SCREEN-CAPTURE INSTRUCTIONAL TECHNOLOGY:

A COGNITIVE TOOL FOR BLENDED LEARNING

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Abstract

Little empirical investigation has been conducted on high school students and teachers using online instructional multimedia developed entirely from the classroom teacher's traditional live-lecture format. This study investigated academic achievement, engagement, preference, and curriculum development using screen-capture instructional technology. A 2-group experimental pretest-posttest was deployed over a four week period on secondary Algebra students accessing their teacher's screen-capture instructional multimedia both inside and outside of the blended classroom. Students who learned Algebra through the screen-capture methodology showed significantly greater gains in math performance than did the students in a live-lecture class, even after controlling for prior levels of math performance. On average, students viewed each online instructional multimedia lesson two and a half times within the classroom using mobile multimedia devices and an additional one and a half times at home. Additionally, a psychometric student engagement instrument (SEI) measured the participant's cognitive and psychological engagement. The screen-capture students demonstrated increased levels of cognitive engagement from their self-regulated learning and added psychological engagement from feeling less inhibited when asking their classroom teacher face-to-face questions. Ninety-three percent of the students indicated their preference for learning Algebra in the future using their teacher's screen-capture instructional multimedia. During the initial lesson development phase, the classroom teacher incorporated the instructional technology as a new tool to evaluate her Algebra instruction and also discovered the online component as an instrument for collaborating with a fellow classroom teacher. This study suggests that a teacher's screen-capture instructional technology can be used toward establishing a blended learning environment within the secondary classroom.

Dedication

This dissertation is dedicated to my entire family, especially my wife Carlee, who managed to take such great care of our amazing children Ellie and Emmett throughout this process. In addition, I would never have had the confidence to take on this challenge if it was not for my mother Karen's Ph.D. accomplishment and the work ethic instilled in me as a child from my father, Bud. Finally, I am beholden to the entire Wilson family for their ongoing support.

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CHAPTER 1

INTRODUCTION

In the climate of accountability, K-12 schoolteachers and administrators are challenged by ongoing federal and state requirements to increase student academic achievement. As these academic institutions comply with annual high-stakes testing mandates, new computer-based instructional technologies are being considered as possible solutions to increase student achievement and testing outcomes (Kingsley & Boone, 2008). With the recent proliferation of multimedia devices and broadband networks within K-12 facilities, online instructional multimedia has become a viable alternative for the classroom setting. As a result, school districts and academic policymakers are incorporating online instruction as a replacement for current teaching practices. Secondary schools are augmenting traditional teaching practices by incorporating online instruction for recovery purposes, remote learning, and teaching alternative curriculums.

With the rapid growth of computer-based instruction, online learning has the potential to replace many traditional forms of K-12 instruction. In 2009, over 3 million K-12 students across the nation were enrolled in online courses (Horn & Staker, 2011), while three quarters of K-12 school districts (74.8%) had online curriculums and more than half of the remaining districts (15.0%) were planning to use some form of online instruction in the near future (Picciano & Seaman, 2009). Christensen, Horn, and Johnson (2008) estimated that by the year 2019, about 50% of all high school classes will be delivered online and by 2024, 80% of secondary courses will be online in a student-centric manner.

Evidence supporting the effectiveness of K-12 online curriculums is, however, extremely limited. School districts are increasingly using Internet classes for instruction, yet there is not adequate research indicating whether the instruction is helping, hindering, or having any affect on learning (Figlio, Rush, & Yin, 2010). Though a 2009 U.S. Department of Education (USED) meta-analysis claimed, "On average, students in online learning conditions performed better than those receiving face-to-face instruction" (p. ix), there is admittedly very little data to support these claims within the K-12 environment. The authors of this meta-analysis also stated that caution should be used when generalizing for the K-12 population, as most research on purely online instruction has been conducted with college level students outside of traditional classroom settings (USED, 2009).

Educational research studies on college-age students do not necessarily transfer over to adolescent learners. For example, middle and high school age students experience rapid cognitive development as they mature, but lack the brain development necessary to balance reasoning and planning (Woolfolk, 2007). Research by neuroscientists into the brain's development reveal significant differences in the way adolescent students process information compared to college-age learners. When learners acquire content from audio and visual stimulus, the new information is held within the brain's working memory (Sweller, 2005). Working memory, necessary for long-term retention and memory recall, is mainly processed in the frontal lobes of the brain and is not fully operational during adolescence (Goldberg, 2001). As humans mature, their brain functions shift toward higher-order processing in their frontal lobes. This area of the brain is believed to contain the rational system of thought, which is a prerequisite for higher-order thinking (Sowell, Thompson, Holmes, Jernigan, & Tofa, 1999). Using magnetic-resonance imaging (MRI), researchers are able to track the brain's activity as new information is being processed. During the ages of 12 through 18, the frontal lobe is rapidly increasing in brain development. Brain activity in the frontal lobe increases from nearly 50% of capacity to over 80% at the age of 18, with the remaining 20% of development completed by the age of 24 (Sousa, 2006).

