sure their internet connectivity is sufficient to support hundreds of active devices. This doesn't simply mean having sufficient bandwidth. The wireless network infrastructure must be examined as well. Are there wireless dead zones in the school? Does each classroom have a dedicated access point, or are access points able to handle the number of devices that may be simultaneously within range? Is up-to-date content filtering in place to control access to the wider internet? If all of these basic internet connectivity issues are not dealt with, student and teacher experiences will be negatively impacted.

The next concern is the setup, management, and maintenance of the devices. For this example, iPads are referenced, although all of these concerns apply to any mobile computing platform. If a one-to-one device program is being implemented, will students be allowed to take the devices home? While this provides the opportunity for students to work from home on apps, it also increases the chances of breakage or loss. Some programs charge a yearly fee for students that allows them to take devices home, the proceeds from which are used to pay for replacements or repairs. However, these fees are generally too small to cover the costs if several devices are lost, stolen, or damaged.

Of course, the cost of device replacement can be mitigated. Using high quality protective cases can help protect the vulnerable screens of tablets—in this study, the program used Speck PixelSkin HD Wrap protective cases. Also, buying cheaper devices can obviously help to lower costs. However, they should be selected with care. Devices need to have fast enough processors and sufficient storage to handle the apps that teachers want to run. Therefore, ideally, the devices should be chosen in consultation with teachers who have some idea of what they want to do with them in the classroom. Again, planning ahead can save the program in the long run. It could result in one device, or operating system, being chosen over another based on the needs of the teachers.

However, it is not enough to simply distribute iPads to students. They must be properly managed and administered to prevent students from changing settings that need to remain static. In this study, the devices were originally configured using a Macbook Air provided in the donation. Using Apple Configurator, device settings were locked down by changing account permissions, and apps for the appropriate grade level were installed. However, the computer did not have enough storage space to store the device images for all the iPads, resulting in technical headaches for the teachers and Apple support staff. These issues were eventually solved by simply switching to a Mac Mini with a larger hard drive. Such a problem would not have occurred had a properly trained technical consultant been working with teachers from the beginning. In fact, the inconvenience of this process was largely the reason for iPad app installations only being updated once per school year. If it were streamlined, teachers would be able to update apps and create custom payloads more efficiently.

Once devices are configured, their daily maintenance must be considered. How will devices be charged? The classrooms in this study used desk paper organizers with 30-pin charging cables for each slot. Students were responsible for making sure their device was properly charged. How will devices be repaired or replaced? Teachers in this program generally had one or two extra iPads per classroom to loan to students whose devices had been damaged or malfunctioned. These devices were returned for maintenance or repair through Apple. While some problems were unavoidable internal hardware issues, others were entirely avoidable.

For example, charging ports are one of the most common points of failure of these devices, especially the 30-pin connector. While switching to Apple's more resilient Lightning connector may help prevent this type of failure, it would require upgrading to newer iPad models and more expensive charging cables. Also, it may be that this connector will soon be replaced by more universal USB 3.0 adapters in the near future. The swift movement of the technology market should be taken into consideration when selecting devices for the classroom. Seemingly small details such as the type of charging port can lead to higher maintenance costs down the road if unaccounted for.

Pedagogical. Of course, getting the infrastructure in place and devices in the hands of students is only the first step towards using them effectively in the classroom. While it is simply stated, pedagogical support is the most important component of a successful device initiative. Teachers will require consistent training in and support for new technology from districts and schools. This might include discussions of the best types of use (such as free choice or focused lessons), classroom discipline issues and techniques specific to the devices, or dissemination of best practices from other schools.

It also must take the form of sufficient budgets to purchase and update apps to accommodate teacher needs. Constant communication between teachers and program administrators is essential. It allows teachers to report issues efficiently and focus on teaching, rather than having to act as technical support. It also gives teachers the freedom to look to the future of these devices. Researchers do not yet know the best way to integrate them into the classroom—the best ideas and practices will come from teachers who have tried to do so. These should be considered by administrators and researchers alike in order to intelligently steer the development of such programs over the coming decades.

In conclusion, although some teachers can effectively implement iPad programs in the classroom on their own, this is not a sustainable model for introducing the devices into our schools. The education community needs to provide additional support, including technical and pedagogical trainings, focused apps for various skills, and a feedback channel for teachers to quickly report problems to developers. Without an active and engaged support structure, device initiatives such as the one described in this study are likely to fail due to high maintenance costs. However, if educators take advantage of the technological abilities of these devices, they can create a more responsive and differentiated environment of mathematics learning than has previously been feasible. The river of data from the devices also brings the possibility of new ways for the research community to learn about how students learn mathematics. This, in turn, could help researchers provide more responsive support to teachers in an effort to improve student mathematical understanding.

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Appendix 1: Splash Math 2nd Grade Skills Assessment

Name ___________________________________

1. Convert to standard form.

$900 + 40 + 2 =$ ____

2. Brent is counting on by 5's. Which number follows 35?

3. Subtract numbers with regrouping. Find the ones and tens in the difference.

$47 - 3 =$

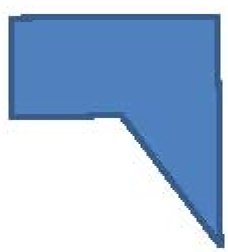
a. 4 tens, 3 ones

b. 3 tens, 4 ones

c. 4 tens, 4 ones

d. 4 tens, 5 ones

4. How many vertices does this shape have?



a. 3

b. 5

c. 8

d. 4

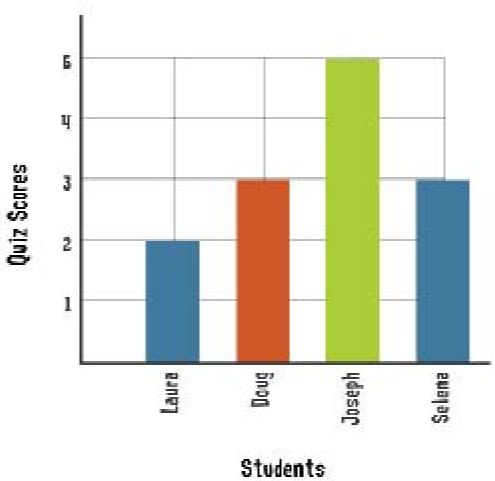
5. Do the following facts form a family?

$3 + 2 = 5$	$2 + 3 = 5$
$3 - 2 = 1$	$5 - 2 = 3$

Circle: Yes or No

6. Doug has 31 marbles. Aaron gives him 20 more marbles to add to his collection. How many marbles does Doug have in all?

7. What is the score of the student with the least marks?



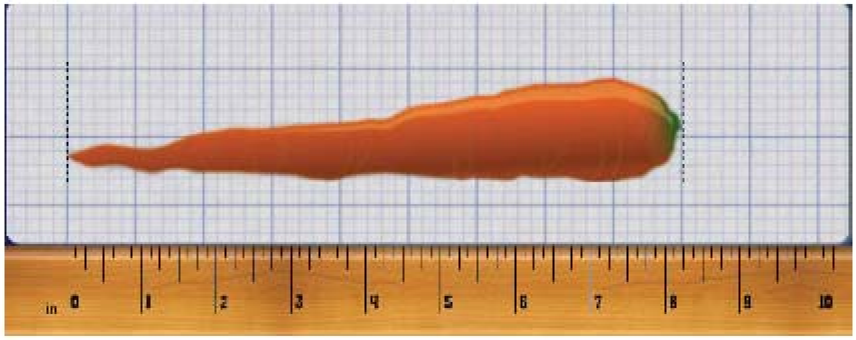
a. 5

b. 2

c. 3

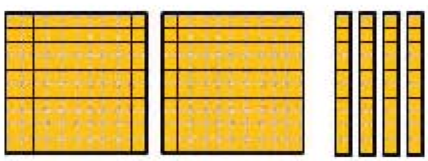
d. 1

8. Use the ruler to estimate the length of the object to the nearest inch.



The carrot is about _____ inches long.

9. Which number is represented by the base-10 blocks?



____

10. Order from greatest to least.

a. 797 > 221 > 705

b. 797 > 705 > 221

c. 221 > 705 > 797

d. 221 > 797 > 705

Appendix 2: Unit Tests 1-3

Unit 1 Test
Form A

Name ____________________

Write the correct answer.

Solve.

1. $7 + 0 = \square$

2. $\square = 6 + 5$

3. $\square = 9 + 5$

4. $5 + 8 = \square$

5. $8 + \square = 15$

6. $\square + 9 = 14$

7. $16 - 9 = \square$

8. $18 - 9 = \square$

9. $3 + 8 + 5 = \square$

10. $9 + 2 = \square$

11. $2 + 1 + 8 + 7 = \square$

Add.

12. $\begin{array}{r} 9 \\ +5 \\ \hline \end{array}$

Subtract.

13. $\begin{array}{r} 14 \\ -6 \\ \hline \end{array}$

Name ______________________

Solve. Show your work.

14. Mason had 12 cars. He gave some to his friend. Now he has only 8 cars. How many cars did he give to his friend?

☐ ________________
label

15. There are 14 bicycles. 5 bicycles are red. The rest are green. How many bicycles are green?

☐ ________________
label

16. Kay has 15 bracelets. Justine has 6 bracelets. How many fewer bracelets does Justine have?

☐ ________________
label

17. Gary has 5 red crayons, 7 blue crayons, and 7 yellow crayons. He puts all the red and blue crayons in a box. How many crayons does he put in the box?

☐ ________________
label

Name ______________________

Solve. Show your work.

18. Joyce draws 6 pictures. That is 9 fewer pictures than Kevin draws. How many pictures does Kevin draw?

☐ ________________
label

19. Beth has a bag of apples. She gives 6 apples to Natasha. Now she has 7 apples left. How many apples were in the bag at first?

☐ ________________
label

20. There are 7 red kites, 4 yellow kites, and 3 blue kites in the air. How many kites are in the air?

☐ ________________
label

21. Evan finds 12 shells. Aaron finds 5 fewer shells than Evan. How many shells does Aaron find?

☐ ________________
label

Name ___________________________________

Solve. Show your work.

22. There were some shirts in a drawer. Rob put 9 more shirts in the drawer. Now there are 16 shirts in the drawer. How many shirts were in the drawer at first?

☐ ____________
label

23. Amy sells 13 peaches. She sells 4 more peaches than Erika. How many peaches does Erika sell?

☐ ____________
label

24. There are 6 basketballs, 2 footballs, and some baseballs on the playground. There are a total of 15 balls on the playground. How many baseballs are on the playground?

☐ ____________
label

25. **Extended Response** Choose an odd number. Write a doubles equation with your number. Explain how you know the sum is even.

____

____

____

Unit 2 Test
Form A

Name ____________________

Write the correct answer.

Draw the number using hundred boxes, ten sticks, and circles. Then write the number in expanded form.

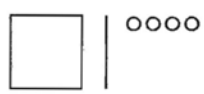
1. 139

____

2. 152

____

What number is shown?
Write the number and the number name.

3. 

____

____

4. 

____

____

Add.

5. 64 + 1 = ____

6. 50 + 10 = ____

7. 20 + 80 = ____

8. 100 + 2 = ____

Compare. Write >, <, or =.

9. 127 ◯ 134

10. 159 ◯ 159

11. 167 ◯ 129

Name ______________________________

Add.

12. $\begin{array}{r} 81 \\ +\ 17 \\ \hline \end{array}$

13. $\begin{array}{r} 74 \\ +\ 43 \\ \hline \end{array}$

14. $\begin{array}{r} 38 \\ +\ 53 \\ \hline \end{array}$

15. $\begin{array}{r} 65 \\ +\ 87 \\ \hline \end{array}$

16. 42 + 35 + 57 = _____

17. 23 + 39 + 12 + 16 = ____

18. Skip count by 5s.

35 ____ ____ ____ ____ ____ 65

Name ______________________________

Under the coins, write the total amount of money so far.

19. 5¢ 5¢ 5¢ 1¢ 1¢

5¢ 10¢ ____ ____ ____

---

20. 10¢ 10¢ 10¢ 10¢ 5¢ 5¢ 1¢

10¢ 20¢ ____ ____ ____ ____ ____

Solve the word problem. Show your work.

21. Michelle has 1 dime, 4 nickels, and 3 pennies.
How much money does Michelle have?
Use ¢ in your answer.

____

---

22. Ben has 1 dollar, 3 nickels, and 7 pennies.
How much money does Ben have?
Use $ in your answer.

____

Name ______________________

Solve the word problem. Show your work.

23. Summer and Alexandra count their beads. Summer has 47 beads. Alexandra has 36 beads. How many beads do they have altogether?

☐ ____________
label

24. Megan read 32 pages on Saturday. She read 28 pages on Sunday. How many pages did she read altogether?

☐ ____________
label

25. **Extended Response** Explain how you find the sum of 38 and 73. Then make a Proof Drawing.

____

____

____

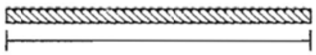
____

Unit 3 Test
Form A

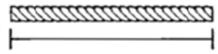
Name ________________________________

Write the correct answer.

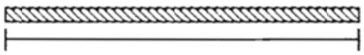
Measure the string to the nearest centimeter.

1. 

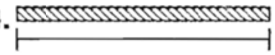
☐ cm

2. 

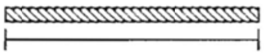
☐ cm

3. 

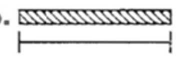
☐ cm

4. 

☐ cm

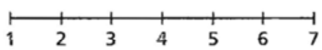
5. 

☐ cm

6. 

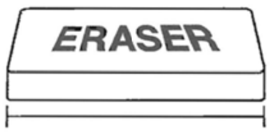
☐ cm

7. Show the lengths of the strings on this line plot.



Lengths of Strings (centimeters)

8. Estimate and then measure the eraser in inches.



Estimate

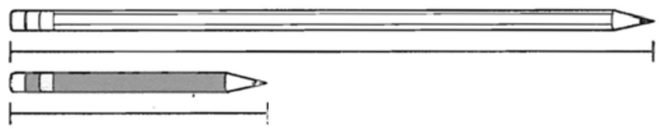
☐ inches

Measure

☐ inches

Name ______________________

9. Draw a loop and then measure to find how much longer the white pencil is than the gray pencil.



The white pencil is _____ inches longer than the gray pencil.

10. Draw a shape with 4 angles.

11. Draw a shape with 5 sides.

12. Draw a shape with 6 angles.

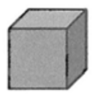
13. Draw a shape with 3 sides

14. Draw a shape with 4 rectangular faces and 2 square faces.

Name ______________________________

Name the shape. Choose a word from the box.

cube	hexagon	triangle
pentagon	quadrilateral	

15. 

____

16. 

____

17. 

____

18. 

____

19. 

____

Name ______________________________

20. Extended Response.

a. Measure the crayon in centimeters.
______ cm

b. Measure the crayon in inches.
about ______ in.

c. Ring **more** or **less**.

The number of inches is **more** **less** than the number of centimeters.

Explain why.

____

____

____

Appendix 3: Interview Rating Instruments

Student Mathematics and Technology Attitudes Scale

	Hardly Ever	Occasionally	About Half the Time	Usually	Nearly Always
1. I concentrate hard in mathematics [BE]	HE	OC	Ha	U	NA
2. I try to answer questions the teacher asks [BE]	HE	OC	Ha	U	NA
3. If I make mistakes, I work until I have corrected them. [BE]	HE	OC	Ha	U	NA
4. If I can't do a problem, I keep trying different ideas. [BE]	HE	OC	Ha	U	NA
	Strongly disagree	Disagree	Not Sure	Agree	Strongly agree
5. I am good at using iPads and computers [TC]	SD	D	NS	A	SA
6. I am good at using things like VCRs, DVDs, MP3s and mobile phones [TC]	SD	D	NS	A	SA
7. I can fix a lot of iPad/computer problems [TC]	SD	D	NS	A	SA
8. I can master any iPad app or computer program needed for school [TC]	SD	D	NS	A	SA
9. I have a mathematical mind [MC]	SD	D	NS	A	SA
10. I can get good results in mathematics. [MC]	SD	D	NS	A	SA
11. I know I can handle difficulties in mathematics. [MC]	SD	D	NS	A	SA
12. I am confident with mathematics [MC]	SD	D	NS	A	SA
13. I am interested to learn new things in	SD	D	NS	A	SA

mathematics [AE]					
14. In mathematics you get rewards for your effort [AE].	SD	D	NS	A	SA
15. Learning mathematics is enjoyable [AE]	SD	D	NS	A	SA
16. I get a sense of satisfaction when I solve mathematics problems [AE]	SD	D	NS	A	SA
17. I like using iPads for mathematics. [MTg]	SD	D	NS	A	SA
18. Using iPads for mathematics is worth the extra effort. [MTg]	SD	D	NS	A	SA
19. Mathematics is more interesting when using iPads. [MTg]	SD	D	NS	A	SA
20. iPads help me learn mathematics better. [MTg]	SD	D	NS	A	SA

Teacher Mathematics and Technology Attitudes Scale

	Hardly Ever	Occasionally	About Half the Time	Usually	Nearly Always
1. I work hard preparing for mathematics lessons [BE]	HE	OC	Ha	U	NA
2. I had to work hard in mathematics as a student. [BE]	HE	OC	Ha	U	NA
3. If students are confused, I work to find alternative methods to instruct them. [BE]	HE	OC	Ha	U	NA
4. If I don't recall material, I can familiarize myself on it easily. [BE]	HE	OC	Ha	U	NA
	Strongly disagree	Disagree	Not Sure	Agree	Strongly agree
5. I am good at using iPads and computers [TC]	SD	D	NS	A	SA
6. I am good at using things like VCRs, DVDs, MP3s and mobile phones [TC]	SD	D	NS	A	SA
7. I can fix a lot of iPad/computer problems [TC]	SD	D	NS	A	SA
8. I can master any iPad app or computer program needed for school [TC]	SD	D	NS	A	SA
9. I have a mathematical mind [MC]	SD	D	NS	A	SA
10. I got good results in mathematics. [MC]	SD	D	NS	A	SA
11. I know I can handle difficulties in	SD	D	NS	A	SA

mathematics. [MC]					
12. I am confident with mathematics [MC]	SD	D	NS	A	SA
13. I am interested to learn new things in mathematics [AE]	SD	D	NS	A	SA
14. In mathematics you get rewards for your effort [AE].	SD	D	NS	A	SA
15. Teaching mathematics is enjoyable [AE]	SD	D	NS	A	SA
16. I get a sense of satisfaction when I solve mathematics problems [AE]	SD	D	NS	A	SA
17. I like using iPads for mathematics. [MTg]	SD	D	NS	A	SA
18. Using iPads for mathematics is worth the extra effort. [MTg]	SD	D	NS	A	SA
19. Mathematics is more interesting when using iPads. [MTg]	SD	D	NS	A	SA
20. iPads help me teach mathematics better. [MTg]	SD	D	NS	A	SA

Appendix 4: Interview Transcripts

Interview 1 Student Transcripts

Benchmark Student 1 – Ethan – Interview 1

Researcher:	Alright, so—I just have a few little questions. And this is just, all I'm doing is I'm just trying to learn about second graders and how you guys are thinking and how you like your math classes. So feel free to like, to speak up good so I can hear you, okay? But it's okay if your throat's a little sore. So first of all, nothing's right and nothing's wrong, ok?
Student:	Yeah.
Researcher:	So you can tell me whatever you think. So, Ethan do you like math class?
Student:	Yeah, a little bit, but I kinda wish it was more challenging, a little bit more.
Researcher:	Oh really? So it's kind of easy, huh?
Student:	Yeah.
Researcher:	Okay—oh, so let's see. Do you feel like you're pretty good at math, then?
Student:	Yeah, I can do times already and division.
Researcher:	Oh really, oh wow—and division too. Okay. Is there anything that you think you're better at? Like, or do you think math is your best subject?
Student:	Yeah, probably.
Researcher:	Okay. What do you think that you're not as good at as math?
Student:	Probably reading.
Researcher:	Oh really?
Student:	Not reading or writing. I really picked up my reading in first grade.
Researcher:	I see—so you think writing is the hardest thing you have to do?
Student:	Probably, to me.
Researcher:	Ok, cool. Well, that's good to know. So I noticed in your guy's class that you have some iPads, do you feel like you're pretty good at using them, your iPad?
Student:	[hesitantly] I am, but I get bored of the games.
Researcher:	Oh, ok. So what games do you play on there?
Student:	My old favorite was SplashMath but now I'm kind of forced to do it, because I'm done with Addimals.
Researcher:	Sure.
Student:	I really like Wings, but everybody in the class has to be done with Addimals before we get to do that.
Researcher:	Oh, I see. So you're waiting on other students to finish that.
Student:	Yeah.
Researcher:	And, so do you use your iPad for other subjects too? Like other applications?
Student:	Yeah, we do [readroom?], use it for typing.
Researcher:	Ok.
Student:	Which I'm pretty good at.
Researcher:	Oh. So do you use computers very much otherwise?
Student:	Yes, I really like buying cards online.
Researcher:	Oh really? What sort of cards?