Though research into adolescent brain development has advanced, its applications have not always transferred into the K-12 classroom. Many secondary classroom teachers are uncertain how to implement new instructional practices or technologies that can replace their outdated forms of classroom instruction. When educational materials are presented by teachers in drawn-out lectures or from a textbook chapter, overall student learning is likely to be minimal (Mayer, 2009). Even though the lecture has been the mainstay of classroom instruction and can be done so in an engaging matter, its overall effectiveness has being questioned, especially with its inherent constraint of time and location (Griffin, Mitchell, & Thomson, 2009). In addition to providing instruction that is neither uninspiring nor engaging, most secondary teachers rely on instructional practices that do not meet their students' cognitive requirements. Kingsley and Boone (2008) noted that students' difficulties in learning are often attributed to an incompatibility between the teacher's instruction pedagogy and the learners' needs.

Background

Educational reforms using instructional technologies within the K-12 classroom are nothing new. While some applications of educational technology have become omnipresent, other technology implementations have been short-lived. The common chalkboard is one of the earliest instructional technologies to have survived the last two centuries, outliving nearly all other classroom reform measures. Though one might deem the chalkboard as a piece of classroom furniture, the introduction of the technology around 1801 (Coulson, Gwartney, McCluskey, Merrifield, Salisbury, & Vedder, 2006) revolutionized classroom instruction. This large and inexpensive reusable writing surface, fabricated from slate with writing utensils made of calcium sulfate (chalk), forever changed how information was presented to a classroom of students.

Many seemingly superior technologies have not faired as well within the K-12 landscape. In 1922, Thomas Edison declared, “The motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks” (cited in Mayer, 2009, p. 11). During the 1930’s, the radio was similarly predicted to revolutionize education by bringing the finest teachers over the airways into the classroom and forever replace blackboard instruction (Cuban, 1986). Education reformers in the 1950’s promised television would provide a less expensive and fuller classroom experience. Later during the 1960’s and 1970’s, the use of computer-assisted instruction promised to forever change classroom instruction, but it also failed to deliver meaningful educational reforms when it was introduced. With all these revolutionary technologies failing to live up to their initial promises, many reformers remain skeptical of new educational technologies that claim to transform the classroom experience.

Early in the 21st century, educational reformers began to experiment with an entirely new form of instructional technology. Primarily used by distance learners, online instruction was utilized by students who were not located in traditional classroom settings, including those learning from the home or remote locations. Unlike traditional forms of classroom instruction, distance learning relies on mediated information and instruction for student acquisition of knowledge and skill (Ndahi & Ritz, 2002). According to the U. S. Department of Education (2005), distance education uses courses for elementary and secondary school students in which the teacher and the student are in different locations. Also referred to as correspondence learning, distance learning initially relied upon the postal service for the delivery of instructional materials, including curriculum conveyed through print and film. More recently, however, online instruction is providing immediate access to educational materials for distance learners.

Online instruction takes place partially or entirely over the Internet (USED, 2009). Though initially deployed for distance learning, online instruction has found its way into K-12 curriculums throughout the United States. The Telecommunications Act of 1996 authorized the Federal Communications Commission (FCC) to provide America's schools direct access to the emerging information age (Telecommunications Act of 1996). The development of a digital infrastructure within K-12 educational facilities has led to an explosive growth of online learning. "The overall number of K-12 students engaged in online courses in 2007-2008, is estimated at 1,030,000. This represents a 47% increase since 2005-2006" (Picciano & Seaman, 2009, p. 1). As a direct result of the broadband infrastructure, most of today's K-12 public schools are able to provide Internet access for online instructional multimedia that is accessible from classroom computers and mobile multimedia devices.

With the convergence of today's classroom broadband infrastructure and technology savvy students, one might anticipate dramatic changes in the overall teaching practices within the K-12 school environment. Yet, there is a concern that any potential increase in academic achievement from online instruction is being offset by the traditional roles of teachers and students (Cesarini, Sinn, & Armentano, 2006). In this new online teaching environment, the face-to-face pedagogy of teachers is being challenged. A classroom teacher using online instruction developed by third party vendors often finds them self in a technologically centered classroom where they are no longer the sole provider of information. "They must rethink the entire teaching and learning processes. Focus moves from the teacher as a lecturer at the center of attention to that of a facilitator and course designer, almost entirely focused on electronically delivered content and process" (Sinn, 2004, p. 41).

Rather than rely on the traditional roles of face-to-face teaching, the constructivist-learning model promotes student self-direction and inquiry in order to achieve a better understanding and increased breadth of knowledge (Wiley & Ash, 2005). Historically, educational reformers such as John Dewey opposed autocratic and overly managed educational environments that prevent the development of student freedom and responsibility (Dewey, 1919). A classroom dependent on teacher-directed instruction rather than a student-centric learning environment can dramatically limit a scholar's ability to make sense or meaning of the curriculum. Still, traditional K-12 classrooms overwhelmingly rely on textbook content and lecture-based delivery for daily instruction.