Student:	Sports cards.
Researcher:	Oh cool, like baseball cards and basketball cards?
Student:	I don't really collect baseball, I like football and basketball cards.
Researcher:	Ok, that's awesome. Where do you buy them then?
Student:	Here is probably Gold & Silver and we're online because you can get really good deals.
Researcher:	Yeah, you sure can. That's cool. Are there electronic devices that you feel like you're pretty good at using?
Student:	iPhones, I can pretty much if you give me a game, I can figure it out how to do the rules.
Researcher:	Nice. Do you mean like on an Xbox?
Student:	On any electronic except Xbox and those things.
Researcher:	Ok.
Student:	Actually, yeah those are really pretty easy for me to figure out that stuff, it's kind of what my dad does. What gives me that is his math and his ability to do that, because he's a tax, he does taxes.
Researcher:	Oh, he does taxes, I see. So he uses a lot of computers and electronics and things like that?
Student:	And he's really good at math.
Researcher:	Oh, cool. That's good to know. Do you like using the iPad for math?
Student:	Right now, because the two apps that they have I'm bored of, so not really now.
Researcher:	Sure. When you first started using those apps did you like them?
Student:	I loved them. Then I stopped liking them.
Researcher:	Yeah, well, then once you finish a game, then it's not as much fun, is it? You need the new one. That makes sense.
Student:	Yeah.
Researcher:	Do you use it other ways than just the games for math?
Student:	Yeah.
Researcher:	How do you do that?
Student:	I actually, in my opinion I figured out a couple other things on my games that they didn't tell us about. One game, there's a typing thing that can tell you math problems and then you can remember them in your head. I do that sometimes.
Researcher:	I see. And it also seems like I've seen you guys use the whiteboard app on there?
Student:	Oh yeah, used to like it, but then they took away all my pictures that I made.
Researcher:	Oh, they got rid of them? They might have cleared them out on a refresh one time, I see. But on that whiteboard app you were able to store all the pictures and work that you'd done?
Student:	Yeah, but now I don't have any.
Researcher:	I see.
Student:	Because that was the first app we learned.
Researcher:	Oh, it was? I see. So what sort of stuff could you do with it?

Student: You could draw pictures and stuff. And now there's another app that I really like, it's called iDiary.
Researcher: iDiary, ok.
Student: And that has typing, it has, you can draw pictures on it. You can use stickers.
Researcher: Stickers?
Student: Uhhuh.
Researcher: How do you put stickers on an iPad?
Student: [laughs]
Researcher: They're little digital stickers?
Student: They, well, they go, they're like fake stickers that I can draw on, stickers. You just press this thing called stickers and you can look at them.
Researcher: I see.
Student: In third grade you can put as many as you want but in second you can only put two—wait, I mean four.
Researcher: Oh, ok.
Student: There's like fifty.
Researcher: That's pretty neat. Do you ever do math without your iPad?
Student: Yeah.
Researcher: And, so do you just use a pencil and paper? Do you use other things to do math?
Student: Yeah, pencil and paper, I use pretty much anything that I can use for math, I would use. Like if I was in the street now and I was bored, I would pull out my homework and do it.
Researcher: I see. Which do you like better, do you like doing math better with a pencil and paper anywhere or…
Student: Pencil and paper, pretty much. I like doing it with pencil and paper.
Researcher: I see. Ok. And why do you like that better?
Student: Um, it's because I really just, I want to work on my writing, so that's pretty much the reason, and that was the first way I learned.
Researcher: Ok, I see. Do you think math is fun?
Student: Yeah, really fun. When I'm doing what I like to do.
Researcher: That's awesome. Is it really interesting to you? Do you like thinking about it?
Student: Yeah.
Researcher: I see. And do you feel like you work very hard in math class right now?
Student: [hesitates]
Researcher: Probably not?
Student: Not that much, except for one thing we did yesterday.
Researcher: Oh, what did you do yesterday?
Student: We did the for/from things, but we had to do it with three or four. Plus you had to write what you did.
Researcher: Oh, I see, so that's hard to explain, huh?
Student: Yeah, very very hard.
Researcher: So how do you answer a hard question in math?

Student: I remember them in my mind, after I figure them out. And then, because I kind of do, I kinda do that with writing and reading, like, I kind of have one [box] for math and one [box] for [writing] and I use reading and writing to put together, so I like open up those two and put it together and it's like a rectangle and I stretch down my math to like, really fast.

Researcher: Interesting, ok. So, but when you're answering that hard question—you mentioned you put it in your mind after you figure it out. How do you figure it out?

Student: I usually use other ones I have in my mind, like easy ones? And I put those together and use those to get up to that other number and then I can actually use those to…like if I already know 8+8, 9+9, I know my doubles really well. So if I just, if I see a double anywhere in a problem, I do that after I do the other things. And when I get that, I just know it like, click, in my mind.

Researcher: So you use the easier things that you know to figure out the hard ones? Is that right?

Student: Yeah.

Researcher: I see, ok, great. Cool. Well, Ethan, is there anything else that you have been thinking about that you, that my questions made you think about, or that you wanted to say?

Student: No.

Researcher: Ok, well thank you so much, that was really interesting and I really enjoyed hearing all your answers to those.

Student: Ok, thanks.

Benchmark Student 2 – Sophia – Interview 1

Researcher:	So there's no right or wrong answers and you can say whatever you think about, ok? Just a couple of quick and easy questions. So, do you like math class?
Student:	Yes, it's my favorite subject.
Researcher:	Really. It's your favorite subject, wow. Ok, so you really like math class.
Student:	Yeah.
Researcher:	Do you feel like you're pretty good at it?
Student:	Mmhmm [affirmative].
Researcher:	Ah, I see. Are there other subjects that you think you're better at than math?
Student:	[shakes head no]
Researcher:	I see, so math is you best. Wow, ok. What do you think that you're not as good at?
Student:	Um, I'm not sure.
Researcher:	Let's see….what are some other subjects that you have? You have reading and writing, right?
Student:	[nods yes]
Researcher:	Do you guys have much science?
Student:	Mmmhmm [affirmative].
Researcher:	Yeah…hmm. Is there any of those that you feel like you have to work hard on?
Student:	MmmMmm [negative].
Researcher:	Ok, they're all easy?
Student:	[nods yes]
Researcher:	Ok, cool. I noticed that in your guy's class you have iPads in there. Do you feel like you're pretty good at using it?
Student:	Yes.
Researcher:	Oh, ok. So what about other computers and things like that, do you use them much?
Student:	Um, not as much.
Researcher:	Just in class, or at home?
Student:	I really only use them in class, not at home.
Researcher:	Ok, I see. Are there other electronic things that you use much at home or that you feel like you're pretty good at using?
Student:	[hesitates]
Researcher:	Like an iPod, or an iPhone or a tablet or a laptop? Dvd player? You're not very good at using things like that?
Student:	No, I don't do it often.
Researcher:	Oh, really? I see. Good, that's ok. I was just curious to see. Do you like using the iPad for math?
Student:	Mmmhmm [affirmative].
Researcher:	What do you like about it?
Student:	Mmm, I'm not sure.

Researcher: Ok, how do you use it when you use it for math? Like, what do you do on it?
Student: Mmm…[pauses]
Researcher: What sort of apps do you guys normally use for math?
Student: Normally SplashMath and Addimals.
Researcher: Hmm, SplashMath and Addimals. Sure.
Student: Yeah.
Researcher: What about…I thought I saw you guys using a whiteboard app on there?
Student: Um, that's called Educreations.
Researcher: Educreations, right. That one's kind of cool. I like it, it's pretty nice. Just a little whiteboard.
Student: [nods]
Researcher: And you can save your pictures with it, I suppose.
Student: [nods]
Researcher: Great. Do you ever do math without your iPad?
Student: Mmmhmm [affirmative].
Researcher: How?
Student: I just write it on a piece of paper.
Researcher: Oh, ok, so just pencil and paper? Sure. Do you use anything else ever to do it?
Student: MmmMmm [negative].
Researcher: Ok, cool. And then, which do you like better then, doing it with pencil and paper or on the iPad.
Student: I'm not sure.
Researcher: Ok, alright, no problem. Let's see. So, if I gave you the choice you would sort of like, pick whichever one you felt like?
Student: Mmmhmm [positive].
Researcher: Ok. And so, in general, do you think math is fun?
Student: Mmmhmm [positive].
Researcher: Sounds like it. Is it interesting do you think?
Student: Yes.
Researcher: Is it challenging to you in math class?
Student: No, well, sometimes. Like with multiplication and stuff.
Researcher: Oh, multiplication, sure. So do you feel like you have to work pretty hard in math, then when you get to that sort of subject?
Student: Yeah.
Researcher: Ok. When you have a hard math question, how do you solve it?
Student: [hesitates]
Researcher: What are some things that you do?
Student: I'm not sure.
Researcher: Not sure—yeah, that's a hard question, right? Because when I give you a hard question…can you think of a hard question that you had lately in math?
Student: Umm…[shakes head no]

Researcher:	Because sometimes when I think of a hard question, I try to think of how I'm going to approach it. Some ways you can do it is to think about easier questions. Have you ever done that, that you can think of?
Student:	[shakes head no]
Researcher:	So you just sort of work on the hard question until you come up with something?
Student:	Mmmhmm [affirmative].
Researcher:	Ok, I see, that works fine. Well, is there anything that you thought about while we were talking that you want to say, or anything that I made you think about that I didn't ask about?
Student:	MmmMmm [negative].
Researcher:	Ok, well thanks Sophia, that was really helpful.

Benchmark Student 3 – Isabella – Interview 1

Researcher:	First of all, do you think you like math class?
Student:	Yeah.
Researcher:	You do? Why?
Student:	Because it's fun.
Researcher:	Ok. Alright. Do you feel like you're pretty good at math class?
Student:	[nods yes]
Researcher:	You do? I see. Is there something else that you feel like you're better at than math?
Student:	Uh, playing.
Researcher:	Playing? Just playing anything? Ok, I can see that. Are there other school subjects that you think you're better at than math?
Student:	No.
Researcher:	Is there any school subject that you know you're worse at than math?
Student:	Uh…
Researcher:	There's no school subject you have to work really hard at to figure out?
Student:	[shakes head no]
Researcher:	Ok. So school is pretty easy overall, you think? Ok, I see. So, I noticed that in your guy's class you had iPads. Do you feel like you're pretty good at using your iPad?
Student:	Mmmhmm [affirmative]
Researcher:	You do? Ok. Do you use other computers and things a lot?
Student:	No.
Researcher:	Even at home?
Student:	Yeah, I have my own iPad and a computer.
Researcher:	At home then?
Student:	Mmmhmm. [affirmative]
Researcher:	I see. So do you use those pretty often?
Student:	[nods yes]
Researcher:	So you've had a good bit of practice with your iPad probably before you even got this one here?
Student:	[nods yes]
Researcher:	Do you have an iPad mini or a full size iPad?
Student:	Mini.
Researcher:	An iPad mini at home, ok, cool. I see. Do you notice any differences between the one that you have at home and this one here?
Student:	One's bigger.
Researcher:	One's bigger? Ok, that's certainly true. But other than that they seem about the same?
Student:	Mmmhmm [affirmative].
Researcher:	Alright, great. Are there other electronic things that you feel like you're good at using?
Student:	Computer.
Researcher:	Ok, computer. Anything else? Do you use a cell phone, an iPhone?
Student:	No.

Researcher: An iPod? Although you have an iPad mini, so you can play all your music and things on that, right?
Student: My mom doesn't let me buy music.
Researcher: Ok, not yet? Good to know. Well, you'll get there, there's lots of music out there. Do you like using your iPad for math?
Student: Yeah.
Researcher: Do you ever use it for math at home?
Student: I don't have any math games on it.
Researcher: Ok, I see. So is that how you use your iPad for math, math games?
Student: [nods yes]
Researcher: Do you use it any other way for math?
Student: [shakes head no]
Researcher: Seems like I have seen you guys use the whiteboard, isn't there a whiteboard app?
Student: Yeah, Educreations.
Researcher: Educreations, right. You use that for math sometimes don't you?
Student: Yeah.
Researcher: How do you do math using it?
Student: You draw with your fingers and it shows up.
Researcher: Sure, then you can draw pictures and you can keep them.
Student: Ugh, if you don't go on it every day then it erases it.
Researcher: Oh, so if you don't go on it for a while, it erases it. I see. Do you ever do math without using your iPad?
Student: Yeah.
Researcher: How do you do it when you do that?
Student: On pieces of paper.
Researcher: Sure, just pencil and paper. Do you ever do it with anything other than a pencil and paper?
Student: MmmMmm [negative].
Researcher: Ok, alright. And which do you like better?
Student: iPad.
Researcher: Really? Ok, why?
Student: Because.
Researcher: Just, because? Do you think it's more fun doing it on the iPad?
Student: Yeah, and also you don't have to write the numbers.
Researcher: Oh, so you don't…
Student: It's already written and you just have to pick which one fits with the equation.
Researcher: So, why is that more fun? Is it easier? Or is it because you can then just sort of sit and think about it?
Student: Uh, yeah.
Researcher: Sure, that's a hard one to answer. It sounds like you think math is pretty fun then? Is that right? It's ok if you don't.
Student: Yeah.
Researcher: Do you think it's pretty interesting?
Student: Sort of.

Researcher: Sort of? Ok. Do you feel good when you finish a math problem?
Student: Sort of.
Researcher: Sort of? Ok. Do you think you work very hard in math class, do you feel?
Student: Yeah.
Researcher: Ok, good. That's great. Can you think of a hard question you had to answer in math lately?
Student: Yeah, but it was like one thousand, three hundred and ninety nine, but I don't remember what the numbers were.
Researcher: Of course, I don't blame you. That's a big number. So that was a hard question it sounds like. How do you normally solve a hard question?
Student: I add the ones, then the tens and if there's hundreds I add those.
Researcher: Ok, so you add the ones, then you add the tens, then the hundreds if they're there. Are there ever any other ways that you solve hard questions that even aren't addition questions? Do you have any strategies, do you use easy questions to answer hard ones? Or do you play around or experiment with anything sometimes?
Student: Umm…[unsure]
Researcher: That's a hard question to answer. When you're thinking about how you think when you're thinking about something, that's really hard. It sounds like you just sort of tackle it ones, and tens and hundreds and get your answer that way.
Student: Mmmhmm [affirmative]
Researcher: Was there anything else that I made you think about?
Student: Sort of.
Researcher: What was it? Feel free, you can say what ever you think.
Student: I forget what the question was.
Researcher: I see. Let's see, I asked you how you like math class, I asked you if there's better at or worse at, if you think you're good at using your iPad, what sort of apps you use on the iPad, do you like using it for math, do you do math without it…am I jogging your memory?
Student: [laughs]
Researcher: We talked about if math was fun or interesting, we talked about if you work hard at math class or how you solve a hard question…I can't think of anything else we talked about. Ok, well, if you think about it later, you can just tell me whenever. That sound good?
Student: Ok.
Researcher: If you have any other thoughts about math or your iPad or anything like that, you're always welcome to just tell them to me when you think about them.
Student: Ok.
Researcher: Do you have any questions for me?
Student: [shakes head no].

Intensive & Strategic Student 1 – Emma – Interview 1

Researcher: Ok, none of these have a right or a wrong answer, it's just sort of whatever you're thinking.
Student: Oh.
Researcher: They're not math questions, just stuff about math.
Student: Oh.
Researcher: Like, do you like math class?
Student: Yeah, I like math class.
Researcher: You do?
Student: Yeah, because we're learning those, I forget they were called, this is I think the lesser number? I think, I forget.
Researcher: Oh, sure, like the alligator mouths where it's like this one is bigger and this smaller, so you can compare numbers? Those are pretty cool.
Student: Yeah.
Researcher: Why do you like those?
Student: I like those because you get to choose the bigger number. You have to see if you get the bigger number, you have to say it first and then see what bigger number you get. So like, one hundred and forty and one hundred and eighty. So I put the alligator mouth.
Researcher: So he would eat the bigger one, which is?
Student: One hundred and eighty.
Researcher: Right, good job. Do you feel like you're pretty good at math?
Student: Yeah, I feel like I'm really good at math.
Researcher: Good, that's awesome. Do you think that there's other subjects that you're better at?
Student: I'm really good at making one hundred boxes and ten sticks and circles.
Researcher: Oh, you mean in math.
Student: Yeah.
Researcher: I was thinking like are there other things that you do at school like reading or science or writing?
Student: I like to read books at the library.
Researcher: Yeah, I agree, I like your library. It's a nice library.
Student: Yeah.
Researcher: So, do you think that math this…if you had to pick which thing that you're best at in school...
Student: I'm super best at school…like it doesn't have to be math?
Researcher: No, anything.
Student: Ok.
Researcher: And if it is math, that's ok.
Student: I like reading. Reading's like really good for me because when I was in kindergarten I was starting reading really good books that are just right for me, but I just came up to first grade and read chapter books and kept reading chapter books.
Researcher: Agreed, I like them, chapter books are fun.
Student: Yeah, but they're too long.