Even though online learning has the potential to create a less teacher-centric environment, there is concern that it will replace student-teacher relationships and eliminate spontaneous classroom discourse. Online learning is also feared by educators as a technology that will one day replace teachers and classrooms in favor of an environment where students sit in cubicles inside office buildings or former school gymnasiums. Fortunately, blended learning offers an alternative to both the traditional lecture legacy and the current online model. According to a USED (2009) meta-analysis, students in a blended learning environment outperform both face-to-face teaching and solely online instruction. In the face-to-face teaching methodology, all students are expected to process new instructional material from the live presentation concurrently. Unlike solely online instruction, blended instruction combines online learning and face-to-face delivery with the potential to utilize the benefits of both instructional methodologies. Instruction can be delivered in the blended classroom in an online format and viewed by classroom learners in an asynchronous manner. A student in a blended environment can pace the online instructional multimedia in a manner that matches his/her cognitive ability and can thereby achieve an increase in learning (USED, 2009). Whereas solely online instruction eliminates the classroom experience, blended learning enables the teacher to be present in the classroom and guide students through online content and classroom activities.

Blended learning covers a broad range of instructional applications that can be used by teachers to assist traditional classroom instruction. With the increasing availability in online courseware, there are varying types of content now available for online instruction in the classroom. For example, students can use online learning to collaborate with their global counterparts or industry tutors, view augmented reality of layered information over screen views of the normal world, and participate in game-based learning (Johnson, Smith, Willis, Levine, & Haywood, 2011). In addition, new forms of online curriculums are no longer dependent on third party vendors. These open source curriculums used by classroom teachers to support instruction have many advantages over copyrighted material. Beyond the reduced expense, the most significant advantage of open source content is the ongoing collaborative effort to build and improve online instructional courseware by a global community of instructors. The use of open source curriculums for online instruction is growing exponentially and its ease of access represents an entirely new paradigm for online classroom instruction (Johnson, Adams, & Haywood, 2011).

Rather than support traditional pedagogies, as commonplace in past classroom reforms, most blended learning environments, and past one-to-one computing efforts (Suhr, Hernandez, Grimes, & Warschauer, 2010), new online multimedia courseware can be used as the primary form of instruction in a blended environment. Picciano and Seaman (2009) state that a blended/hybrid course uses online content as the primary source of instruction, while the majority of definitions state online content for blended learning is anywhere between 30% to 79% of overall classroom instruction. To provide a more concise definition for using online courseware as the primary form of content delivery in the classroom, the term *hyper-blended learning* has been created. Instead of using online materials to support face-to-face teaching, hyper-blended learning uses online content as the primary teaching method (80% to 100%) for new content in the blended classroom. It should be noted that the 80% to 100% figure of hyper-blended learning does not necessarily correspond to the amount of class time required for the actual delivery of the instruction during class. A high quality hyper-blended instruction will often provide no more then 10 minutes of new content delivery during an individual classroom session. The remaining class time can be used by the teacher to reinforce the instruction, used by students to apply the information into their workbook activities, used by student to work on group activities, or used by students to engage in project-based activities that rely on the content knowledge from the hyper-blended instruction.

Screen-capture instructional technology enables teachers to create and edit their own hyper-blended learning environment by incorporating their existing teaching practices into online instruction. Screen-capture technology allows for the real-time recording of computer screens, digital whiteboards, and document-camera devices. Many screen-capture based software applications also have the capability to add audio commentary. For example, an instructor who relies on a whiteboard to teach new material can use the digital whiteboard's embedded screen-capture software to discreetly record all of his/her writings in conjunction with the recording of an auditory explanation. The multimedia file can later be made available for students' viewing over the school's intranet network on a school computer or remotely from a teacher's website.

Screen-capture instructional technology has the potential to not only bridge the technology gap for teachers by combining traditional classroom practices with online instruction, but also incorporate the teacher's content knowledge into an online multimedia lesson. The increasing demand for education that is customized to each student's unique needs is driving the development of new technologies that provide more learner choice and control and allow for differentiated instruction (Johnson et al., 2011). The hybrid-blended instruction enabled by screen-capture technology creates a multimedia environment that allows for self-paced student learning within the traditional classroom based on the classroom teacher's core subject knowledge. Rather than disregard the teachers role in education by incorporating a *canned* online curriculum geared for a broad education market, screen-capture technology can be used as a *value-added* component that maintains locally relevant instruction in the hybrid-blended classroom. However, further research is needed to assess the value of blended learning that is created from a classroom teacher's instructional multimedia. As noted by Mayer (2009), research on multimedia learning in the classroom is still in its infancy.

As teachers attempt to create their own online instruction in the blended environment, there are various bodies of research available for assistance. Human-factors offers instructional designers and practitioners improved methods for assisting users of technology. Human factors research includes the study of the interaction between humans and visual displays. The study of the interaction between the user and screen-based technology has created the emerging field of interaction design. Interaction designers work to develop positive relationships between people and the products being used, including computers, mobile media devices and interactive appliances (IXDA, 2011). These displays include both static and dynamic information. Where visual displays of static information might include the best size of typography on products or road signs, visual displays of dynamic information analyze graphical information that are subject to change, such as the myriad of flashing indicators located on a nuclear power plant's control panel.

The study of the interaction with computer screen devices has led to new research methodologies within human factors. The field of human factors, also referred to as ergonomics, studies the interactions between humans and designed objects. The goal of human factors is to push technology into directions that can benefit all of humanity (Sanders & McCormick, 1987). As noted by Sanders and McCormick (1987), human factors research is most often classified into one of three types: descriptive studies, experimental research, or evaluation research. Using data from human factors research, designers can create user friendlier educational products and more efficient learning environments that accommodate the physical and mental requirements for differentiated instruction. In some scenarios, the ergonomic design will even attempt to accommodate the entire human spectrum. "What we really need to do to design is look at the extremes. . . . If we understand what the extremes are, the middle will take care of itself" (Dan Formosa, 2009).

The cognitive theory of multimedia learning (CTML) provides teachers and instructional designers guidelines for the creation of curriculum by incorporating the brain's information-processing functions that foster active cognitive processing in the learner (Mayer, 2001). Online instruction based in Mayer's cognitive theory of multimedia learning has many advantages over basic forms of static online instruction that fail to incorporate multimedia. Embedded in this theory, Mayer's (2009) modality principal stated that words should be presented as narration rather than on-screen text. The theoretical framework behind Mayer's multimedia research can be found in Paivio's dual coding theory that suggested "thinking involves the activity of two distinct cognitive subsystems, a verbal system specialized for dealing directly with language and a nonverbal system specialized for dealing with nonlinguistic objects and events" (Paivio, 2007, p. 13). Students simultaneously watching and listening to multimedia content use both their visual and auditory channels for learning. Unlike reading online text, learners listening and watching instructional multimedia process information through both their auditory and visual channels (Mayer, 2009).

Problem Statement

The federal government has specifically targeted math, language arts, and science for annual yearly improvement in order for states to receive education funding (NCLB, 2001). As an increase in the academic achievement for K-12 students is mandated, new online and computer-based instructional technologies are being incorporated by school districts in the hopes of improving student learning. Though school districts throughout the nation are implementing these new online instructional technologies, there is little assurance student learning will result (Figlio et al., 2010). There is currently a lack of data from research conducted on online learning within the K-12 blended classroom.

Many school districts across the United States have been forced to incorporate online instruction, not in an effort to increase student academic proficiency, but due to a decline in local and state revenues. In 2009, over one million K-12 students (1,030,000) were enrolled in at least one online or blended course, representing 2% of the total K-12 population, and nearly 80% of K-12 academic administrators surveyed in 2007-2008 claimed fully online and blended courses enabled their students to take courses that would been otherwise unavailable (Picciano & Seaman, 2010). Increasingly, it has become less expensive to purchase online courseware from third party vendors than to pay for teacher salaries and benefits. As a stealthy way to cut corners, many schools across the country have decided to circumvent teachers entirely in favor of online courses (Gabriel, 2011, April 5). Once teachers have been removed from the classroom, they are replaced with solely online instruction. With severe budgetary issues and legal requirements to maintain the state's class-reduction amendment, many public schools have chosen to implement online courseware over classroom teachers with little regard for teachers or their students.

> "All there were, were computers in the class," said Naomi. . . . "We found out that over the summer they signed us up for these courses." Naomi is one of over 7,000 students in Miami-Dade County Public Schools enrolled in a program in which core subjects are taken using computers in a classroom with no teacher. (Herrera, 2011, January 11)

Teachers are often resistant to incorporate new instructional technologies into their classrooms. Research findings point to serious problems with the efforts of academic institutions to prepare teachers adequately with the use of instructional technology (Zhao, Pugh, Sheldon, & Byers, 2002). Even though it is becoming clear that digital literacy is an important skill for K-12 instructors, there are few K-12 schools training teachers in digital literacy skills with professional development (Johnson et al., 2011). The unwillingness of teachers and school administrators to embrace technology is leading many students to feel disconnected with their education. "More than 40 percent of students polled in grades 6-12 cited their teacher as an obstacle to using new technology in the classroom" (Martinez & Harper, 2008, p. 64). Surprisingly, teacher inhibition with student use of technology contributes to this overall chasm (Windschitl & Sahl, 2002). As noted by Zhao et al. (2002), insurmountable roadblocks against teachers' technological innovations are often due to the culture of other teachers within the schools.

Students are often dismayed by outdated instructional methods used in their classrooms. Little has changed in the teaching practices of K-12 classroom teachers from the mid-20th century with the educational uses of technology (Means, 2010). There is considerable uncertainty specifying the type of instructional methodology that would best support these technologically savvy students. Though generally adequate in content, didactic classroom lectures and traditional textbook instruction pedagogies appear more and more antiquated in modern educational settings (Cesarini, Sinn, & Armentano, 2006). With ubiquitous access to online data, the culture of today's *plugged-in* students has dramatically changed. Unlike previous generations, today's students expect to access information from anytime and from anywhere (Dale & Pymm, 2009). As noted by Smith (2006), broadband Internet access has been brought into K-12 schools faster than other comparable technology. What may have been appropriate for instruction a decade ago no longer feels right in high school classrooms filled with high-speed broadband access, multimedia computers, and students who have grown accustom to constant online access (Cesarini et al, 2006).

Purpose

Instructional technology can increase overall achievement scores for adolescent learners (Kingsley & Boone, 2008; Mayer, 2009), but it is not being effectively incorporated by most academic institutions. A recent 2009 U.S. Department of Education's meta-analysis found that blended learning instruction within the classroom outperforms both traditional and online learning (USED, 2009), yet there is a strong institutional resistance to incorporate new technologies in the classroom. Many teachers are unwilling to utilize teaching practices that they have not been trained for, or do not fully understand. "Even with a comprehensive increase in wiring and telecommunications infrastructure in education, teachers continue to work incrementally to appropriate technology" (USED, 2003).