Researcher: That's certainly true. Ok. I did notice that in your guys' class you use iPads in there?
Student: Yeah, we use iPads. Sometimes we go to Educreations. So if we were doing a problem, we would just go there and then you pick your color to write with and some people go on the board and write.
Researcher: Ok, so some people write on the iPad and some write on the board?
Student: Yeah.
Researcher: Do you like using those for math?
Student: I like using…well the iPads are a little hard to write with, it's just, I had an iPad thing so I could just write it.
Researcher: Sure, so you need a stylus thing for that?
Student: Yeah.
Researcher: Do you feel like you're pretty good at using it otherwise? You can get to things…
Student: Yeah. And I feel like, well last year at my other school, it was Lewis and Clark, we went to a lot of field trips. A lot.
Researcher: I see.
Student: And had to pack cold lunches.
Researcher: Fun.
Student: I had two.
Researcher: So I saw you use the iPads in class. Do you use computers or iPads or things like that at home very much?
Student: I don't have a iPad, I have a DS that you could go on and then I do some math problems, it has a little pen on it.
Researcher: Oh really.
Student: And I did math problems on it. Only my sister just scribbled it up.
Researcher: Oh, that's kind of cool. So you can use the DS for that. Do you ever use a laptop computer?
Student: What's a laptop?
Researcher: One that has a keyboard attached…
Student: Oh yeah, my mom has it, except it clicks to our computer and she does types on it.
Researcher: Sure, so she uses that then.
Student: Also, sometimes I go on PBS Kids and I go on math problems on [super y?] and when I get one wrong I have to do it again.
Researcher: I see, and you do that on the DS or…?
Student: No, I do that on my mom's computer. Sometimes I have to do that so I get math stuck in my head.
Researcher: Oh, that's a good idea. Cool. So do you use phones or anything like that?
Student: No. My mom doesn't, well, my mom lets us go on her phone, because there's like some things you can do and then you just turn it over and it has a little teeny keyboard and you type it, the phone number. So if I wanted to call maybe my grandma's house, I would just type her phone number.
Researcher: That's nice, I see.
Student: So I could call her.

Researcher: Ok, so thinking more about math class now, it sounds like you guys use your iPads in a few different ways, you use Educreations, what else do you do on there?
Student: Yeah, we do Splashmath and Math Bingo, Animals, but it's not Animals it's, Adams'?
Researcher: Addimals. Right, I've seen that.
Student: Yeah. And then, that's all we use now, we're using that penny thing now.
Researcher: That new coin app, yeah, I saw that. So do you guys do math without the iPads then pretty often?
Student: Yeah, sometimes we do not, but I do sometimes I go on the whiteboards, like because I'm really good at the whiteboards and I just get some equations going when the teacher says go, and then I just get started before everyone.
Researcher: So you use the whiteboards, do you use anything else to do math? iPads and whiteboards…
Student: Sometimes paper.
Researcher: Sure, just pencil and paper, by hand.
Student: And the math equations.
Researcher: Which do you like better to do math on out of all those, do you think?
Student: I think, whiteboard.
Researcher: Whiteboard, ok why?
Student: Because it's hard to draw on the iPad. Because it might mess up and do that
Researcher: So you like the whiteboard better than a pencil and paper?
Student: I like the pencil and paper one, I have so many decisions, I have to pick one.
Researcher: Ok.
Student: So, it's the whiteboard.
Researcher: I see, that makes sense. So, in general, do you think that math is pretty fun then?
Student: It's really fun for me, and my dad's been teaching me math in kindergarten, first grade and second grade.
Researcher: Cool. Why do you think it's fun? Is it interesting, do you like the…?
Student: I like when we just do math problems, hard math problems I don't know. Like if we do a new math problem we've never done before, I would just get going and if I'm confused I just draw a one hundred box and do the thing.
Researcher: So that's how you tackle a tough problem, you draw a hundred box…
Student: Yeah. Like, one hundred, wait, ok. Fifty plus fifty, if I couldn't do that, that would be really hard for me, so, I would….well, fifty plus fifty is actually one hundred [laughs].
Researcher: Right.
Student: Yeah, that one's too easy.
Researcher: That's true, you made up an easy one. What if we did one that was like, one hundred and thirty-five plus fifty.
Student: One hundred and thirty five plus fifty?

Researcher: Yeah, see that one's a little harder.
Student: Yeah.
Researcher: So, what would you do if you started to work on that?
Student: So, well, if I had paper right now, I would just draw a one hundred box, and what was it again?
Researcher: One hundred and thirty-five.
Student: Ok. One hundred and thirty-five, so [gestures] here's a one hundred box, and one, two three [counting on fingers]
Researcher: Three ten sticks.
Student: And then one, two, three, four, five and five.
Researcher: Five ones.
Student: So one hundred and thirty-five and …
Researcher: And I said plus fifty….
Student: Wait, one hundred and fifty? Yeah, I got it right.
Researcher: Ok, I see what you're thinking. That makes good sense—it sounds like you like answering hard problems.
Student: Mmmhmm. [affirmative]
Researcher: Fun. Do you feel better when you finish one of those?
Student: Yeah, I feel really better when I finish one of those, like math problems, my dad sometimes he gives me like hard math problems on the back of my homework. He filled up my whole homework back and then I put an arrow like this and then the teacher flipped it over and she was really amazed.
Researcher: That's pretty cool, wow. So have you ever gotten a problem that you couldn't solve before?
Student: Yeah, I forgot what number it was. [laughs]
Researcher: Well, that happens.
Student: Yeah, because when you become a little bit better at math you just forget the number, what one you were doing, before it was really hard for you, now it's not.
Researcher: Oh, that's right, sure. So you don't really remember it as much, because now it's just easy and you just do it without thinking.
Student: Yeah.
Researcher: That's great. Cool. Well, those were all the questions I had, Emma, is there anything that I made you think about as we were talking, is there anything that you wanted to say or do you have any questions for me?
Student: Um, I think I have more, like a lot of things to tell, I have so much.
Researcher: Well, go ahead.
Student: I really like reading because these books, I'm reading these really small words, my daddy's teaching me, it's the Lord of the Rings?
Researcher: Oh, yeah.
Student: We have, I think all the books of the Lord of the Rings, so my dad, I have to read one page every night. So I get better at reading.
Researcher: That's still going to be a lot of nights!
Student: Yeah.
Researcher: Those are hard books to read too. They have a lot of…

Student: Yeah, that's why my dad said, well, my daddy told me if you get stuck on a word and if it was like, it was a really hard word I would try to sound it out and if I couldn't sound it out I just would skip it, maybe, because that's what my dad said.

Researcher: Sure, and you know something else you can do too is, a lot of times, I might not know what a word means, but I sort of understand what's going on….

Student: Yeah. Oh!

Researcher: So I sort of make up a word that would go there.

Student: Yeah. Sometimes, I, I'm thinking what you're saying. Because you have to get, you have to just see if you got it.

Researcher: So, for example if I told you that I elevated my notepad.

Student: Yeah.

Researcher: If you didn't know what that word meant, what do you think it probably means?

Student: Lifted?

Researcher: Yeah, lifted, right. So a lot of times, if you don't know what a word means, we call that "by context", we say you look at the "context of a situation" and then say, I bet I know what that means.

Student: Yeah.

Researcher: Sometimes you're wrong, but, you know, that's ok.

Student: Sometimes, fairy books are just like really, you know those fairy books? And those magic poems? That's the good ones for me.

Researcher: Yeah, and sometimes they have really long names in those Lord of the Rings books too.

Student: Yeah, like I forgot what his name, Gig….

Researcher: Gandolf, maybe?

Student: Yeah.

Researcher: The wizard with the big beard.

Student: Yeah, he's really cool.

Researcher: So are you still on the first one then?

Student: No, I'm kind of on the second page.

Researcher: On the second page, wow. You've got a long way to go!

Student: Yeah.

Researcher: Of course, there's movies and things too you can watch of them now, to kind of get some pictures and things.

Student: Yeah. And mostly just chapter books have like no colors in it.

Researcher: That's true, they usually don't.

Student: But some chapter books do.

Researcher: Yep, it depends on the book, you know, some people like to draw and some people don't. Great, thanks.

Intensive & Strategic Student 2 – Aiden – Interview 1

Researcher:	First of all, just so you know, there's no right or wrong answers to any of my questions, this is all just seeing what you think, ok?
Student:	Ok.
Researcher:	For example, if I asked you something like, do you like math class?
Student:	Yes.
Researcher:	You do? Why do you like it?
Student:	Because you learn a lot. And it gets you smarter. And my brother, so he, actually, no, my brother told me a lot of times, but I did get him sick on accident.
Researcher:	I see, you do have to watch out for that.
Student:	Yeah, so what happened is, I got it, then I gave it to Dad, now I'm giving it to [my brother], then he's going to give it to mom, then I'm the first one that gets it off first.
Researcher:	So you're the one that infects everybody else, but then you get better first.
Student:	Yeah.
Researcher:	That's pretty convenient for you then.
Student:	I'm lucky. I'm starting to feel better, my brother is just getting it and my dad is starting to get it.
Researcher:	Ok. Do you feel like you're pretty good at math then?
Student:	Yes.
Researcher:	Do you think that…because sometimes you can be good at something but better at something else. Do you feel like there's other things in school that you're better at than math?
Student:	[hesitates]
Researcher:	Or are there things in school that you know you're worse at than math?
Student:	I'm good at science, I'm good at math, I'm not good at not really anything.
Researcher:	Ok, so you're pretty much the same at everything, like reading and writing, you think?
Student:	Yeah, I can't read much though.
Researcher:	Ok.
Student:	I can't read chapter books yet.
Researcher:	I see. Sometimes it's good to know, that way you know which things you're better at than others. You know, lots of people can be really good at math and not be able to read as well as they do math. Sometimes it's the other way around, you know?
Student:	Mmmhmm [affirmative].
Researcher:	That's all pretty common. I noticed that in your guys' class, you use iPads in there pretty often.
Student:	Yeah, this one app is called SplashMath Chapter 1 that we can do yet and Chapter 2, and it helps you with math, it helps you with reading, and it has a lot of stuff.
Researcher:	Wow, that's cool. I didn't realize it helped you with reading also.
Student:	Yeah, because it has problems that you need to read.

Researcher: Oh, sure, to do the math problem, you have to read the problem on the app, ok.
Student: Yeah.
Researcher: Well, that makes sense.
Student: Or sometimes, they'll read it to you, but if you're not paying attention…
Researcher: Do you feel like you're pretty good at using the iPad?
Student: Yes.
Researcher: Ok, cool. Like, you can find apps pretty easily?
Student: Yeah.
Researcher: Do you have a lot of experience using that sort of thing? Like, do you have computers at home that you use?
Student: We used to have one, but once we were watching it on our computer, me and [my brother]'s, and we were having a drink and suddenly I had a drink too close and it got on the computer. Luckily it's happened before so, but it started to work, so that was the second time it went through that so, after that it couldn't be working. So me and [my brother] are saving up but not for a computer, because there's this one remote control helicopter out, the [Mauler?]? We wanted it but they just moved the helicopter store somewhere else.
Researcher: Oh, bummer. Is that the one with the four blades?
Student: No, we had the army one and the huge one. Me and [my brother] wanted that.
Researcher: Cool. So you had that laptop that you used, are there other electronic things that you like to play with or that you feel like you know how to use pretty well?
Student: Our mom's phone, our dad's phone, pretty good at walking my dog, Blackjack, he's a great dane.
Researcher: Ok, cool. I noticed you using your iPad for math, you said you used SplashMath, you use…
Student: Math Bingo.
Researcher: Sure, what else I have seen you guys do…? Well, there's that coin app that you started today.
Student: Yeah, Counting Money.
Researcher: Right. What else? Do you use the iPad for anything else when you do math?
Student: Wings.
Researcher: Right. Oh, when you're drawing on it.
Student: Yeah, that's called…what was the name of it….
Researcher: Educreations?
Student: Yeah, Educreation.
Researcher: Great. So you guys don't only do math on the iPad, right?
Student: No, so we can do it at home. I don't use my dad's phone because if you like, do a problem and then hit equal, it just shows the answer.
Researcher: Sure, it just has a calculator.
Student: Yeah, and if you use your dad's phone and then hit equal and it just shows, that would be not really doing your homework.

Researcher: Sure, that's not really doing the math to add it up.
Student: Yeah.
Researcher: That makes sense. So you do math with those, do you also do it with just a pencil and paper?
Student: Yeah. I make problems for my dad and [my brother] and they solve it and then I go back on my dad's and type the answers and hit equal to check their answers.
Researcher: That's cool. Now which do you like better, do you like doing math on your iPad or with just a pencil and paper?
Student: Pencil and paper.
Researcher: Why?
Student: Because, when you're on the iPad, it just like says, you can't read it by your own self. And it doesn't have, because you can't use your fingers, and it says problems that you don't even know.
Researcher: Ok, so I think I see what you mean. Let me see if I understand you there. So you like it on pencil and paper more because…
Student: You can actually read, use your fingers, where the iPad on Addimals, you can't really use your fingers. Because there's this evil guy, you have to remove the blocks, find out the answer, but he has his little robot that has this chainsaw that cuts metal.
Researcher: I've seen that, he's coming across, so you have to be really quick about it.
Student: Yeah, you have to think quickly. So I don't really do that one because it's much more harder. But I'm almost finished with the puzzle.
Researcher: I see. Because on the iPad you're using your fingers, so you have to do it all in your head. But on a picture and paper, you can draw a picture or put your pencil and down and use your fingers.
Student: Yeah [nodding]. But if he cuts one chain, then there's only one hanging on and then a little bubble comes up and it takes a break and tells you something. That's when I actually use my fingers.
Researcher: I see.
Student: I don't always make it do that, because, one thing you wouldn't really get any gold. Because you need the gold to show the picture.
Researcher: Sure. Do you feel like you're getting faster at those?
Student: Yes.
Researcher: So you're able to get the pictures a little bit better?
Student: Especially, there's this, if you don't get it by the time it cuts each chain, it shows a red block and it falls and it will cover up that answer on your puzzle, so it won't show that half that you just got wrong. If you got green, you can only see the green, and once you got it gold, you can actually see it.
Researcher: Ok. It sounds like you sort of enjoy math? Would you say you think math is fun?
Student: Yes.
Researcher: Why? What makes it fun?

Student: It's fun because you don't actually get it off online, and then when you like are a grown-up and you get asked some kid what's like ten times ten, then you'd have to look it up on your phone.
Researcher: Ok. So math is fun because you…
Student: Learn a lot and you don't have to actually go online and look up the answer.
Researcher: You don't have to look it up, you know how to do it yourself?
Student: Yeah, you just know how to do it.
Researcher: Do you think it's neat to think about math stuff? Or is it just that it's fun when you finish a problem?
Student: It's fun once you finish the problem, but at home I have to do my spelling words ten, five times, so it sucks. But today was the last day of our old spelling words.
Researcher: That's nice.
Student: And now I don't have to do my spelling words today ten times.
Researcher: So it sounds like you have to work pretty hard in spelling?
Student: Yeah.
Researcher: Do you have to work hard in math class too, do you think?
Student: Yes. We have two iPads, I mean, not iPads, I mean DS's at home. So what you do is there's games, but you have to buy them but they're not math games unless there's one there. But there's this one, [sands of fur?], it's a fun one. And Mario racing. Because those games…I lost my DS, cause somehow, but I know where it was, I remember where I put it, and then I heard a thunk so I know where it is.
Researcher: I see, it fell then.
Student: It fell down the heater, conditioner thing.
Researcher: Oh, the vent.
Student: Yeah, I'm hoping we can get in there. And I'm hoping that we haven't had the heater on too much, because it's made out of metal.
Researcher: That would be rough. You'll have to get in there and find out.
Student: And if there's a game in there…
Researcher: The game would probably be ok, I'll bet.
Student: No, it's made out of plastic and there's metal on it.
Researcher: True.
Student: But, we do have other games—my brother shares his.
Researcher: So, I was think about how you mentioned you have to work hard in math class, but when you get a hard math problem, what do you do when you get a hard math problem?
Student: I use my pencil and like, if it's a one hundred, I make a one hundred, then like, one hundred fifty I make five lines, and then I can just see the answer. I can count up.
Researcher: So it sounds like that you then are just drawing a picture of the number and that way you can hold onto that to think about it?
Student: Yeah. Because if you just use your dad's phone, my mom's told me it doesn't really work, because if you hit nine plus, it just shows it, the nine.
Researcher: And you then have to know what the other number is and hit it?

Student: No, every time I hit nine, it will show the nine. Then I try to hit plus and it wouldn't work, it kept hitting plus, plus, plus, plus,…

Researcher: I see, some calculators are like that.

Student: But my dad's isn't, I don't like his very much because if I have a problem on my math homework and I say that, then I don't really use it cause I don't. Because, we have other calculators, but one actually you'd hit a button and it'd have something, like you could have a stand? But we lost that one.

Researcher: Oh, I've see those, where it folds over the top? And stands up?

Student: Yeah.

Researcher: Was it silver?

Student: It was blue and silver.

Researcher: Well, thanks Aiden. That was all the question that I had, was there anything that I made you think about while we were talking, that you didn't get to say, or did you have any questions for me?

Student: No.

<u>Intensive & Strategic Student 3 – Jackson – Interview 1</u>

Researcher: So first of all, with these questions there's no right or wrong answers or anything, it's just some general questions to talk about.
Student: Are they asking about what we're learning about and stuff?
Researcher: You got it, that's it. And a lot of it is what you think. So for example, if I asked you something like this, do you like math class, for example?
Student: Yeah. I do.
Researcher: You do? Why do you think you like math class?
Student: You get to think a lot and use equation and stuff, like in your mind, and it helps you get smarter and when you get college, you can go to college.
Researcher: Oh, so when you get good at math, you can go to college?
Student: Yeah, and school.
Researcher: I see. Do you feel like you're pretty good at math then?
Student: Yeah, sometimes.
Researcher: Ok, sometimes. I feel that same way. But sometimes it's pretty hard, right?
Student: Yeah.
Researcher: Sometimes it helps me to compare it to other things, so like, do you feel like you're better at math than some other things at school?
Student: Well, I think I'm better at PE, because it's like exercise and I usually do exercise more than math.
Researcher: What about reading and writing and that sort of thing?
Student: Yeah, reading. My favorite subject in school are library, PE and math.
Researcher: Ok, so your favorite subjects are library, PE and math. I see. In that order, or are those all kind of equal?
Student: Equal.
Researcher: I noticed that in your guys' class, you use iPads pretty often.
Student: Yeah.
Researcher: Do you feel like you're pretty good at using the iPad?
Student: Yeah, I don't, like, throw it and stuff.
Researcher: Sure, and are you able to find the….
Student: Games? Yeah.
Researcher: Ok. Because for some people, it's confusing if they don't get to use that sort of thing much. Do you get to use computers or laptops or any sort of electronic stuff like that…
Student: At home?
Researcher: Yeah, at home.
Student: Yep, play Playstation, Xbox, computer, my phone (which is broken)…
Researcher: Oh, you broke your phone?
Student: Yeah, I threw it off of a 12 feet house.
Researcher: Well, that would probably break the phone, I think.
Student: Yeah, but it's not like all the way broken, it's the cover that's broken.
Researcher: Well that's good then, so you can still kind of use it?
Student: Yeah.
Researcher: It sounds like you feel like you're pretty good at using technology then?

Student: Yeah. Because it wasn't my fault because my brother tapped me when I was playing a game that, you have to go like that [gestures]and sometimes it slips.
Researcher: Ah, you weren't holding on to it very well?
Student: Yeah.
Researcher: Cool, ok. In that case, when you started using iPads here, had you ever used anything like that before?
Student: Yeah, I have used a tablet.
Researcher: Oh, you have? Cool. So you knew what those were before. I saw that you guys use them for math a good bit. What sort of stuff do you do on the iPad when you're doing math with it?
Student: We usually just use like math games or book, or we could just go on our iDiary, that's like a diary that we use, or notebook.
Researcher: I see. So you can write things in there?
Student: Yeah.
Researcher: What sort of apps do you use?
Student: iDiary, Addimals, Splashmath,….
Researcher: There's that new one today….
Student: Counting Coins.
Researcher: Right, what else do you use for math?
Student: Math Bingo.
Researcher: Good call, what's the one that's a whiteboard, you can draw with different colors?
Student: [hesitates]
Researcher: Educreations?
Student: Yeah.
Researcher: I've seen you use that one for math pretty often too. Do you do math without your iPad too?
Student: Yeah.
Researcher: So how do you do it then?
Student: I just use my fingers or just go to our free choice and grab a couple blocks and put those together and do that.
Researcher: I see, that's pretty sweet. So which do you like better, do you like doing math better with the iPad or do you like doing it better with the other things you mentioned?
Student: iPad, pretty much.
Researcher: Oh really, you like the iPad better? Why do you like it better?
Student: Because you don't have to use your strength, you have to just touch it.
Researcher: Oh, so it's easier to just touch it?
Student: Yeah.
Researcher: So you mentioned that you enjoy math, do you think math is fun generally?
Student: Yeah.
Researcher: Ok, why do you think it's fun? Is it interesting? Do you just like it when you finish a problem?

Student: It helps my brain think and when I'm at home doing my homework, then I remember what I did at school and then that helps.

Researcher: So it just helps your brain think. It's like exercise for your brain?

Student: Yeah.

Researcher: I like that, that's a good idea. Do you feel like you have to work pretty hard in math class?

Student: Yeah.

Researcher: You do? Good. So when you work hard in math class, like when you have a hard question, how do you answer a hard question?

Student: I ask the teacher if I can use some blocks.

Researcher: Oh, ok. So you use the blocks to answer a hard question? I see. Why does that make it easier, do you think?

Student: Um, it's pretty much blocks, that, if you have a whole bucket of blocks and you're doing your math, you can put then all on here and just count.

Researcher: Ok, so you can just put them out and then count it from there.

Student: Yeah.

Researcher: I see, that's cool. Well, that's about all of the questions I had, Noah, is there anything that I made you think about while we were talking that you didn't get to say or do you have any questions for me?

Student: No.

Interview 1 Teacher Transcripts

Intensive & Strategic Teacher – Interview 1

Researcher: So basically, these questions are pretty much the same as the student questions. I guess, if you want to see them, those are the student interview questions that we gave them.

Teacher: Oh, I'm really curious to see how they responded, yes.

Researcher: Of course, I kind of tweaked them, or bent them and bounced around as needed.

Teacher: Modified them depending on the kids.

Researcher: The teacher version is basically very similar. So we can just kind of tackle these, I guess probably in order would be easier to keep track of.

Teacher: Yeah, let's do it. So I started teaching in 1989. And I love math, math has always my favorite. It was my favorite subject as a kid. This year was a little more challenging with having so many intensive and strategic kids in our math class. I think it's amazing that we can have a smaller strategic intensive group, but the kids learn at such a slower rate. So that's kind of a challenge.

Researcher: So did you always feel growing up that math was your best subject?

Teacher: Yeah, I was just like really good at math, so I loved it as a kid.

Researcher: And so, when you did your training in college, do you remember, did you have to take math for elementary students?

Teacher: Yeah.

Researcher: Where were you certified?

Teacher: So, I went to the University of Great Falls and we did have a math for elementary teachers, methods—they were all methods courses at that time. And it wasn't great. I think curriculums have changed a lot since then, for sure. I think Math Expressions is a really, really strong curriculum. When I taught in Great Falls, before I moved to [this city] in 2007, Great Falls had really good math training and really good math curriculum, and I taught kindergarten, first, second and fourth grade. And I particularly loved 4th grade math because it's a little more interesting and the kids are learning so much, and that was great. Really, really enjoyed that.

Researcher: So did you feel like you had to brush up when you came to second grade here?

Teacher: Yes. Just kind of moved backwards. But it is really interesting, from 4th grade in the early 90s, to 2nd grade in 2014, many second graders are learning what we used to teach in 4th grade.

Researcher: Oh really? Interesting.

Teacher: Not everything, but some.

Researcher: So there were students in the 4th grade that still were missing this material?

Teacher: Sure, like subtracting across zeroes, you know that used to be a 4th grade thing. And now we teach it in 2nd grade. So it's amazing how much quicker acquisition is expected and most kids are up for it, so it's super cool. But think that we're seeing the gap get wider as the curriculum gets more rigorous. I think that the kids that have the basic skills are zooming and that the kids that don't have the basic skills are struggling because of the pace.

Researcher: I guess the question is just, how do the numbers compare to what you previously saw in fourth grade as far as, are more, like you said, zooming ahead, or are there….I guess that would be the thought, that if you do that early on, by 4th grade we would hope that more of them are at a higher level than before, but that's a hard thing to measure, I guess.

Teacher: It's a hard thing to measure. I wonder if, just comparing teaching second grade now to teaching second grade when I started, I'm sure there were a lot of second graders that were probably bored in math because the pace was pretty slow and they were probably ready for more. But I think the kids that were struggling didn't fall as far behind, because the pace was slower.

Researcher: Sure.

Teacher: So I think it will be interesting to follow these kids, or if we touched based with the 4th grade teachers about the kids that did have this Common Core math and are now in 4th grade, where are they? Are they pretty much all benchmark? Or do we still have a lot of intensive and strategic kids?

Researcher: That's interesting to see, because I guess the problem would be like, if all you end up doing is widening the gap that you previously had before, but now you have certain kids who have moved on further, but other kids who are right where they were before.

Teacher: It's a challenge, and really, mastery is the goal for everybody in math. So…tricky, yeah.

Researcher: I guess technology would be the next thing to talk about. Where would you put yourself use of technology-wise? Are you confident about it at home?

Teacher: Yeah, I use it a lot. I have a PC that I do a lot of, all my home stuff on, and I have an iPad and I use that a lot, and I have an iPhone…yeah, I feel pretty good.

Researcher: As far as in the classroom, if you started in '89, then you got to see the whole push for computers coming into classrooms.

Teacher: Yes.

Researcher: Did you have computers in classrooms when you first started out?

Teacher: So, the way it was then, it was a lab. So we had, a couple of the schools, they had two labs, and you scheduled lab time every day with your students. And in Great Falls they did what was then called CCC, and now is called Success Maker, are you familiar with that?

Researcher: No.

Teacher: So it's a differentiated program. We used reading and math, and the kids were to be on 20 minutes a day, every day, and you could alternate reading and math. And then they just worked at their level, so first they were given a baseline assessment and then the computer placed them and it was all aligned with the curriculum. And so, if they needed remediation, that's what they got. If they needed a challenge, that's what they got. It was actually pretty cool. Now, [in this district], some of the schools used Success Maker, and [this school] is now getting five licenses for that, which we will share among the entire school. So, what it means by a license is that five students can be on at one time, anywhere in the school.

Researcher: Ok.

Teacher: So, we have decided that we're going to use it as an intervention to start with. I think for those days, we were probably pretty savvy.

Researcher: So that was in the lab, did the students, did you go down as a class to the lab?

Teacher: Yes.

Researcher: Since it was trying to hit them all at their level, then the whole class would be there, not just a few of the students.

Teacher: Yeah, the whole class would be there and as the teacher, you would just monitor. You would go around and the kids that were accelerated, they would bring paper and pencils and often times you had to get in and help them because, as a 2nd grader, they might be already on multiplication, or get a problem that they just didn't have the vocabulary for. If they were on intervention, it was really just a lot of practice with the skills that they were deficit on. Then, when I taught 4th grade, we also taught keyboarding in the computer lab.

Researcher: Sure. I remember typing class.

Teacher: Back in the day. Yep, that's what we did. And I don't think they teach that in [this city].

Researcher: Yeah, that's a good question. I think that nowadays, they're sort of expecting it to happen naturally?

Teacher: I think so too.

Researcher: I guess it's probably true that most students get exposure, but….

Teacher: Eventually.

Researcher: Ok. Obviously, you guys have iPads in the classroom. What do you think? Do you like using them?

Teacher: I love them. I think it's super cool how engaged the kids are when they are on an iPad, and I think it's differentiation, right there. Some apps are better than others. And because our budget is really low, primarily we're using all free apps. So, the assessment tool is not as good as it would be if you were buying the paid version.

Researcher: Because those would allow for more specific assessment?

Teacher: Yeah. Ours are typically all the lite version, because they're free. But I think it gives the kids great practice, I think they're totally engaged, and that's huge and I think it's awesome, I can't imagine not having them.

Researcher: So, do you think it affects your teaching then, of math?

Teacher: I think probably, I think it's positive. The kids—it's a great tool for early finishers. That they've always got something that they're really engaged in and they can be independent at. And I think that's huge. I think it's also, we use it a lot in here for a warmup.

Researcher: I've noticed that.

Teacher:	So when the kids kind of flow in at different times and rather than just waiting or getting off task they can go back to it. I think it's great. Ideally, I think that there would be more money so we could get some apps that are just really fantastic and also have the assessment tool in them. Maybe a little more training on really how to best….best practices for using iPads in the classroom.
Researcher:	Ok, sure. I suppose that the other question there would be, how do you feel the support or training is now, just for math teaching? What I'm trying to divide between is the technology support on one side of it, but do you feel like you have enough support on the math side of things?
Teacher:	So, I think just to address, first of all for the technology support, it's really not existent in [this district]. And for the teaching math support, there are DMI courses that all teachers are expected to take at least two of, and those are pretty fabulous and I really got a lot out of those. But for new teachers coming into the district, I bet it's extremely challenging. I have a lot of experience teaching math, but I think for new people just out of college, I bet they have a big challenge.
Researcher:	I wondered what you saw in student teachers coming through.
Teacher:	Yeah, they've all taken the math for elementary teachers, and [the Benchmark teacher] and I and [the Spanish Immersion teacher] (when [she] used to teach math), we do a lot together and that really helps. I think if you have a team to work with—yes, yay! But I think a lot of people are flying solo and really struggling.
Researcher:	Ok, that's good to know. Do you find yourself putting more time into math lessons compared to any other subjects?
Teacher:	Probably more into reading because of all the number of reading groups that we have? So that takes a lot of time.
Researcher:	So, you mean the many different levels of reading.
Teacher:	Yeah. And when I first started teaching math expressions, I put a lot of time, a huge amount of time into it. And not so much now. It's more hands-on.
Researcher:	Yeah, it's always that way when you start to teach a new prep.
Teacher:	Yeah, you're learning right along with them.
Researcher:	So when you started with Math Expressions, was that your first year teaching second grade, then?
Teacher:	No, Math Expressions was when I moved to [this city]. So, my first year I taught kindergarten and then the next year, so 2008, I came to [this school] and taught second and we had Math Expressions. And then a couple years ago we got the Math Expressions aligned with Common Core. And that's definitely more rigorous. It's basically just the same as the Math Expressions but there's more rigor and the pace is faster.
Researcher:	So, did you have to refresh yourself much? And if you did, how did you do it?
Teacher:	Yeah. Well, the vocabulary is different than when I first started teaching 2nd grade. And actually, the whole, quick draws, showing your work, all of those things, there's a much higher expectation for that, making sure

that kids really understand what they're doing. We've really gotten away from just learning the algorithm and really moved more toward show me that you know. Really, there's a huge expectation for kids to be able to explain their thinking, and I think that's great.

Researcher: Were you just able to use the prep materials that came with the Math Expressions curriculum? Just sort of sat down and cranked through them on your own?

Teacher: Yeah.

Researcher: Did you have to hit Google for videos and things like that?

Teacher: No, although when I first started teaching Math Expressions, we had a TSA who did make some videos. And particular, with the calendar routines—calendar routines are a huge part of the Math Expressions, and that's where a lot of the skills are introduced.

Researcher: I guess I don't know about that, calendar routines?

Teacher: Yeah. She really knocked herself out making videos on that and modeling it, it was really cool.

Researcher: I'm the same way, I tend to just sit down with the book and sort it out, but you were also good at math, too, which could probably change the way that people have to prep.

Teacher: Yeah, but there are a lot of YouTube videos on teaching Math Expressions, a lot. And I've had a lot of student teachers that go and look them up and are like, oh my gosh, that was amazing, so cool.

Researcher: Oh, I think that was all the basic questions that I had. Is there anything else? Obviously we have all the time in the world to talk and you can go on about whatever you like that I can include, but is there anything else that I stirred up that I made you think about or skipped over that you didn't get to talk about just then?

Teacher: Not really, I want to just say having you come in and having [our other volunteer] and people come in that really know and understand math is amazing, because particularly with the learners at the intensive and strategic level, they really need more one-on-one or small group, and most of them are non-readers. So that is really a disability for them, so it's just awesome and powerful. And I think that hour flies for them because they're so engaged. And I think that [the Benchmark teacher] and I making the decision to do Walk to Math, her willingness to take on a bigger group and all that has really been amazing for the kids because if most of these kids were in a regular math class, I think they'd be really, really struggling.

Researcher: True. And honestly, from what I've seen, many of the ones in the other one would probably be pretty bored.

Teacher: Yeah, they would be.

Researcher: That's such a tough thing. Because that sort of tracking is certainly what was done back in the 60s, where you may have had A math and B math and C math or whatever, and they would go between those. That's still an open debate, I guess I feel.

Teacher: It is, and I really am torn about it too and I think one of the things the intensive and strategic kids miss is that modeling by benchmark and benchmark plus kids. I really feel it's tough and I know a lot of schools are moving towards clustering, which really is tracking. And philosophically, I'm really torn.

Researcher: But at the same time, when you see these students able to succeed and actually learning some skills and proceeding along and not just always being…

Teacher: Left behind or not finishing. So, it's tough, it's really tough. And you know, our goal is that we can catch up those strategic and intensive learners so they will benchmark, because we know that's so important. When you leave second grade, if you are benchmark reader and math student, there's a much higher likelihood that you're going to continue on that path.

Researcher: And I was really surprised too at how big of an impact reading makes.

Teacher: It's incredible isn't it?

Researcher: So many of them, I feel like deep down they understand the math at some level, they seem to see it once they can get through the reading.

Teacher: Yes.

Researcher: Which then makes it really difficult to assess too and figure out is it a reading issue or is it a math issue?

Teacher: And that reading affects everything. Scary.

Benchmark Teacher – Interview 1

Researcher: A few questions to just get some background, I guess. So how long have you been teaching math?

Teacher: This is my 20th year. And all the years, I've taught math, so I've had 20 years of math.

Researcher: So, how would it work where you wouldn't teach math at the second grade level?

Teacher: So sometimes in the schools that I've taught at, we've had teaming. So kind of like the same idea, but we'd swap kids. Like in Bozeman, I taught all of the science and the math. And then my partner taught the social studies and the language arts. So, it was kind of interesting.

Researcher: I see. So at that point you were teaching math and science, and not the other side.

Teacher: Yeah.

Researcher: Are you more confident in math, do you feel?

Teacher: Since the beginning?

Researcher: Well, I don't know. That's a good question. How confident were you with math at the beginning vs. now?

Teacher: Right, well definitely confident at the elementary level with math, but if you put me in middle school and high school, I would be stretched. But even now I think over the years, hugely I've improved on my strategies and my delivery of math concepts. And also the classes that we've taken through our Math Expressions, like our base ten and all those classes they were eye-openers, honestly.

Researcher: Cool. I guess there's a little bit of a difference between as a student when you were growing up, were you confident in math, versus how confident you are at teaching it?

Teacher: That's true, because as a kiddo, no. Math was not my forte. And I did not feel strong in it. I felt much better with language arts and things like that. But as a teacher, math is actually my favorite thing to teach, right now.

Researcher: Really? Why?

Teacher: Yeah, out of everything. I don't know, I guess I really enjoy the talk of math, I like to see the ah-ha's, I like to see success and I think with this program and with the way I teach now, I think there's a lot of success and I just really thrive on it. I think it's cool.

Researcher: When you say the way you teach now, how is it different?

Teacher: Well, I think now, from the beginning there's just so many strategies offered and kind of a more open ended way to solve, whereas before we just kind of pigeon-holed and showed kids just the rote ways to do things, but now we're doing the explaining and the understanding and show me how you understand and I just think it's so much more successful.

Researcher: So as far as the algorithm of stack it, or put the 1 on top or the bottom, before did you pretty much go from basic addition facts to here's how you add?

Teacher: Yeah, maybe manipulatives. And then it went straight to carry your ten. And that's it, instead of quick draws and all the other methods or even combining them together. And even just the things like kids don't know that they do, but making it apparent to them, like our anchor numbers of tens—all the tens. Our anchor of fives—fives are beautiful for kids to anchor to. Understanding doubles, doubles plus one, it just helps them to maneuver around those numbers much more quicker.

Researcher: The doubles plus one is one that I think I never really remember doing as a kid, but you're right, it's one that I see them using very often. Really in places where I wouldn't normally use it, I would, like you say, anchor to a ten or something.

Teacher: Yeah. I like it.

Researcher: I guess a couple other questions about just technology in general. How confident are you using technology at home? What tech do you use at home? Is that your job, or is that somebody else's job in the family?

Teacher: I survive with technology, but I'm not that great. But I am good, I do have an iPad, I do have a personal computer, so I use those. Then my iPhone. So I use all three, even though they're different a bit. And then, with all the other technologies at the home, yeah, I'm not so great. Are you talking remotes and anything [laughs].

Researcher: Exactly.

Teacher: No, internet, no I don't feel super confident. I feel actually better in my classroom.