Regardless of teacher opposition, online instruction is rapidly expanding for K-12 schools throughout the United States. According to Picciano and Seaman (2009), 69.8% of school districts around the nation have students using online instruction in some capacity while 41% have one or more students enrolled in a blended course. Of these online courses, 46.5% are acquired from postsecondary institutions and 34.7% are from independent vendors, while 27.1% of content for the blended learning classes are purchased from postsecondary institutions and 17.5% are from independent vendors. With this new style of curriculum, a growth in teacher experimentation with online instruction has begun. However, there is currently no data suggesting teachers are developing their own online or blended instruction based on their current teaching practices or unique content knowledge.

Screen-capture instructional technology enables teachers to create their own online lessons for students to view and review the teacher's instruction in a pace and manner that best suits his/her learning needs. Using screen-capture technology, a classroom teacher can preserve quality instruction. Since the screen-capture instruction is in a digital audiovisual format, the screen-capture instruction can be enhanced in media editing software. By editing the digital instruction, the teacher or courseware designer can eliminate verbal or visual mistakes and remove content that is deemed irrelevant. Further instruction or additional media can also be added to the screen-capture lesson along with various signaling techniques that can seamlessly direct learners through the instructional multimedia.

By utilizing screen-capture instructional technology into pedagogy, teachers can also pre-teach or *flip* their lessons. In this type of learning environment, teachers provide online instruction prior to class meetings to create a *flipped* classroom. Unlike the typical classroom mechanics, students in a flipped classroom acquire their content knowledge prior to the class meeting. By virtue that the screen-capture instruction is in an online format, the student's online learning experience is relegated to the acquisition of declarative knowledge. This declarative knowledge typically includes facts, events, and concepts (Anderson, 1993). When students acquire content knowledge from the online format, the classroom experience can be reserved to reinforce declarative knowledge into long-term memory. Students who do not comprehend the teacher's screen-capture lesson can also be provided with direct one-to-one teacher instruction during class. This teacher would not necessarily be available during class for individual instruction due to time constrains from the classroom lecture.

In the context of school reform, a K-12 teacher using screen-capture instructional technology to record his/her face-to-face instruction could offer a viable approach to constructing online content for the blended learning environment, without dramatically changing current teaching practices. Rather than waiting in the classroom for other learners to comprehend instructional materials from a live-lecture, students who acquire content knowledge from their teacher's online instruction can transition to other activities without waiting for all the other students to comprehend the instruction. The versed learner can move on to other screen-capture instructions, engage in group activities, work on project-based curriculums, or participate in experiential learning activities that require the content knowledge.

Research Question

Even before the one-to-one personal computing initiatives of the early 1980's (Dunleavy, Dextert, & Heinecket, 2007), researchers have posed the question whether or not computer technology use can effect student achievement in face-to-face classrooms as compared to classrooms that do not use technology (Tamim, Bernard, Borokhovski, Abrami, Svmnid, & Schmid, 2011). In this spirit, the research questions for this study were intended to determine the extent screen-capture instructional technology increases the academic achievement for student learning within a face-to-face classroom. To that effect, the preferences and engagement of the students were also sought. The role of the teacher using screen-capture instructional technology to create and teach lessons was also explored. It was hypothesized that secondary students would exhibit equal or significantly higher academic achievement using a teacher's screen-capture instructional technology over their classmates learning from a lecture-based methodology. The research questions for this study were as follows:

1. To what extent, if any, is there a difference in the academic outcomes of secondary Algebra students learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
2. To what extent, if any, do secondary Algebra students prefer learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
3. To what extent, if any, are secondary Algebra students more engaged learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
4. To what extent, if any, does the experience of creating and instructing multimedia Algebra lessons developed from a secondary classroom teacher's screen-capture instructional technology change the teacher's instructional practices?

Summary of Methods

This study was a controlled quasi-experimental design measuring student academic achievement between lecture-based classroom teaching and instruction from a blended learning environment. A high school's math department chair was willing to participate in this instructional research study. Convenience samples from two Algebra classes were created from approximately 68 high school students. It was anticipated that a sixth period Algebra class would be the screen-capture group and a seventh period Algebra class would be the live-lecture group. All classroom activities and instructional content met the current California content standards for high school mathematics. The research study's academic lessons and corresponding workbook activities were based in the Algebra II content standards. Additionally, the Algebra II textbook's curriculum and workbook exercises were used to create a pretest-posttest activity.

During the fall of 2010, the school district's community passed a 42 million dollar bond measure created exclusively to increase educational technology within each classroom. As a direct result, the school district's director of technology showed an interest in the results of this research and was willing to help facilitate the study. This research study intended to take the school district's disjointed educational technology and bring it under one umbrella using a novel methodology. By integrating the school's instructional technologies with a classroom teacher's pedagogy, a system to create online instruction for the blended learning environment can be achieved. Based on the objectives of this study, the math department chair was awarded a classroom set of tablet computers.