Researcher: That's what I was going to ask next. How do you feel using it in here, because it seems to me like you use it quite well.

Teacher: We do use our document camera in conjunction with our Apple TV, and then our iPads of course. And then sometimes, I pull out my iPhone too, to integrate with it as well.

Researcher: And how are you using that—just next to a student showing them something?

Teacher: Pretty much. Or sometimes, I'll even put my iPhone underneath the document camera and it will display. So if I had a short video that I saved or something, I will project it through that.

Researcher: I see, so not necessarily an app that's on there that you don't have on the iPad.

Teacher: Yeah.

Researcher: How long ago, do you recall, did you guys roll out all of this technology?

Teacher: Really, that new document camera is probably only four or five years old, and then the InterWrite boards I've only had for like three years, and that's big technology of course. I felt like we were really late in getting the whiteboards in our school.

Researcher: Yeah, I guess that just depends, school to school. Over at the university, it's like the future over here where you guys have whiteboards. Only a few of our classrooms have them.

Teacher: Ok. Well good. Just comparing with some other districts and such, I know Hellgate Elementary had them all in their classrooms, like five years ahead of us. But that's different. Yeah, so I do love the technologies of it and I do love obviously the iPads and the apps that we do try to download.

Researcher: Using the iPads in class, that's only been three years now?

Teacher: This is the third year.

Researcher: How did that feel when they first rolled out? Was it more of a daunting and scary thing? Or was it an awesome thing?

Teacher: Huge, it was daunting and I just didn't know how we were going to manage all of them. And I was just worried, as a mini-computer, how were those going to be handled by students. But all my worries were really put to rest rather fast. Except for as you see, at the beginning of the year, when we're downloading all the apps back onto the iPads and trying to manage those, it's tough.

Researcher: So, the management end of them is hard, but as far as the way that the students are using it…

Teacher: Lovely.

Researcher: What were some of the fears that you had? Were you afraid they were going to break them?

Teacher: Break them for one thing. Be in areas, like having access to internet, where they shouldn't. But that hasn't been really a problem. We've had a couple of kids that have perused around, but they're savvy because they do it at home.

Researcher: So they know what a web browser is.

Teacher: Yep. And into some things that should not be, yeah. But our district's pretty good now with all the blocking, so I feel a little bit better.

Researcher: That's good.

Teacher: So yeah, the breakage of it, and we also have some apps that have, they're free, so they have some commercials on it.

Researcher: Ads and commercials.

Teacher: Yes, and that bugged me at first, a lot. And I thought we'd have a lot more parents that would be uptight about it, and we do have some, which I understand. But for the most part, the kids don't even notice them. They're really in tune with what they're doing on them. But what I would like, I know we have our tried and true apps for math, and for reading and social studies and things that we like, but we just don't have the time or the manpower or the money to download more specific. Like, we should have an app that's all about what we're learning about now with geometry and such, but we don't.

Researcher: That's what I was kind of curious to see.

Teacher: I want more specific, pinpointed apps that I feel like, it's just another second chance for them to apply what they know, or learn while they're moving along. But we just don't have the…

Researcher: You guys are just sort of getting them set up in the summer or something and pretty much what you roll out then is what you use for the rest of the semester then?

Teacher: Yes, and there's not funding to allow for additional—most of those would be paid that are so specific.

Researcher: I see.
Teacher: We need funding, we need more time, we need someone to help...
Researcher: To roll those out to the iPads and to manage them.
Teacher: Yeah, to support us. I think they will be, in time, hugely supportive. And I do think that they are supportive, but I just want it to be a little bit more focused. Very focused.
Researcher: That makes sense. Do you think that having them affected your teaching?
Teacher: Yes, I really do like it. It's more progressive, it makes me feel like I need to be more progressive in terms of how I teach. So I try to be cognizant of how could I make this more adaptable or more current to what kids want to see, or how they learn, or whatever. So yes, it does add a little spark. I liked it.
Researcher: Ok. And you think the kids like them?
Teacher: Yeah, they love them.
Researcher: Yep, that seems to be.
Teacher: They do. Although, Ethan, he prefers to do paper/pencil stuff.
Researcher: Interesting.
Teacher: So even though we have a couple of the new apps that are quite challenging, they get into multiplication and such, if you find him over here, he'll be working on his supplemental packet that I have for him instead of working on that.
Researcher: It's funny, in his interview—because he's actually pretty technical. His dad's an accountant or a CPA, and he was talking about a lot of the technology he knows. But I think you're right—to him the fun of math is sort of just pencil and paper.
Teacher: He loves that. I've asked him, I said I could download the 3^{rd} grade splashmath for him and he said "Yeah….ok." And I said so, then his mom reiterated at conferences, that he prefers honesty to get down in the gritty and just, you know. And so, I asked him, if I give you the choice of two different things, what would you choose? And he said, I'd grab the paper pencil activity. And I said, ok. But I think I am going to download the 3^{rd} grade math for him.
Researcher: Just in case?
Teacher: Yeah, so it'll be, we'll pay for that separately. But that's what's good about the iPads, if we could have a little bit more funding and a little bit easier downloading of these apps, it really could be very individualistic. Super individualized.
Researcher: So you're imagining a different payload for each student.
Teacher: Exactly. So, the kids that are with you, over in [the Intensive & Stragetic teacher]'s class, they'd be working on SplashMath 1^{st} grade. And then we'd move them into 2^{nd} grade when they're ready. These guys, 2^{nd} grade, we'll move them into 3^{rd} grade, so it's a little bit more…
Researcher: So right now, they all just have SplashMath 2^{nd} grade?
Teacher: Yeah, they all just have 2^{nd} grade.
Researcher: That's a good thought. Ok.
Teacher: I think that'd be really helpful.

Researcher: So this is more about, back to you as a student. When you were a student, you mentioned that you didn't feel just super comfortable in math, but did you think that math was interesting? Or was it just sort of an unpleasant task?

Teacher: Kind of unpleasant. Yeah. Because when I was taught, I basically was just told what to do to get through the problem, but didn't try to apply it to something that would link me in personally or to make it relatable to our own world. Really not good.

Researcher: So it became more interesting then as you started to try to teach it to students? Saw where it would apply?

Teacher: Yes. I loved it. All of a sudden my eyes were just opening. And even in college, I didn't like the way they taught us our math for elementary at all.

Researcher: Was it very rote?

Teacher: Yes. Again, it was just algorithms, duh-duh-duh-duh-duh-duh-duh-duh. That was a long time ago.

Researcher: Where was your teaching training at?

Teacher: So, I went to Montana State and graduated in '89.

Researcher: Ok. I don't think I know anybody that would have been teaching over there at that point. I know the crowd we had teaching here at that stage, Johnny Lott, and Rick Billstein.

Teacher: Yep.

Researcher: I guess this isn't as relevant of a question for when you were just teaching math and science, but do you find that you put more time into the math lessons now as compared to other subjects that you teach?

Teacher: I do put a lot, but I think I've always put a lot more into math, just because I think, I know personally I want to make sure that I know what I'm doing because I had such a, I think seriously because I had such a rotten experience.

Researcher: So you're worried that you might sort of accidentally get in a corner where they ask a question about parallel lines or something….

Teacher: Yeah. And of course, still I don't know—sometimes they'll catch me and I'll just say, you know what? Good question, I'll have to look that up and make sure that we're on the right track on this. Rarely in second grade, but still, some things.

Researcher: They catch me sometimes.

Teacher: Yeah, interesting.

Researcher: And you mentioned, as far as refreshing yourself on the material when you need to for a lesson, are you mostly just using the book materials for that or are you using the internet, or other teachers?

Teacher: Yeah. Obviously, the book drives the lesson of what I'm going to be teaching, but honestly now that I have it down—I piloted this program to begin with to even see if we'd like it.

Researcher: I see.

Teacher: So that was kind of fun, so I've been teaching this program either five or six years…maybe even seven. So I taught a whole year ahead of everybody, then we met as a team to decide if this was the best program.

We had other teachers teaching other things too. So that was cool. And then I got to be actually in on the training of teachers of this program too.

Researcher: Ok.

Teacher: So I like that. It was cool, so I took some autonomy over it and I really liked it. That's why I said I would do it. Because again, not so good of a math student, but then I felt super confident about teaching it and conveying it so while we were teaching it and implementing it I did have quite a few people coming to watch how I did this, how I teach this math, this program and such. That was kind of scary at first, but then I just got used to people coming in and watching.

Researcher: Do you feel like you got yourself refreshed on the material by fire then, just going through it that first year?

Teacher: Yes. Even then, I'll write myself little hints on my teacher manuals all the time—remember this, this worked best for you, type of thing, and I always tell them, the student teachers and the other teachers, just write all over it, remind yourself. Don't make that mistake twice, you know, for the next year.

Researcher: Is there much in the way of trainings throughout the year that you go to that you find are useful?

Teacher: You know, at the beginning, yes, because they made you take three of the classes, and I say made because at first we were all just like, oh my gosh, but once we went, we were like, yep, we totally get it, they're very good. But since, then, no I haven't have very many refresher.

Researcher: That's as far as math goes, as far as technology training, of the use of that, that's just sort of been…

Teacher: Horrible. I mean there was a few trainings, like on the whiteboards. We've had no official, when we first got our iPads, a little bit of setup training and how to do it, but that's it.

Researcher: It sounded like, from talking with [the Spanish Immersion teacher] a couple of years ago that a lot of it was you guys just sort of figuring it out on your own.

Teacher: And I think that because it was so new for us to have all and we were kind of…it's silly to say, but paving the way with those iPads, because they were figuring out at Apple too when everybody was trying to do all the iPads under one Apple book or whatever.

Researcher: Yeah, how to manage that software.

Teacher: The best way with our server and how they've changed that so many times because it just doesn't work.

Researcher: Yeah. It sounds like they sort of have it sorted out now, but am I right in thinking that it was more like [the Spanish Immersion teacher] and maybe [the Intensive & Strategic teacher] to some extent were really taking the lead on that then?

Teacher: Yes, they were at the main training of those because I was gone, out of town. Otherwise, I would have been, but no, I was not.

Researcher: They both sound like a little bit more into technology type people to me, just from whenever I've spoken to them.

Teacher: Yeah, [the Spanish immersion teacher] did her masters in tech….
Researcher: Educational technology or something?
Teacher: Exactly. That's her masters.
Researcher: Wow, I didn't…that makes a lot more sense.
Teacher: That makes sense huh?
Researcher: I know she was much more comfortable with students using the Airplay app where you could Airplay it to the screen and things. Have you tried that with your students before?
Teacher: Yeah, I do that all the time.
Researcher: I was just curious, I hadn't really seen it too much in these lessons.
Teacher: Yeah, in math yep. Yeah, we do it a lot, especially with our writing and our iDiaries, we project and read out loud to each other.
Researcher: Excellent. And that seems to work ok?
Teacher: Yes, our wifi is better than last year, which is better from the previous year.
Researcher: That's good then.
Teacher: But it'll drop right in the middle too and it's frustrating for the kids.
Researcher: I see. Well, I don't want to take up any more of your time, that's plenty. You've answered all those that we needed.
Teacher: Okay.

Interview 2 Student Transcripts

Benchmark Student 1 – Ethan – Interview 2

Researcher: Ok, so you might remember some of these from the last time we talked.
Student: Yeah.
Researcher: And that's ok—so if you want, just answer however you happen to remember, Ethan and if you think your answer's a little different, that's cool too. Ok?
Student: Ok.
Researcher: So, first question is, do you like math class?
Student: Yeah, but it can get a little boring because I know most of it.
Researcher: Ok, so you know most of it, so it gets kind of boring? So do you feel like you're pretty good at math then?
Student: Yeah.
Researcher: Are there other things that you're better at?
Student: No.
Researcher: No? So really math is your best?
Student: Mmmhmm [affirmative].
Researcher: What are the things you feel like aren't your strongest subject?
Student: Uh, writing is my weakest and … in kindergarten and first grade it was reading and at the end of first grade it was writing.
Researcher: Oh, interesting. So over the first grade you think you got a lot better at reading then?
Student: Yeah.
Researcher: That's good. Did that help your math, did you notice?
Student: Umm….yeah, a little bit with story problems and stuff.
Researcher: Sure. I could see that. That's kind of neat sometimes how that all blends together.
Student: Yeah, and then what probably helped me the most was probably getting glasses in kindergarten.
Researcher: Oh really?
Student: I got them halfway through.
Researcher: So getting glasses helped a lot to be able to read better?
Student: Yeah, and write and do math.
Researcher: Sure. That's interesting. I always forget about things like that, but you're right—before I had glasses, I had trouble reading the board in a class from the back of the classroom and stuff like that.
Student: [nods affirmative]
Researcher: Good. So I noticed you guys of course have your iPads in the class.
Student: Yeah.
Researcher: Do you feel like you're pretty good at using yours?
Student: Yeah.
Researcher: Really? Ok. Do you use other computers much?
Student: Yes, I'm one of the three that uses them lots.
Researcher: Oh, I see. So you mean the computers in class?

Student: Yeah, I do.
Researcher: I see, so what do you like to do on the computer?
Student: Well, there's a thing called Educreations, and it's like a math thing. So then we always have to go to e-games and do stuff, and I still have the record for most friends gotten.
Researcher: Wow, I see.
Student: And I did it in third grade math, so the others hadn't.
Researcher: So that's on the computer website that you go to?
Student: Yeah.
Researcher: Got it, sure. So, do you feel like there are other electronics that you're good at using at home? Things like TVs or DVD players…
Student: Yeah. I'm good at using practically any electronics.
Researcher: Cool, I see. What sort of other devices do you use at home? Do you have a phone? Do you have an iPod or…
Student: No.
Researcher: I see. Do you have an iPad or another tablet at home also?
Student: No. My mom has the iPhone 6 and my dad has the iPhone 5 and we have like three computers. They all work slow so I asked my mom and dad if I could have one, because I like looking up stuff, so they said…I don't know what their answer is yet. [laughs]
Researcher: Sure, they're thinking it over.
Student: Yeah.
Researcher: I see, great. So you mentioned Educreations, do you like using your iPad for math?
Student: Yeah.
Researcher: So then, how do you use it for math usually?
Student: I just do the games I like to do, and stuff like that.
Researcher: Ok, then. What games do you like to do on it now?
Student: Splash Math I used to, Wings I used to.
Researcher: And that was Splash Math second grade?
Student: Yeah.
Researcher: But you finished it, is that right?
Student: No, when I was one of the few that actually, I was supposed to get Splash Math for third grade, but we just forgot about it.
Researcher: Oh, huh—we'll have to try to remember that. It's sort of hard to get it on the iPad, installed and so [your teacher] may have forgotten about that.
Student: Yeah.
Researcher: Ok. So you used that, you used Wings you said. You probably finished Addimals a long time ago, huh?
Student: Yeah, it was the first one.
Researcher: I see. I guess you use Educreations to do math too a little bit.
Student: Yeah. A little bit for me.
Researcher: It's not a game, right? And do you ever do math without it? Without the iPad?
Student: Yeah.
Researcher: So that's just when you're using a pencil and paper?

Student: Yeah, that's my favorite, is pencil and paper.

Researcher: Ah, it's still your favorite? I was curious to see if still like it. Good. So do you think math is fun, or are you just good at it?

Student: Fun.

Researcher: It's fun? Nice. Is it interesting to you, or is like a game? I'm just trying to think, what makes it fun to you?

Student: Uh, I was born with a math minded brain, because my Papa was a teacher and really good at math, and my grandma was a teacher, she was really good at math. My dad is a CPA…

Researcher: Ok. So you think from all of this you came away with a math brain, huh?

Student: Yeah. [laughs]

Researcher: That's possible, I wouldn't be surprised. So I know that you said you're getting sort of bored, do you feel like you work very hard in math class?

Student: Sometimes I work really hard and sometimes I don't.

Researcher: Sure. It just depends on the problem?

Student: Yeah.

Researcher: Great. So when you're working on a really hard question…can you think of one you've had lately that was really hard?

Student: [pauses]

Researcher: That one we worked on last week was a little tricky. Remember the one with the buses?

Student: Oh yeah!

Researcher: The one with all the legs and stuff?

Student: Probably the times one I did. But I got thinking really well and I, because I know what 18 times 18 is, and I know what 100 times 100 is, so that was easy. Breaking it up made it easy, a little.

Researcher: Yeah, so thinking about that one—that was hard question. How did you…do you remember anything about what you were thinking? How did you answer it?

Student: I knew the two and I combined them.

Researcher: Ok. So you knew the two smaller things and then put them together?

Student: Yeah.

Researcher: Is that pretty much what you normally do when you have a hard question, do you think?

Student: Yeah. So how I like to do it is I like to memorize every single problem I do.

Researcher: Oh, wow.

Student: I try to, at least. And I keep them in my brain and then I can use them for other times.

Researcher: Interesting. That's really impressive. I like it. Was there anything else that you were thinking or that I made you think about or that I didn't mention?

Student: No.

Researcher: Well great, thanks Ethan. I think that's everything I needed. That was really interesting. I'll have to think some more about some of that.

Student: Yeah.

<u>Benchmark Student 2 – Sophia – Interview 2</u>

Researcher:	So again, it's the same as last time, no right or wrong answers, just say whatever you think and that's fine. So, Sophia, my first question is just, do you like math class?
Student:	Yes.
Researcher:	You do? And why do you like it?
Student:	Because I just like doing math.
Researcher:	Oh, you like doing math, ok. And do you feel like you're pretty good at math?
Student:	Kind of.
Researcher:	Ok, sure. Are there other things that you think you're better at than math?
Student:	Um, reading.
Researcher:	Reading? Ok, so you think you're better at reading. Are there things that you think you're worse at than math? Things that are a lot harder for you than math?
Student:	Nothing.
Researcher:	Nothing? So like, writing, science, math is probably harder than all those?
Student:	[nods affirmative].
Researcher:	Ok, alright. And so, in your guys' class you do have iPads. Do you feel like you're pretty good at using your iPad? Are you able to figure out games on it?
Student:	[nods affirmative].
Researcher:	Ok, yeah. And do you ever have to like, change the settings or try to fix it when something hangs up on it?
Student:	[shakes head no].
Researcher:	Oh, ok, so you're lucky. So your iPad…
Student:	Well, sometimes. One time my iPad glitched a little bit.
Researcher:	What did you have to do to fix it?
Student:	I had to turn it off.
Researcher:	Ok.
Student:	Except it still doesn't work, so I can't go on that anymore.
Researcher:	Oh. What is it that's not working, or do you know?
Student:	Um, it's on Splash Math. Three digit addition.
Researcher:	Oh, and it's kind of hung up on it, so when you go in it…
Student:	I can't, and it just stays there for a long time.
Researcher:	Ok, alright. That's good to know. I might take a look and we can see if we can fix it maybe. Great. So do you use the computers in [your teacher's] class very much?
Student:	[shakes head no].
Researcher:	Ok. And at home, are there electronic things that you use there? Do you have any tablets or iPads?
Student:	I have an iPad.
Researcher:	You have an iPad at home? Ok, I see. Anything else that you use, like a TV or a DVD player?

Student: TV.
Researcher: What else? What are other things like that that you use at home?
Student: DS.
Researcher: Oooh, a DS, a Nintendo DS, sure. And do you feel pretty good at using those at home?
Student: Mmmhmm [affirmative].
Researcher: Do you think that, are you like the person in your family where when your mom's trying to figure out how to hook something up, does she ask you for help on it?
Student: [shakes head no].
Researcher: Ok, not yet. Who is that person in your family?
Student: My dad.
Researcher: Oh, he's the one who gets everything all hooked up?
Student: Sometimes, but normally it's my mom who's getting us stuff.
Researcher: I see. Good. And do you like using your iPad for math?
Student: [nods affirmative].
Researcher: And what sort of stuff do you do on it when you're doing math?
Student: I'm not really sure.
Researcher: That's a hard question, yeah. So when [your teacher], let's sort of think, when you're in math class, [your teacher] says take out your iPads, she usually has you do, like what sorts of things?
Student: [pauses].
Researcher: You can play your math apps?
Student: [nods affirmative].
Researcher: What are some of the math apps that you've been using lately?
Student: Splash Math. Wings.
Researcher: Splash Math, Wings. What else?
Student: Sail through Math.
Researcher: What was that?
Student: Sail through Math.
Researcher: Sail through Math? Oh, I don't know that one. What is it like?
Student: There's a ship and then the questions come at you kind of quick so you have to answer them quickly.
Researcher: What sort of questions are they?
Student: There's multiplication, subtraction, addition and division, I think.
Researcher: Oh, I see. So you're like, sailing the ship and it says like, five times seven, or something?
Student: I haven't gone on the times yet. I'm not good at times [laughs].
Researcher: I was wondering, that's pretty hard. Alright, cool. Do you also ever use Educreations for math?
Student: [nods affirmative].
Researcher: Ok, where you're just drawing it, like a whiteboard kind of, right? And so when you're no using the iPad for math, how are you usually doing math then?
Student: Paper and pencil.

Researcher: Ok. So that's how you do, paper and pencil. And which do you like better? The iPad or paper and pencil?
Student: Paper and pencil.
Researcher: Really? And why do you like that better?
Student: I'm not sure.
Researcher: Oh, just more, is it just more fun do you think, or more…
Student: Umm…I'm not sure.
Researcher: Ok, no worries. Sometimes I kind of like paper and pencil because the iPad can be sort of distracting, like there's a lot of stuff going on, you know? Sometimes paper and pencil is kind of quieter. That's a reason some people like it, but see some people like the iPad because there's more stuff going on, they get bored with paper and pencil. But you don't get bored with paper and pencil you don't think?
Student: [shakes head no].
Researcher: Ok, cool. And that's good, you might have a really good imagination. Do you think you do have a pretty good imagination?
Student: [nods affirmative].
Researcher: Ok. That could be part of it. So you mentioned you think math class is fun, but what about math makes it fun, do you think?
Student: Um, I'm not sure.
Researcher: That's hard, right? So when you're doing math, like when is it fun? Is it fun the whole time when you're working on a problem?
Student: [nods affirmative].
Researcher: It is? So it's fun just to think about it, you think?
Student: [nods affirmative].
Researcher: Ok. And so how about when you finish a problem? How do you feel then?
Student: Um…good.
Researcher: Good? Ok, so you feel good that you finished it. What about when you're working a problem, and it's really hard and you haven't been able to finish it?
Student: I go on to the next one.
Researcher: Oh really? Ok. Are you worried about that problem?
Student: Sometimes, depends.
Researcher: Ok, sometimes, are you just sort of like "Oh well, didn't get it" and then move on?
Student: [nods affirmative].
Researcher: Ok. So, talking about working hard on problems, do you feel like you have to work hard in math class pretty often?
Student: Sometimes.
Researcher: Sometimes, ok. And when you're working on a hard problem, can you think back to a hard math problem you've had lately?
Student: Um…[shakes head no].
Researcher: Yeah, it's hard to remember, right? So, can you imagine, because you have a good imagination, can you imagine a hard math problem?
Student: Um…

Researcher: You don't have to think of the numbers, just imagine you're working on a really hard math problem, right now. What sort of things do you do to try and solve it?
Student: [pauses].
Researcher: Hmm….so what would a hard one be…maybe it would help if we thought of one…
Student: 9 times 3.
Researcher: Ooh, there you go, that's a hard problem. Ok, so if you had to try to figure that out, what sort of things would you do to try and figure it out? Because if you don't just know it, then…
Student: I'd draw it out.
Researcher: Draw it out, ok, sure. So you could draw out nine three times or something like that maybe, and see what you see, and count?
Student: [nods affirmative].
Researcher: So that's a good thing, you could draw it out. Do you ever sometimes think back to easier problems that you've done?
Student: [shakes head no].
Researcher: Not really? Ok, good. Well, Sophia, that's everything I had to ask, is there anything I made you think about, or that you wanted to say?
Student: [shakes head no].
Researcher: Well thanks a lot, that was just great, I appreciate it.

Benchmark Student 3 – Isabella – Interview 2

Researcher:	Alright, so I guess my first question, Isabella, would be, do you like math class?
Student:	Uh, sort of.
Researcher:	Sort of, I see. Do you feel like you like it more than you used to or less than you used to?
Student:	Uh, more.
Researcher:	More than you used to? Good. Why?
Student:	Because we get to used colored pencils and markers and crayons.
Researcher:	Ok, so you have more ways to draw now? Sure I see. Do you feel like you're good at math?
Student:	Yeah.
Researcher:	Do you feel like you've gotten better or…
Student:	Yes.
Researcher:	Are there other subjects that you think you're better at than math?
Student:	[pauses]. I don't know.
Researcher:	So like, reading and writing…are those harder for you than math, do you think?
Student:	Easier.
Researcher:	Easier. I see, that's good to know. So you think reading and writing is a little easier than math a lot of times?
Student:	Mmmhmm [affirmative].
Researcher:	Great. So the iPads that you guys use in class, do you feel like you're good at using your iPad?
Student:	Mmmhmm [affirmative].
Researcher:	You do. What about other things, do you use the computers in the classroom there very much?
Student:	No.
Researcher:	Sure. Are there other things at home that you feel pretty good about using, other electronics, like DVD players, or computers at home?
Student:	My tv, my computer and my dvd player.
Researcher:	I see. So you feel pretty good on those? You have a computer, is it a laptop or a desktop?
Student:	We have it at a desk, by the front door.
Researcher:	And do you have anything else that you use, like a tablet?
Student:	A mini iPad.
Researcher:	Oh, an iPad mini. And do you use that or do you share it with your brother and sister?
Student:	My two older sisters have an iPhone and my other sisters have an iPad. My little brother has a Leapfrog, so he never asks for it.
Researcher:	I see. So he has a Leapfrog then you said? Alright, that makes sense. As far as the iPad mini at home, do you use it the same way you use the one in class?
Student:	Mmmhmm [affirmative].

Researcher: Do you have some of the same apps downloaded on it then?
Student: Mmmhmm [affirmative].
Researcher: You do? That's great. Do you like using your iPad in class for math?
Student: Mmmhmm [affirmative].
Researcher: You do? And how do you use it for math?
Student: Uh, we use Educreations to do math problems and it's fun to me to also go on math apps.
Researcher: So what sort of math apps do you use?
Student: Splash Math and Wings. And Sushi Monster.
Researcher: Right, I like Sushi Monster. Do you like using it for math?
Student: Mmmhmm [affirmative].
Researcher: Do you also do math without the iPad?
Student: Yeah.
Researcher: And how do you do that normally?
Student: With pencil and paper.
Researcher: Oh sure, just traditional pencil and paper? Which do you like better? On the iPad or with pencil and paper?
Student: Uh….iPad.
Researcher: Ok, why?
Student: Because, sometimes when I write with the pencil, it gives me blisters.
Researcher: I see. So you get blisters when you write with the pencil too much, but the iPad screen, you can just…
Student: Touch on it.
Researcher: Just tap it and touch and it doesn't hurt your fingers. Ok, good to know. So do you think math is fun?
Student: Sort of.
Researcher: Sort of? Ok. What do you think is fun about it and what do you think is not fun about it?
Student: [pauses]. I think the fun part is that you get to use your iPad and you get to color with it.
Researcher: I see.
Student: And the not fun part is that sometimes it takes you a long time.
Researcher: It takes a long time to solve a problem, you mean?
Student: Sometimes.
Researcher: I see. So if it's a hard problem that you're thinking about. Do you feel like you have to work pretty hard in math class usually?
Student: Uh, not really.
Researcher: Ok, I see. So you feel like you don't have to work too hard, but can you think of, if you think back, can you think of a hard math problem that you've had lately?
Student: No.
Researcher: Ok. So maybe we could just imagine. Imagine that you have a hard math problem. What sort of things do you do to figure it out?
Student: Uh, I draw it out. Like, if it was subtraction, I'd try and subtract it without messing up.

Researcher: Ok, so if it was a hard subtraction problem, you could draw it out. Do you mean, like a quick draw?
Student: Uh, I do it in my head, and then I do the ungroup first method.
Researcher: Oh, the ungroup first method, where you scratch it out and draw one…
Student: Mmmhmm [affirmative].
Researcher: Great, so you like that method now to do it?
Student: [nods].
Researcher: Alright. Well, was there anything else Isabella that you thought of while we were talking?
Student: No.
Researcher: Nothing else that I didn't ask or that you wanted to say?
Student: No.
Researcher: Great. Thanks, that was really interesting.

Intensive & Strategic Student 1 – Emma – Interview 2

Researcher:	So this is just like last time, there's no right or wrong answers, you can say whatever comes to your mind, ok?
Student:	Ok.
Researcher:	My first question is just, do you like math class?
Student:	Yes.
Researcher:	You do? Why?
Student:	Because I like doing proof drawings and like whenever you do them like, like 200 minus 45 [drawing with finger on table] you would make a box, you would make two boxes right there and that means it's a hundred and you make ten sticks, like probably two ten…wait, no. I forgot. I thought that because we're learning a new method.
Researcher:	Oh, you are. So what's the new method you're learning?
Student:	Well, I don't think it's new, I think it's old, we used to do it but now we don't, it's just like if I did 150 minus like 21 equals , and then I would do one box and that means a hundred, like I told you, and then I put five tens [gesturing drawing tens], one, two, three, four, five. And then I have to take out one and then I make a new ten and then I put ten circles, then I cross out like one circle, then I cross out the box, then you gotta add another one, that makes ten sticks.
Researcher:	Oh, so you can break the box up into ten sticks.
Student:	Yep.
Researcher:	And the ten sticks into ones. And then subtract whatever you need to?
Student:	Yeah.
Researcher:	Awesome. So Emma, do you feel like you're pretty good at math?
Student:	[hesitates]. Mmm…yeah.
Researcher:	Yeah? Well it's sometimes hard to compare. Are there things that you think you're better at than math?
Student:	I like reading, like library is my favorite thing to do.
Researcher:	I see.
Student:	And I like gym and music. I like playing instruments.
Researcher:	Oh, what do you play?
Student:	Sometimes I play like, other different kind of instruments, like drums or like…or you know those things like you hold onto the sticks and then you…I don't know what they're called, but it has…
Researcher:	I do, I know what you're talking…a xylophone?
Student:	Yeah, yeah. I'm really good at them.
Researcher:	Cool. Do you think, or is there anything you can think of that is harder than math?
Student:	Um…hmmm. [pauses]. What did you say?
Researcher:	Anything that's harder than math?
Student:	It's hard to write a skateboard.
Researcher:	Ok, but nothing in school that's harder than math?
Student:	Yeah.

Researcher: Ok. Now you guys have iPads in your classroom, do you feel like you're pretty good at using your iPad?
Student: Yeah, we keep care of them, we always clean the screen when like if it's like dirty with crumbs all over it, you can just clean it with the rag.
Researcher: And do you feel like you can use it pretty well to find apps and to play games?
Student: Yeah. I've learned some new apps, like my friend showed me and, it's about this game that you, you're supposed to count. And if it says to the two hundred, you're supposed to do that and it goes to the two hundreds? [gestures a pinch]
Researcher: So you pull your fingers together?
Student: Yeah and then you do this and try to find it and then you just pop the bubble and just move right there.
Researcher: Oh, you swipe your finger and pop the bubble. Is that Zoom? Is that what it is, the name of that game?
Student: Yeah.
Researcher: That's Zoom, ok. So do you ever use the computers in your classroom much?
Student: Yeah, I use them like sometimes every day, like we use, we don't really use them for math or anything. We just use them for like when it's Walk to Read, I use them after I group and it shows, it's called, it's like this thing that you read books on there? And then you have the answer like questions on there, but you do what you learned.
Researcher: So even thinking about it at home, what sort of electronics do you have at home that you use?
Student: I use my video cam.
Researcher: Oh, you have a video camera?
Student: Mmmhmm [affirmative]. My dad's thinking about getting a three, a Playstation 3, because we have a Playstation 2 and he really wants one.
Researcher: And do you use that very much? Or does he play on it mostly?
Student: No, my dad doesn't really like it so much. But he likes it, but he doesn't play it so much. Like whenever I get home, my mom gives me a snack and then she says, do you want to go on your video game or just like, do math first? So when I have to do that, I said I'm going to do math first.
Researcher: Nice, so you do math first do you?
Student: So I don't have to do it after dinner. I don't like doing math then.
Researcher: That makes sense. So you do that, do you use like a TV or a DVD player much?
Student: Well, we don't really use DVD players at my house, we only use VHS. We had one before but then I have no idea where it went. I don't know if it broke…
Researcher: Do you feel like….so are you the person that they kind of go to to help figure things out on that, or are you pretty good at it, or do you always have to get help when you want to watch something?
Student: No, I'm really good at it, it's just sometimes the CDs don't work and then, like I think my dad's magic, so he cleans the CD…

Researcher: And gets them to work?
Student: Yeah. That's what I think.
Researcher: Ok, nice. So in math class, you use your iPad for math pretty often, it sounds like with different apps and things?
Student: Yeah, like reading.
Researcher: I see. When you're doing math on it, what are some of the apps that you're using for math?
Student: So, I use Addimals, Math Bingo, Zoom, [pauses], what else…
Researcher: Addimals, Math Bingo, Zoom…
Student: I know this one but it's like this Pirate one, it's called Fast Math, you like…
Researcher: It's the one with the ship or something, right?
Student: Yeah! I know that one. And there's one that times you, like it times you and then you press it, and then it's like this timer game, like you can put it on a time. Like if you do it one minute, you have to do it.
Researcher: Oh, so you get to choose how long you want to do it?
Student: Yeah, I think.
Researcher: Like the minutes and things?
Student: Yeah.
Researcher: I see. And then it counts down while you're doing it?
Student: Yeah. So I have to go really fast.
Researcher: I see. So how do you do math without the iPad?
Student: Well, without the iPad sometimes people their iPads taken away, and they have to do it on the board, like, so pretend there's a board right here…
Researcher: Oh, like a whiteboard?
Student: Yeah. A whiteboard, and you grab a sock and a marker and then you could like, the teacher tells a problem to you and then you write a problem down and then do the proof drawing.
Researcher: I see. So you can use a whiteboard. You can also just use pencil and paper, I suppose?
Student: Yeah. It's kind of hard with the pencil, so it's kind of hard to draw circles. Because when you use a marker, you can just put a dot, dot, dot.
Researcher: And the same thing on the iPad, right?
Student: Yeah.
Researcher: On Educreations you can just tap and make a dot.
Student: Yeah, you don't have to like, circle, circle, circle, but on our pencils, we have to.
Researcher: Sure, that makes sense. So which do you like doing math on more? Do you like doing math on the iPad or the whiteboard or the pencil and paper?
Student: Well, I kind of like on the iPad.
Researcher: Nice. And why do you like it more on there do you think?
Student: Because you don't have to have a pencil and write on it. So you don't have to do that and you can just tap on it.
Researcher: I see. And do you feel, do you do much drawing with the pencil or with an iPad?
Student: Well, I like drawing, it's my favorite thing.

Researcher: Sure. So you like drawing with like colored pencils or markers and things?

Student: Yeah, my dad said he's gonna sign me up for something, I have no idea what it is.

Researcher: I see. Do you think you're pretty good at drawing? See, I've always enjoyed drawing, but I know I'm really bad at it, and I'm the only person that likes my drawings. Do you think you're a pretty good artist?

Student: My dad is, and he's trying to teach me how to like, put a cover on your painting.

Researcher: I see.

Student: And then like when, you have to let it dry for a sec, for like five minutes or so. And then you could like make something, like if you were, like my dad can make humans like really good humans. I'm really good at making flowers in a painting. So I make flowers.

Researcher: Ok, that's good to know. So you make flowers with a brush?

Student: Yeah, I do that and stuff.

Researcher: Ok. So thinking back to math, do you think math class is fun then?

Student: Uh, it's fun.

Researcher: And what makes it fun to you?

Student: I like doing like, making like, I just, when sometimes, when you're all done, the teacher gives you a hard math, really hard math, like a third grader. And then we do it.

Researcher: Got it. So she'll give you those, and you like it whenever you get to do those?

Student: And sometimes, she says you can make up your own one, and then I said, one time I did it and I said 2000 minus 200 [laughs].

Researcher: Did you figure it out?

Student: [nods head yes].

Researcher: It was hard, huh?

Student: Yeah. I was like, I'm confused. But I figured it out.

Researcher: I see. But that feels good to figure out the hard ones, you think?

Student: Yeah. Like, one plus one is two. And my mom said you should like, if you do one plus one, one plus one….wait, one plus one equal two and then you could just keep adding it and then you know like, I know eight plus eight is sixteen.

Researcher: Oh, I see. So you can learn those small ones and get up to bigger ones?

Student: Yeah. Like that.

Researcher: And so, do you feel like you have to work pretty hard in math class?

Student: Yeah.

Researcher: You do? And when you're working on a hard question, what are some of the things that you do to figure it out?