Significance

Online instruction is rapidly expanding throughout K-12 schools in the hopes of improving academic achievement for federal accountability requirements, reducing personnel expenses, and providing students with a self-paced learning environment. A majority of K-12 school districts (63.3%) anticipate an increase in fully online classes while 61.2% forecast an increase in blended learning (Picciano & Seaman, 2009). School districts throughout the country are incorporating these new instructional technologies with little assurance student learning will result. By relying on technology that is not completely understood, its potential benefits could be mitigated. As noted by Sweller (2005), instruction that is created without anticipating the needs of human cognition is likely to be ineffective.

Even as K-12 content moves toward a national common standard, one might also expect the teaching of curriculum to be uniform. Yet the same content is often approached differently by local communities with varying emphasis and relevance of the knowledge (Brown & Cooper, 2009). Rather than be instructed uniformly, curriculum is often individualized toward community expectations and the needs of each student. For example, earth science taught in schools ranging from Texas to Maine may use the same common standards, but invariably the content will be taught differently based on the local context and shared values. Screen-capture instructional technology offers the benefits of self-paced online instruction while maintaining the teacher's localized content knowledge.

As academic institutions and policy makers look at alternative instructional methods for K-12 public education, online learning has become increasingly favorable. However, with strict federal requirements to increase student achievement for all learners (NCLB, 2001), more data are required for the varying types of online pedagogies (Figlio et al., 2010). There is currently a lack of research on the use of online instruction within the K-12 blended learning environment (USED, 2009). If blended learning created by current K-12 classroom teachers can increase the academic achievement for learners over traditional instruction and solely online instruction, policy makers and educators will be in a better position to make informed decisions that determine instructional practices not only for today's students, but also for the next generation of learners.

Theoretical Framework

The theoretical framework behind this study can be traced to the advent of Paivio's 1971 dual coding theory that stipulates humans possess separate information processing channels for visual and auditory material.

> The theory [dual coding theory] elaborates on the idea . . . that cognition involves the cooperative activity of two functionally independent but interconnected systems, a nonverbal system specialized for dealing with nonlinguistic objects and events, and a verbal system specialized for dealing directly with language. (Paivio, 2007, p. 34)

When applied to online instructional multimedia, researchers hypothesize that humans have separate information-processing channels to acquire verbal and pictorial knowledge. Moving images, such as video and animation, are processed through the visual/pictorial channel, while words presented as narration are processed in the auditory/verbal channel. Based on the dual coding theoretical framework, this proposed research study will employ audio and visual instruction in the secondary math setting.

Assumptions and Delimitations

The sample for this study included students from a Northern California high school located near a large metropolitan city. These students encompassed a broad range of social and economic backgrounds and included a diverse ethnicity. Though the school district was the seat for the county's court system, the neighborhood managed to maintain a small town and working class environment due to the concentration of oil refinery and trade workers. The school's ethnicity consisted of 72% White (non-Hispanic) students, 20% Hispanic students, 4% African

American students, 2% Asian students, and 2% Indian students. It was anticipated that the students in the study would be generally representative of students nationally.

It was foreseen that the results of this instructional research study could be transferred to other math curriculums. In addition, the math curriculum was selected due to the teacher's dependence on writing numeric equations on a whiteboard for her students as their primary form of instruction. The Algebra teacher's systematic instruction and pacing appeared well suited for the asynchronous component of blended learning. Furthermore, it was presumed that the electronic whiteboard's discrete screen-capture process would require little modification of the teacher's pedagogy. If screen-capture instructional technology provided equal or greater academic achievement than does the traditional lecture model, it was assumed that secondary public education institutions could be transformed into blended learning environments.

Summary

Public school teachers and administrators are uncertain how to meet ongoing federal and state mandates to increase the academic achievement for all their students. Traditional classroom instruction does not permit for asynchronous learning that can dramatically increase student cognition. Only recently have K-12 academic institutions started to incorporate online instruction that can provide students with easy access to asynchronous learning. Yet many teachers and policy makers are resistant to incorporate the online instructional technology into their public schools. Based on its current trajectory, the use of online learning may dramatically reshape the K-12 educational landscape in the near future. Hyper-blended instruction provides an alternative model to traditional classroom instruction and solely online learning by incorporating online learning and traditional teaching practices into a blended learning model. Screen-capture instructional technology gives teachers the ability to create their own online multimedia lessons for the blended learning environment based on their current teaching practices. However, little research has been conducted on the effects of online instruction in the blended learning environment or screen-capture instructional technology.

Definitions of Terms

Table 1

Definitions of Instructional Technology Terminology

Key Term	Definition
Asynchronous Instruction	Students have control over when, where and how they watch the lecture - "how" meaning that they control the sequence, duration, and repetition of the video clips which make up the lecture (Smith, 2006).
Blended Learning	Combines online learning and face-to-face instruction with the potential to utilize the benefits of both instructional methodologies where 30% to 79% of the instructional content is delivered online (Allen & Seaman, 2010)
Blended Multimedia Learning	A type of teaching that incorporates online multimedia content into the traditional classroom so that face-to-face instruction is still available. Classroom students are also able to interact with other classroom students for group activities.
Cognitive Load Theory	The theory assumes a limited capacity working memory that includes partially independent subcomponents to deal with auditory/verbal material and visual/2- or 3-dimensional information as well as an effectively unlimited long-term memory (Sweller, van Merriënboer, & Paas, 1998).
Cognitive Tools	Cognitive tools are computational devices that can guide and mediate the cognitive processes of learners (Kong 2011).
Constructivism	Theory of learning that proposes that individuals actively construct their understanding of the world (Wiley & Ash, 2005).
Distance Education	Credit granting courses offered to elementary and secondary school students enrolled in which the teacher and the student are in different locations (USED, 2005).