Student: Well, how I figure it out is like, I like doing proof drawings, but sometimes, like if it's a plus one or a minus, I could just say like ninety plus [pauses]…

Researcher: 90 plus…

Student: Ninety. I could do…

Researcher: 90+90? Ok we could do that.
Student: Yeah. And then I say, zero plus zero is zero. And nine plus nine is…[whispering to herself and using fingers], nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen. Eighteen, so that's one hundred and eighty.
Researcher: Oh, I see. So you can just write 18, but you know really it's a hundred and eighty, is the answer?
Student: Yeah.
Researcher: Ok, good. So you can kind of get some tricks like that and use the little things you know to solve the big ones?
Student: Yeah.
Researcher: Ok, great. Well, that sounds good to me, Emma. That was all the questions I had, is there anything I made you think about or that you wanted to say that you didn't get a chance to?
Student: Well [pauses]. I like reading chapter books, is my thing.
Researcher: Really? You like reading chapter books?
Student: Yeah, because I'm a really avid reader, like if you gave me a book I would read it.
Researcher: What was the first chapter book you read?
Student: It was like…it's over here, it's called Magic Buddy.
Researcher: Ok, and that was the first one you read, huh?
Student: Yep. And my teacher said, I think I should sound out the words and then…but my dad says you just should sound out the words but if it doesn't make sense you should skip on and when you're all done with the story you can just figure out what it means.
Researcher: That's what I do. Or you can kind of look in the sentence and see what word sort of makes sense there?
Student: Or you could get a book that's the same word, or you ask your parents what it was.
Researcher: Sometimes, a lot of times, you can figure out what a word means without actually know it.
Student: Yeah.
Researcher: Cool, alright, well thanks a lot, Emma.

Intensive & Strategic Student 2 – Aiden – Interview 2

Researcher: Even if you remember what you said last time, you can say it again or you can say whatever comes to mind.
Student: Ok.
Researcher: No right or wrong. So, first question is just this, do you like math class?
Student: Yes.
Researcher: You do? And why?
Student: Because you get to learn a lot about, what's that and what's that.
Researcher: Ok.
Student: And you know, then when somebody asks you, "I forgot, can you help me with this answer", you can show them a proof drawing, you can help them, you can say "24, I've had this problem in my class, so I can help a lot". But then when they say, and they could also say "hey dad, is this right" and you'll have to check it.
Researcher: Ok, that's cool. And so do you feel like you're pretty good at math then?
Student: Mmmhmm [affirmative].
Researcher: Ok. Good. I guess it's good to compare though. Do you think there's other subjects that you're better at than math?
Student: [pauses].
Researcher: Like reading or writing or science…
Student: Um, not really anything unless I do science out of a book.
Researcher: So, science out the book, you think…
Student: Yeah, because we have a science book at our house. We wanted to try something but our mom won't let us because it involves an egg and the microwave.
Researcher: Oh, so it's like a science experiment book? That's cool. So you feel like reading or writing is harder than math?
Student: Reading and writing…reading is kind of hard and writing is kind of hard, so I'm kind of good at each.
Researcher: Got you. So you guys have iPads in your class, do you feel like you're pretty good at using your iPad?
Student: Mmmhmm [affirmative]. I know games, everywhere, then if somebody needs help I can just show them, or if they can't find it, I just swipe two fingers down it, and then it's just like that.
Researcher: Ok, so you can swipe down two fingers and find the app?
Student: Yeah, you just shows a search, so you just type in one letter and it will show some games, so you have to keep searching until you find.
Researcher: Got it. And do you use the computers in your classroom also very much for math?
Student: Yes, we use them for our Walk to Read, and we use them for Weird, and for…that's pretty much.
Researcher: And what's Weird?
Student: It's where we do independent silent reading. We have beanbags so you can sit on there, we all take turns with jobs and stuff, right now I'm on the

bean bags, for like reading. And before I do reading, but today reading group got cancelled, because I have library. And so we had this reading group after lunch. So, that we do.

Researcher: So it sounds like you do reading on the computer, do you ever do much math on the computer that you can think of?

Student: Not, I don't really know because I don't on Walk to Read, just once when our Walk to Read got cancelled.

Researcher: Ok. So what other things like that do you use at home? Other electronics. Do you have an iPad or a computer at home or…

Student: No, I don't have a iPad or a computer, well, we used to but we broke it on accident, we have some computers at home. And we also have DS's, we've got iPhone touches, so yeah.

Researcher: Do you use a DVD player or a TV much?

Student: Yeah, we use the TV downstairs, there's going to be one in our new room that we're getting. Because we wanted to redo our room, so we had to take stuff apart and stuff like that, so right now we're still working on our room, my dad has lied to us twice.

Researcher: So when you have to take that stuff apart and hook it back together, like TVs and DVD players and things…

Student: We didn't have a TV when we first got up there, so right now they're putting cabinets, and then in between the cabinets are going to be one TV.

Researcher: I see.

Student: And then we're going to have beanbags and chairs…

Researcher: In the room?

Student: Yeah, where the TV's going to be. You got a bed, whoever, we did rock paper scissors because one of us each thought over who would want their bed right on, nearest to the toy bin, where they're going to go, so we each wanted it, so we had to do rock paper scissors two rounds. I won.

Researcher: Nice, that's lucky.

Student: And then one time we went to the circus, me and [my brother] got bored because we were waiting and waiting because sometimes it'll like take breaks, so we were like rock paper scissors, and that was at church or somewhere else, we kept doing rock paper scissors. Like we did a hundred times and the 101th time one of us would win.

Researcher: Ok, so you did it a lot of times and were you keeping count of how many times each one of you won?

Student: No.

Researcher: Oh, you just did it 100 times and then the last one was for everybody?

Student: We just did rounds and whoever won.

Researcher: Ok. So thinking back to your iPads and math class, do you like doing math on your iPad?

Student: Yes.

Researcher: Ok. When you're using it for math what sort of things are you doing on it?

Student: Math apps, like Bingo, Math Bingo. We have this other game I forgot its name, like…

Researcher: Addimals?
Student: Addimals, yeah. And it's where you have all kinds of animals. So you have to use one of the animals and swipe….
Researcher: So you use one of those animals to swipe?
Student: And use your math, then you go against this evil person, I'm almost done with it, so yeah, then you go against this evil person with a robot, every answer you get right, if you get it right before it actually cuts half of the chain, you'll get it gold. If you don't get it in time, it cuts each chain. You get it wrong and it's red and you add it to your puzzle. And then you also…
Researcher: So on that one, when you have to get it right before it hits the chain, how do you solve it whenever you…
Student: So this like, math line, with numbers. I'm up to fifteens, so you have to hurry up and get it. […] actually, a kid in our class, she goes "1, 2, 3, 4, 5" and then swipes, but I think it's easier to just tap and then lift because then you have more time instead of just going.
Researcher: I see. So when you're figuring out the answer, do you just know it in your head, or do you have to solve it very quickly?
Student: You have to solve it really quick. I sometimes have to use my fingers and I make it in time barely.
Researcher: Oh, just barely get it in?
Student: Yeah. It was like, one inch.
Researcher: Wow, awesome. Were you going to say, there were other things that you do math on on the iPad?
Student: There's other math games, but I forgot their names.
Researcher: No worries.
Student: Like Wings, Zoom …
Researcher: What about Educreations, do you use that for math?
Student: Sometimes, we use it for like drawing problems. But Geoboard is like more of a free choice, because it has rubber bands, but you can use it for math, just make the rubber bands into the letters, like on a clock it would be like that, you could just go [gestures radial arms of a clock] for a five.
Researcher: To show the time?
Student: Mmmhmm [affirmative].
Researcher: Sure, that makes sense. Then, but you don't always do math on the iPad, right? So how else do you do it?
Student: We also, do it on our boards, we sometimes do it on paper.
Researcher: Sure, on paper. So which do you like better, do you like doing it on the boards, or the paper or the iPad best?
Student: I don't really care.
Researcher: Could you do it on any of them you think?
Student: Mmmhmm [affirmative].
Researcher: Ok, that's good to know. Do you think math is fun, then?
Student: It is lots of fun.
Researcher: I see. And why? What makes it fun to you?

Student: Because you get to meet people on the first day of school, because you all like, you know their names because [the teacher] calls their names, you get to know people, because that's why on math you also get to learn a lot and help friends and it's really nice to help people.

Researcher: Ok, yeah. So when you're working on a problem, do you find you enjoy it and think it's fun, even when you're working on it?

Student: Yeah.

Researcher: And what about when you get it right?

Student: I don't really care.

Researcher: Do you feel different?

Student: I don't really care if I get it right, but our mom wants my brother and me to get A pluses a lot, so yeah.

Researcher: I see, so you try to. But if you get it wrong, then you don't, it's just kind of like "well, ok, I got it wrong", like that?

Student: Like, right now she doesn't really grade us. In third grade you get to A pluses, F plus is not a good one. I mean, it's like Fail.

Researcher: I see. That's true, it's not, is it? So do you feel like you have to work pretty hard in math class?

Student: Yes, you have to work, because on the iPad you really gotta work fast. I mean, because right now when I'm in there I knew what, because I've learned so much, about proof drawings in first second and not third yet. Because I'm not in third yet.

Researcher: Ok.

Student: Um, I've got called 4th grader, because I'm so tall…

Researcher: I could see that. So you were saying it's hard because with the iPad you have to go fast…

Student: Mmmhmm [affirmative].

Researcher: But then you know how to do proof drawings…so is it because you're trying to do a proof drawing, but you don't have time?

Student: On the iPad you can't do proof drawings, unless you're like on Geoboard.

Researcher: Or, Educreations?

Student: Yeah. Because on the apps you don't time to do it in your head and you don't know what's going to come next.

Researcher: I see. So how do you do it? Do you just guess?

Student: Sometimes, on some games if you still add and doesn't make sense to you, you kind of have to guess. Or, sometimes on Zoom though, it has this help thing so you just tap on it and it says, "yes" and you hit yes if you need help, so take it to you and then you just have to pop the bubble.

Researcher: Ok. Now if you think back to when you were working on a hard math question last, when you're working on a hard math question, what sort of things do you do to figure it out?

Student: [pauses].

Researcher: You mentioned you do your fingers sometimes?

Student: Yeah, I use my fingers sometimes, proof drawings sometimes, but on the iPad you have to think it in your head.

Researcher: Think it in your head, ok. And when you're solving that and figuring it out…
Student: Sometimes on Wings I just hit pause, and then I can actually think.
Researcher: And then what do you do, do you just sort of sit and think about it?
Student: Yeah, because you can see the things before you hit it. Or you can, if you're about to like done, off and there's no more, and you can't see the circles you can actually just like ditch, just turn so hard that the wing just goes up and skips the problem.
Researcher: Oh, I didn't know you could do that.
Student: Yeah.
Researcher: That's kind of a nice little trick.
Student: As long as it doesn't flap, otherwise it hits.
Researcher: Got you. That's tricky. But even with a pencil and paper, so you can draw it out and things like that, do you ever have to think back to problems that you did before?
Student: Mmmhmm [affirmative].
Researcher: And how does that work?
Student: I keep a lot of problems in my head, and then if I want to finish a story on something I have to put it in my head or put it on the paper. Or sometimes I just put it on a sheet of paper, the answers on Addimals, because you have to work fast.
Researcher: So that way, you can have your paper and use it?
Student: And to actually put the same answers that you're just working on practicing. But it's kind of like cheating.
Researcher: I see, because you've got it beside you when you're playing it.
Student: I'll either just do one problem, I only do one because otherwise it's cheating, the whole game.
Researcher: I see, that makes sense.
Student: Then you don't want to cheat, because you don't really get your math done.
Researcher: Ok. Well, Aiden, was there anything else that I made you think about, or that you wanted to say and didn't get a chance to?
Student: No.
Researcher: That was really great, thank you. You're getting good at talking about math.

Intensive & Strategic Student 3 – Noah – Interview 2

Researcher:	So there's not any right or wrong answer to any of these questions, it's just whatever you think. So you can talk about whatever comes to mind, ok? My first question, Noah, would be, do you like math class?
Student:	[nods affirmative].
Researcher:	You do? Why? Do you feel like you're good at math?
Student:	It's fun.
Researcher:	It's fun, ok. Do you feel there are other things you're better at than math?
Student:	[shakes head no].
Researcher:	No?
Student:	Drawing.
Researcher:	So you're better at drawing than you are at math?
Student:	[nods affirmative].
Researcher:	What about things like reading or writing, that sort of thing? Are they harder than math to you?
Student:	[nods affirmative].
Researcher:	I see. Good. I noticed you guys have iPads in your classes, do you feel like you're pretty good at using it so far?
Student:	[nods affirmative].
Researcher:	Is this your first time ever using it in school?
Student:	[nods affirmative].
Researcher:	It is?
Student:	Using an iPad at school.
Researcher:	What did you use before?
Student:	iPods. At Big Pine. iPods.
Researcher:	Oh, at Big Pine. So they had iPod touches?
Student:	Just iPods.
Researcher:	Just for music and stuff like that?
Student:	Well, it had games on it.
Researcher:	Oh, ok. Had games on it. Sure. Were they using it in class then, for like math class?
Student:	No. We just used in like spelling and stuff.
Researcher:	Oh, to do your spelling and stuff. Do you use the computers in the classroom much here?
Student:	[nods affirmative].
Researcher:	What other electronics do you feel like you're good at using?
Student:	Like my phone.
Researcher:	Oh, so you have a phone? And you're good with that. Other stuff at home, like a dvd player, a tv and stuff like that?
Student:	TV, DVD player.
Researcher:	So like gaming, like an Xbox or stuff like that?
Student:	I have a Wii, but it's not set up yet.
Researcher:	A Wii? But it's not set up.
Student:	We have to buy a cord or something for it.

Researcher: Oh, I see. Do you feel pretty confident on setting that sort of stuff up usually?
Student: [nods affirmative].
Researcher: I see, good. So do you like using the iPad for math in class?
Student: [nods affirmative].
Researcher: Yes, ok. So, how do you use it for math?
Student: Hmmm.
Researcher: So, you're using it for math, but do you just play games on it?
Student: You can play math games and reading games.
Researcher: Sure. There's also another app I've noticed called Educreations, have you seen that, where it's like the whiteboard and you can draw on it? Have you used that for math yet?
Student: No.
Researcher: You haven't. Ok, cool. You can also use it for math too, I've seen that before, where you can just sort of draw math problems on it. So what sort of apps have you been using for math, then?
Student: I don't really know any of the games.
Researcher: Ok, no worries. There's a few I guess I've seen. Addimals, have you played that yet?
Student: [shakes head no].
Researcher: Wings?
Student: [shakes head no].
Researcher: Splash Math, have you played that yet?
Student: [shakes head no].
Researcher: No, you haven't played that yet? Counting Money? Did you do that one on there?
Student: [shakes head no].
Researcher: I'm not sure if we still have it or not.
Student: We do.
Researcher: Sushi Monster?
Student: Yeah.
Researcher: You've done Sushi Monster. Ok, that's all I can think of offhand. Oh, Math Bingo?
Student: Mmmhmm [affirmative].
Researcher: You played that one too? Ok. Do you do math without the iPad then, also?
Student: [nods affirmative].
Researcher: And how do you do that normally?
Student: Get a board and just write down the problem.
Researcher: Ok, so get a whiteboard and write it down. Do you do it with pencil and paper too, pretty often?
Student: [nods affirmative].
Researcher: And which do you like better, math on the iPad or math just on a whiteboard or pencil and paper?
Student: Math on an iPad and whiteboard.
Researcher: Ok, so iPad and whiteboard are your two favorites?

Student:	[nods affirmative].
Researcher:	Ok, so why do you like those better?
Student:	[pauses].
Researcher:	Is it more fun to draw stuff than it is with a pencil?
Student:	Mmmhmm. [affirmative]
Researcher:	Ok. I see. Now, just thinking about math, do you think that math is fun usually?
Student:	[nods affirmative].
Researcher:	What makes it fun though? What's fun about it to you?
Student:	That sometimes you can write down your own problems.
Researcher:	Sometimes you can write down your own problems, ok. Yeah, that is kind of fun to be able to do that. Does it feel good when you get a problem right, or you figure something out?
Student:	[nods affirmative].
Researcher:	Ok. Do you feel like you have to work pretty hard in math class?
Student:	[nods affirmative].
Researcher:	You do? Is it satisfying to you when you work hard on a problem and get it?
Student:	[nods affirmative].
Researcher:	What does it feel like when you're working hard on one and you still can't figure it out?
Student:	[pauses].
Researcher:	That's a hard question, isn't it? Well, let's think about that. Can you remember a hard math problem that you worked on recently?
Student:	[pauses].
Researcher:	Hmmm…I'm trying to think of something, where the last time you had to work hard…
Student:	[pauses].
Researcher:	And maybe just think back, have you ever had a problem where you had to work really hard to figure out?
Student:	[nods affirmative].
Researcher:	And when you're doing that, how do you think about it to answer it?
Student:	[pauses].
Researcher:	What do you do in your brain to have to figure things out?
Student:	[pauses].
Researcher:	Are there techniques that you …
Student:	Mmmhmm [affirmative].
Researcher:	What sort of things do you do?
Student:	Use my brain sometimes.
Researcher:	You what?
Student:	Do it in my head sometimes.
Researcher:	Do it in your head sometimes, ok. And when you do it in your head, do you just remember what you did before?
Student:	Mmmhmm [affirmative].
Researcher:	Alright. Is there anything else that you do sometimes? What about when you can't do it in your head?

Student:	Write it down on a piece of paper.
Researcher:	Ok, write it down. Well, is there anything else you can think of that you do when you're working on a hard problem?
Student:	[shakes head no].
Researcher:	No? Ok. That's all the questions I had, was there anything that I made you think about or that you wanted to say that you didn't get a chance to?
Student:	[shakes head no].
Researcher:	Great, Noah, thanks a lot.

Interview 2 Teacher Transcripts

Intensive & Strategic Teacher – Interview 2

Researcher: A lot of this, as far as your history teaching math, we don't have to, that hasn't changed.

Teacher: That hasn't changed [laughs].

Researcher: So we won't be as long. I guess first off, personally, like yourself as a student, how confident in math were you?

Teacher: As a student? Good. Math was like my best subject, and I loved it, yeah.

Researcher: And do you still feel that way?

Teacher: I love teaching math.

Researcher: Ok.

Teacher: I guess I have just always enjoyed math, and so, yeah, it's just something I really enjoy.

Researcher: Ok. So you feel confident teaching it then?

Teacher: Yeah.

Researcher: Are there other subjects that, as a student, you were better or worse at than math?

Teacher: Probably, as a student, math and reading were my best subjects. Probably the one that I liked the least was the hardest was writing.

Researcher: Ok. That's not uncommon.

Teacher: Yeah.

Researcher: Do you feel, as a teacher, how does that play out? Are there some subjects you feel like you're a stronger teacher at than others?

Teacher: I think probably reading and math I'm better at. And I think with the new curriculum, I think it's easier to teach than the old way where we just, kids were kind of taught there was one way to do things, I think with Math Expressions and you teach the kids a number of strategies and then they choose the one that works best for them, I really like that. I do wonder a little bit about Math Expressions and how developmentally appropriate some of it is. I think the pacing might be a bit much for some 7 and 8 year olds, and that worries me a bit.

Researcher: Do you think that's going to change, how is that changing with the Common Core version?

Teacher: It's definitely amped up. I notice a difference with the Common Core aligned Math Expressions that it's amped up a lot, and what's really got me thinking about that is, because I work with the strategic and intensive math students and I know what the third grade curriculum looks like, and it worries me for them because they just need more repetition and a little slower pace. And so many of them have really gained confidence as mathematicians, and I worry that that going to change. I know, gosh, years ago I taught 4^{th} grade, and some of the stuff we teach in 4^{th} grade is now taught in 2^{nd}. And I really do wonder about the development aspect of all of that.