Distance Learning	The acquisition of knowledge and skills through mediated information and instruction (Ndahi & Ritz, 2002).
Dual Coding Theory	Cognition involves the cooperative activity of two functionally independent but interconnected systems, a nonverbal system specialized for dealing with nonlinguistic objects and events, and a verbal system specialized for dealing directly with language (Paivio, 2007).
Face-To-Face Instruction	The instructor delivers the content live and interacts with students both in and outside class meetings (Zhao, Lei, Lai, & Tan, 2005).
Hyper-Blended Learning	A course blends online instructional multimedia and face-to face support so the substantial proportion (80% to 100%) of the educational content is delivered online. Classroom students asynchronously view online content while a teacher is available for face-to-face assistance within the classroom.
Interactive Instruction	Providing variable control over the pace and course of instruction and being actively responsive to performance (Wetzel, Radtke, & Stern, 1994).
Modality Principle	Learning is more efficient when words are presented in spoken form and not in printed form (Mayer, 2009).
Multimedia	Multimedia is a system that combines two or more media into a single product or presentation, such as a software program or a webpage (Kingsley & Boone, 2008).
Online Learning	Learning that takes place almost entirely over the Internet (80% - 100%) and typically has no face-to-face meetings (USED, 2009; Allen & Seaman, 2010).
Podcast, Screencast, Video Cast	Completed multimedia lessons created from screen-capture that are available online for streaming or downloading on multimedia computer devices.
Screen-Capture	Screen-capture is the process for capturing segments of any movements that appear on a computer screen, including any *click* or selections made by the instructor (Folkestad & DeMiranda, 2002) from a digital whiteboard, computer screen, or digital camera projector.
Screen-Capture Instructional Technology	The amalgamative process that allows teachers and courseware designers to record, edit, and upload multimedia lessons to the Internet based on screen-capture instruction.

Screen-Capture Instructional Multimedia	The digital multimedia curriculum generated for educational purposes from screen-capture instructional technology
Student-Centric Learning	Student to learn in ways that match their intelligence types in the places and at the paces they prefer by combining content in customized sequences (Christensen, Horn, & Johnson, 2008).

CHAPTER 2

LITERATURE REVIEW

With stringent state and federal mandates requiring increases in student academic proficiency, many K-12 public schools are looking at new computer-based instructional technologies to assist classroom teaching. Complicating matters for public schools, severe local and state budget cuts have forced school districts to reduce their teaching staff and increase the number of students within each classroom. "The No Child Left Behind Act clearly places additional financial burdens on states and school districts throughout the nation" (Dye, 2008, p. 137). Under the No Child Left Behind Act, today's public schools abide by strict state subject matter standards and often follow tight textbook pacing guidelines. The combination of additional students within each classroom and the requirement for ongoing improved academic achievement has become overwhelming for many K-12 public schools using traditional instructional practices. When educational materials are presented by teachers in drawn-out lectures or from a textbook chapter, student learning is minimal (Mayer, 2009). Making matters all the more difficult for student learning under NCLB is that the rigidity of strict classroom guidelines often fails to permit experimentation in new teaching methods or allow for creative input by both teachers and students.

As K-12 academic institutions comply with annual high-stakes testing mandates, new computer-based instructional technologies are being considered as solutions to increase student achievement and testing outcomes (Kingsley & Boone, 2008). In an attempt to improve academic achievement, teachers are attempting to incorporate new online multimedia technologies in hopes of improving student learning. When implemented correctly, interactive instructional multimedia can significantly enhance overall academic performance for students

(Mayer, 2009). As suggested by Choi and Johnson (2005), instructional multimedia can be an effective method to enhance learners' retention in context-based learning.

Unfortunately, research revealing the effectiveness of K-12 online instructional multimedia is extremely limited for teachers and policy makers (Figlio, Rush, & Yin, 2010). As noted by Mayer (2009), research in multimedia learning is still in its infancy. As a result, today's classroom teachers are not certain how to implement multimedia technologies to assist their instructional practices. Not only is there very little research for K-12 practitioners on the technology's overall effectiveness, but there is also no agreement on which type of delivery methods are best suited for learning (Ndahi & Ritz, 2002). Even with the recent comprehensive increase in broadband infrastructure in educational facilities, most K-12 teachers continue to work incrementally with technology (USED, 2003).

The dearth of online multimedia research within K-12 institutions is due in part from the relatively new availability of broadband and corresponding one-to-one multimedia devices within the classroom. With the proliferation of fast and inexpensive multimedia devices and corresponding high-speed networks in K-12 schools, new computerized instructional techniques are becoming all the more practical. These high-speed networks enable students to stream rich online instructional multimedia with embedded audio and video. The ensuing hybrid-blended classrooms differ from past one-to-one computer learning models where the majority of computer time was not spent on learning, but rather was used to write papers and surf the Internet (Suhr, et al., 2010).