Researcher: That's certainly true, like you say, the students that are having, that will lose it, that will be able to do it, and then lose it after a day, but then just need it reinforced for a while until it sticks.

Teacher: Yeah.

Researcher: Yeah, that's hard. And so, next year then, they're switching over? Or you guys are switching over to the Common Core aligned?

Teacher: We did a couple years ago, yeah.

Researcher: Oh, I see.

Teacher: We did a couple years ago, switched to Common Core and we noticed a big difference.

Researcher: Ok, so that switch occurred a couple years ago then. So right now, they're still kind of, they're in that.

Teacher: They're in the Common Core, yeah.

Researcher: But at the same time, next year in 3rd grade they're already on to, I guess they probably start out with what, multiplying two digit numbers?

Teacher: They start with multiplication and then I know that another thing that the 3rd graders are doing a lot of is elapsed time, and that is, that's a challenge. It's really, you really have to have such a firm understanding of telling time and then you also have to really have your, really strong math concepts and it's tricky. Anyway, I think that, I think with Common Core probably what we've seen too is that the gap has become wider. Those students that are proficient and strong in math, they're just flying, they're sailing, doing awesome. And the kids who need more repetition, and who have some holes, they are, it's much more difficult for them to keep up the pace.

Researcher: Ok, so turning over to technology then. So technology at home, DVD players, TVs, computers, how confident do you feel using it usually?

Teacher: Pretty confident.

Researcher: Ok. Are you the one in your house that takes care of all that stuff?

Teacher: I will be shortly, currently I have son who's a senior, and he kind of does everything for us, and we have teased him that we can't let him go off to school until he's got me proficient. My husband is not, he is not very tech savvy, I guess you would say. Not interested in learning it.

Researcher: That's really the key.

Teacher: Yeah.

Researcher: Ok, so are you also confident in the classroom then, using the technology you have here?

Teacher: Yeah.

Researcher: Ok, let's see, what sort of things do you have. You have computers that you, are there certain websites that you use or programs that you use?

Teacher: There are some programs that we use, and I actually use more reading programs on the desktops and more math, we have more math apps on our iPad that are individualized and each student has an iPad. And some of the reading programs are only available on the PCs. So, yeah.

Researcher: That's good to know. And you also use the doc cam pretty often, the whiteboard…

Teacher: Yeah. Yeah, and the interright board all the time, yeah. I like that, I think it's captivating.

Researcher: Ok, that was kind of interesting. So the whiteboard, you feel like that it catches their attention more than just regular whiteboard.

Teacher: More, much more. I think, much more. I think it's bigger, I think it's almost like a movie screen for them. And I don't know if the light plays into that as well and I think it's….

Researcher: Because really when you're writing on it, it's not functionally different than writing on a whiteboard.

Teacher: But it does seem to be much more captivating and attention grabbing.

Researcher: Interesting.

Teacher: Yeah. Maybe it's this generation, they're screened.

Researcher: Maybe so. It's a screen and you look at a screen or something.

Teacher: Yeah.

Researcher: Maybe we just need to put better frames around our whiteboards on the wall.

Teacher: Yeah, I think so too. Have a light or something.

Researcher: Yeah, have a light on it, then just write on it.

Teacher: Yeah.

Researcher: Alright, let's see, where were we. And so, the iPads that you guys have, do you like using them in math class then? It sounds like it.

Teacher: Yeah, I think the kids are so engaged and they can work at their own pace. I think, yeah, it's great. I can't imagine not having them now.

Researcher: Yeah, they seem to like them pretty, quite a lot.

Teacher: Yeah, they're so savvy with them too.

Researcher: Oh really? So you mean being able to…

Teacher: Use a touch screen, figure out how games work, find out if there's little twists or turns or challenges that they need to meet in order to like build their nest, they totally figure it out.

Researcher: Oh, ok, so like in Wings, where they have to do all the weird little things to…

Teacher: Yeah.

Researcher: Ok. Do you think it affects your teaching then of math?

Teacher: I think it makes it more fun actually. I think it's, I think to have that go-to piece, you know just for example, I often use it first thing on some days, as the kids are streaming in, and then they're all getting her at different times, I give them five or ten minutes to warm up. And I think it encourages kids to hustle over and get to math, get seated, get rocking and rolling. And then I also think, for early finishers, it's great because they have something super engaging math-wise to do, that they enjoy. So yeah, I think it's great. I think it makes management really good, easier.

Researcher: Sure, so getting them transitioned and settled in.

Teacher: Yep.

Researcher: So, just thinking about interest in math, as a student you enjoyed doing math, but did you think it was interesting or was it just sort of…

Teacher: I thought it was interesting up to a certain point. I can't remember if, it was probably junior geometry, when I probably took that I was sophomore in high school, and I wasn't really interested in geometry, and I didn't really have a very good teacher, and I think my math interest did begin to wane then a bit. But I think a huge part of it was that I didn't have a very good teacher.

Researcher: Ok. As a teacher, then were you , did you find it interesting to teach when you first started? Or has that changed over time that you've read of?

Teacher: To teach math? When I first started, yeah.

Researcher: Or even just really I guess the subject itself of math, once you've taught it for a while, did it affect your interest at all?

Teacher: No, I don't think it affected my interest, just because I've always really liked math and really liked numbers. And every group is a little different, you know, their strengths and their weaknesses and how they see it. And then, just over the course of my career, I've had so many curriculums, so it's been ever changing and that's been pretty interesting too. I think teaching fourth grade math is more fun than teaching little kids math because it's more interesting. So I do think that a little higher grade level math is a little more fun.

Researcher: Ok. As a teacher, more fun to teach it.

Teacher: Yeah.

Researcher: So do you find yourself putting in more time to math lessons compared to other subjects?

Teacher: Reading is definitely the most, the most preparation, and I think it's because we have so many reading groups, and so you spend a lot of time preparing materials and differentiating all those materials. The math workbook we have is fabulous, and so that really cuts down on preparation time. And so, you know, it is significant planning, but not as much as reading.

Researcher: And do you feel like the iPads affect your planning for math lessons?

Teacher: Maybe a little bit, just aligning which apps correspond with what you're teaching.

Researcher: Ok, I've got you.

Teacher: Yeah.

Researcher: So, do you find yourself having to work to integrate them into the lessons, or is it easy to integrate them, harder to integrate them?

Teacher: It's become easier as we've become more familiar with the apps, yeah.

Researcher: Alright. I guess the only other question would be, as far as refreshing yourself on the material, do you find yourself having to do that much as the curriculum changes? And how do you do that usually?

Teacher: You know, I think as the curriculum changes, yeah, I think it really is important to stay refreshed. A couple things I've done is taken a few of the DMI courses that the district offered, because those course really have me working as a math student, and so I think it's good to kind of take yourself back to doing problem solving and thinking through math and talking math. And then, just ever changing groups. This year, we're particularly having a group that is strategic and intensive learners. I've really had to take a look at how I teach and maybe scaling back the number of strategies that I'm teaching to kids, so they're not overwhelmed. And then constantly staying current with assessment on what they know and filling that in. And then this group has been particularly challenging because we've had so many kids move in and out. And so many of the new kids haven't had Math Expressions or are significantly behind in math too, and so just trying to figure out where their holes are and catching them up as best we can has been, you know, a challenge and takes assessing and just finding out how you're going to reach those kids.

Researcher: Do you, do the iPads assist you at all in assessing their knowledge do you thing?

Teacher: You know, I really don't use those as an assessment tool. Yeah.

Researcher: Great. Well, that's everything I had, were there any thoughts you had, or things I made you think about or that you didn't get to say?

Teacher: No, I don't think so. I think that one of the things I do have as a goal is to use some of the iPad apps more as an assessment tool. You know, just not there yet.

Researcher: Yeah, no worries, it's a lot of work.

Teacher: Yeah.

Researcher: Ok, great. Thank you.

Teacher: You bet.

<u>Benchmark Teacher – Interview 2</u>

Researcher: Rough day today?

Teacher: Lately, it's weird, it cycles. They're super needy, then it will nicely taper off and you're like, alright, they're getting ready for third grade, then boom.

Researcher: I always forget about that—by the time they get to third grade a little less needy.

Teacher: And they are better, but they're really needy. But that's ok.

Researcher: Some of this, like how long you've been teaching, we've already talked about that. So, how confident with math do you feel usually, yourself?

Teacher: Personally?

Researcher: Yes, sorry—personally, like you yourself were doing work on math.

Teacher: I feel a lot more confident now that I'm more mature and have taught math many years. And I have the foundational, honestly, the skills, because I think we were just rushed through math so quickly. And taught how to do the math without the knowledge of the basics of it. You know, kind of like the algorithms, specifically. So, I think the kids who were lower, like me, I didn't think I was a great math student at all, were just kind of pushed through and rushed through and not given the necessary time to build that benchmark base….

Researcher: Sure, base knowledge, or understanding really, I guess.

Teacher: Yes. I really feel that. All the way through high school even.

Researcher: So just always sort of barely holding on…

Teacher: Barely holding on, but not given the extra time or made to feel like "you're fine, you've got it" just provide some more practice, you know, modelling—no, never. Yeah.

Researcher: So, you feel more confident teaching it then?

Teacher: Yes. Super confident. I think even at the beginning of my teaching career I felt fine because I was teaching the lower levels, but I think I'm much more methodical and I think I have much more background knowledge to share with them now that I totally understand. And I remember how I thought—actually sometimes I think it helps me that I was a struggling mathematician because now I can identify more with them.

Researcher: That's true—so you remember what went wrong for you...

Teacher: Yeah, things I couldn't understand or get, yeah.

Researcher: And are there other subjects that you're better at or worse at than math, do you think?

Teacher: No, I think I'm good at all subjects, there's just some that you take a nice liking to because I guess it's a nice challenge, I think. I love science, as well, because it's again very methodical and it's scientific and knowledgeable, it's fun. I like reading too. But that is more…well, that is also methodical too. So, that is kind of interesting to think of it that way. So no, I don't think I'm better at any of them, but I do feel like I have a rich understanding of the math ideology, basically, now.

Researcher: So, that's more from like a teaching perspective. Personally then, do you feel like math was your hardest or worst subject?
Teacher: Math was the hardest.
Researcher: Was there a subject in your student career that was your best one?
Teacher: So, language arts and writing, I'm fantastic at. So where I would struggle with math, I would help college writers, because my paper would go in for review and they'd be like, "it's done", and I'm like, what seriously? Good. It's ready to submit. I loved that.
Researcher: That's not an uncommon thing, right, to kind of have it be one or the other.
Teacher: I know.
Researcher: How confident are you using technology at home?
Teacher: It's getting better, but I'm still not that great. Even VCRs and all the stuff that…
Researcher: Well, you're lucky, VCRs are not going to be around for much longer.
Teacher: I know, they're going to be gone. I know, hooking up all the blu-rays and the speakers, and all your technology that goes with everything else, it's getting better. We do have lots of iPads, we have two iPads in the house, two iPhone now, one PC computer, we have two Apples with our kids, Apple computers. We're getting better. But still, no, I'm not very techie.
Researcher: Are you better in the classroom then, do you think?
Teacher: Yes.
Researcher: Why?
Teacher: I think because I use them every day. Whereas at home, you just don't use them all the time, every day. Whereas here, I use all my technology every day it seems.
Researcher: So, the doc cam, the whiteboard…
Teacher: The iPads. I incorporate the iPhone sometimes with teaching too. Apps I've downloaded.
Researcher: I see, just your own iPhone.
Teacher: And printing, wireless, and then just PC.
Researcher: Ethan had mentioned he liked, there's a website he's been using a good bit on the computers…
Teacher: Yep.
Researcher: He apparently holds the record for the most friends or something?
Teacher: He does.
Researcher: What program or site is that?
Teacher: I think that's his Educreations one.
Researcher: Oh, it's the Educreations website.
Teacher: Yeah, through our math expression.
Researcher: I thought he meant the one on the iPad, the app Educreations, I thought he meant that app.
Teacher: Oh no, I think it's the one on the computer. Because we're putting him on third grade and he's doing some of the multiplication, like he's on, yeah.
Researcher: So, do you like using the iPads in math class?

Teacher: I do, yeah. If I had to take them away, I'd be really sad, because I do think it adds an element of, it just sparks their interest so they stay a little more focused and you can adapt it and, like you've seen, you can reapply what you already know, but in a different fashion so you're….I guess the time on task is much more focused, I think. I do.

Researcher: Do you think it affects your teaching then?

Teacher: It has affected my teaching.

Researcher: How so?

Teacher: Well, from the beginning at first, I was really nervous using them, because I always thought there's going to be a malfunction, and it's going to have downtime, the kids are going to go crazy, what do you do. And I just didn't want to go there at first. But then as soon as you move through those and, you know, you have good classroom discipline, and you become more competent, then I really have them incorporated every day, in terms of thinking what I'm going to do with them, how is that going to impact what we'll do, how much time am I going to allow. So it does, it really…I don't know, it makes me think about how I'm going to integrate them, and if it's acceptable for that day, or not, or whatever. Whereas before, I wouldn't have even…

Researcher: I see. So as far as being acceptable, do you feel like you're having to work hard to integrate them?

Teacher: A little bit.

Researcher: It's kind of hard to integrate them?

Teacher: At first it was, because I didn't want them to be on things that weren't appropriate and a waste of time. But now that we have most of the programs that we like downloaded, and they are working, for the most part. Like you saw with Splash Math, with the double screen.

Researcher: Sure, having that graphic problem.

Teacher: There's always that stuff, that just bugs you. So yeah, prep time has been more, but in the last year, it hasn't been. I feel like there's …

Researcher: Sort of a hump thing.

Teacher: Yes, the frontloading paid off. I think there's definitely a learning curve, and also finding out which programs serve you the best. Or the apps, I guess I want to say.

Researcher: So, as far as interest in math, as a student growing up, were you interested in math, and it was just difficult or was it just…

Teacher: Yeah, I don't think I was really interested in math from the get-go. There wasn't an interest sparked at all from teachers. And I had some good teachers, and some so-so, of course. But it really did hinder me later on, going into the sciences and such. Like, my dad was a physics/chemistry teacher, but I just did not have the background knowledge for math and such, so I felt like I couldn't even take those classes. And that was bad, because I probably would have been fine, and my dad tried to get me to, but I didn't . Now my oldest sister, she's a pharmacist, so she did all that stuff and was fabulous at it. But she is much more inclined with math than me.

Researcher: Did you get more interested in it after teaching it for a while?

Teacher: Yeah. And also, I think you all, at the college level, are providing so much more of a nice enrichment for the teachers to learn how to teach math than what I got, it was horrible. I went to Montana State and the methodology and even just the practices taught were so, it was just all algorithms again.

Researcher: And so, this is from your experience with student teachers coming through?

Teacher: Yes, and what they've told me, and how they're prepared, and they'll tell me, "yes, I've seen that, we've been told this, this is not new, I haven't actually taught it yet, but", yes I have heard them say that. I'm happy to hear that.

Researcher: That's good to know.

Teacher: It's carrying over.

Researcher: You mentioned having to put in a little bit more time up front to get the iPads going, do you feel like you have to put more time into your math lessons than your other lessons?

Teacher: It's pretty comparable to reading lessons, with reading groups you have to have all the supplies specific to that individual for their reading level, so that's pretty time consuming. So this is pretty comparable. Science is a little bit of prep too, getting all of your supplies. Social studies is the easiest.

Researcher: I see.

Teacher: And then the writing parts, that just goes right around with reading, so it's not….

Researcher: So math is as hard to prep for as reading is, because of the different levels?

Teacher: Yeah.

Researcher: Especially when you have students that are already working on third grade.

Teacher: Mmmhmm [affirmative], exactly.

Researcher: Do you find yourself having to refresh yourself on new material much? How often do you have to look something up to refresh yourself on it?

Teacher: Yeah, so the first couple years of teaching this new program, I had my manual by me almost all the time. And I had a cheatsheet of key ideas for me to hit, because it's so meaty. And it's lovely, but there's so much to it that I didn't want to just miss. Now I don't even have my manual by me, I know it and feel confident now, but this is my fourth year teaching it. So yes.

Researcher: So you get it down pat and find you're not having to switch it up too much.

Teacher: Not too much, although they switched to the Common Core version, which is really great. So yes, I had to familiarize myself with a couple of the key areas that maybe I hadn't been hitting as hard, but they want.

Researcher: Do you remember what any of those were off hand?

Teacher: Um, one of them would be the three digit addition and subtraction. They want them to have that really ingrained before they go into third grade, because they start off with multiplication now with the Common Core. Where as before they started off with three digit addition and subtraction. So I made sure to hit that, but maybe not as strongly, but now I know I have to really hit that prior to them, because they're going to scoop into multiplication and go back to three digit addition and subtraction after they hit multiplication first.

Researcher: So, multiplication of three digits?

Teacher: Just two digits. So the whole idea of multiplication comes first. So that's one area. And one area that they took away from me was time, in terms of really specific increments. They only want me to teach to the hour, half hour. Really, only hour and half hour.

Researcher: So no telling time with minutes?

Teacher: No. Not extra, like 12:37, no. Before I did that really specifically. Also, coins—really hit hard prior with quarters, nickels, dimes, pennies, really hard. And it's not so much this year. They only had a few lesson on it, so I'd really beefed it up.

Researcher: Ok, so you…

Teacher: I feel like that's not enough. Because if they only receive a few lessons in first grade and a few lessons in second…yikes.

Researcher: So in third grade they're not still doing addition of money?

Teacher: Not a lot. They are hitting it, but not as many lessons on it. It is interesting.

Researcher: That's interesting too, because working with some of these other students that are doing that, even though they can do the math problem behind it, for some reason with coins it can be…

Teacher: I know, it messes them up a bit.

Researcher: But once Noah, I was working with him, once he kind of figured out which each coin was and what it was worth, he was better, but it was still pretty tricky to begin with.

Teacher: Yep.

Researcher: And lots of good skip counting skills there.

Teacher: Oh, very good skip counting. Yeah, I'm trying to think if there's anything else…

Researcher: Yeah, that's all the questions I had, so I don't know if there's anything else that you've thought about or that I made you think of.

Teacher: One thing I like with the new common core is that first with our new math expressions we taught addition just singular, very easy specific singular addition problems, and then, like in unit three finally hit subtraction. And I thought, why in the world are they doing that. So now with the common core we hit addition and subtraction in unit 1.

Researcher: So they can start tying them together pretty early on.

Teacher: Exactly. So that's one key thing I hit when I first started looking at that program, I was like, "yes", because that makes total sense.

Researcher: Good to know. Ok, well thank you.

Teacher: I don't know if I answered very well, but…

Researcher: Oh, that was great, thanks.