This study sought to explore the effect of screen-capture instructional multimedia on students learning within the secondary classroom environment. The research explored if teachers can create online multimedia lessons that improve student academic proficiency from readily available classroom technologies. The research questions developed for this study were as follows:

1. To what extent, if any, is there a difference in the academic outcomes of secondary Algebra students learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
2. To what extent, if any, do secondary Algebra students prefer learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
3. To what extent, if any, are secondary Algebra students more engaged learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
4. To what extent, if any, does the experience of creating and instructing multimedia Algebra lessons developed from a secondary classroom teacher's screen-capture instructional technology change the teacher's instructional practices?

The interest for this study pertained to the teacher's use of one-to-one instructional technology within the secondary classroom. Therefore, the direction of research and literature review for this paper targeted instruction on secondary classroom students utilizing online instructional multimedia. This dissertation explored the current instructional technologies available for K-12 public education and analyzed the learning theories that demonstrate the distinctive utility of this technology. This chapter is divided as follows: I. Multimedia Instructional Technologies, II. Cognitive Theory of Multimedia Learning, III. Literature Review, and IV. Summary.

I. Multimedia Instructional Technologies

According to Mackenzie and Jansen (1998), there are two basic models of multimedia computer-based instruction. Multimedia lessons are generally viewed either on an individual basis, where each student can view a lesson in an asynchronous manner, or the multimedia lesson can be presented at the teacher's own pacing in conjunction with his/her live instruction. With asynchronous computer-based instruction, students can directly interact with the instructional materials, controlling the pace and sequence of the instruction (Mackenzie & Jansen, 1998). In contrast, a teacher with complete control over the pacing and sequencing of instructional multimedia can pause the presentation to exchange ideas with the group of students and verbally explain concepts in as much detail as necessary. These two models are drastically different for student learning. Students learning from asynchronous instructional multimedia *pull* their teacher's instruction, while a teacher *pushing* the computer-based lesson provides little or no interactive control for the student during the acquisition of new information. Students who are learning in an interactive and self-paced method have shown superior academic performance to those learning in a teacher-paced environment (USED, 2009).

New instructional multimedia technologies have recently become available for K-12 instruction. Classroom teachers and instructional designers are experimenting with multimedia production tools that can incorporate existing K-12 curriculums and pedagogies into the domain of online instruction. Screen-capture instructional technology offers a method to replicate and enhance a teacher's current instructional practices for both online and blended multimedia learning. Figure 2.1. maps two possible directions for the implementation of screen-capture instructional technology.

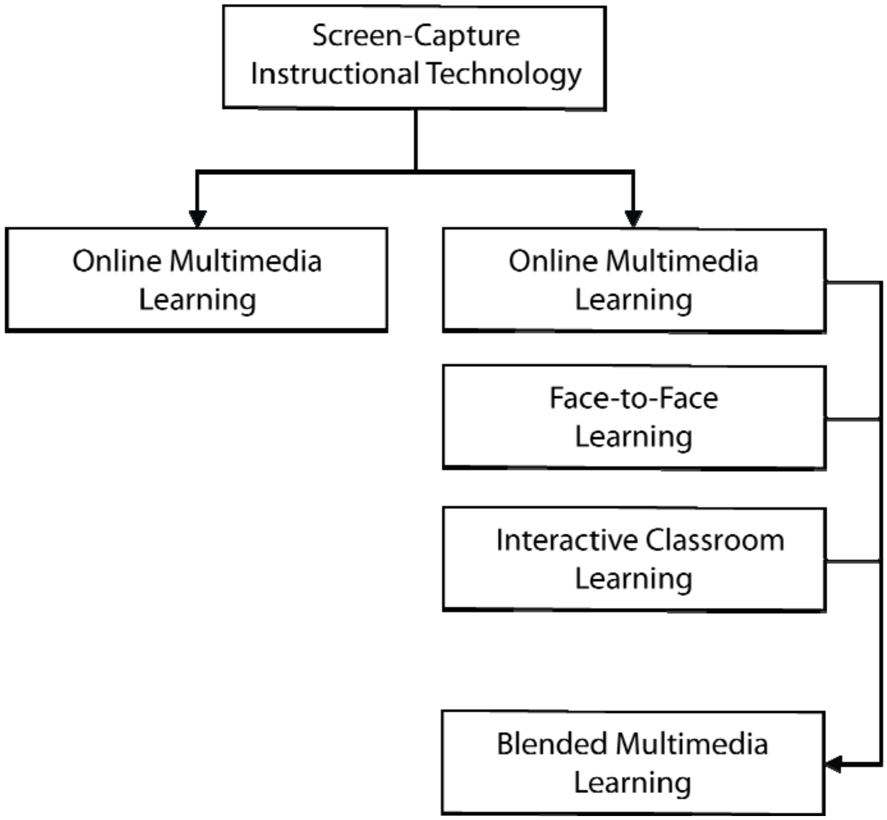

Figure 2.1. Spatial Diagram for Screen-Capture Instructional Technology.

Screen-Capture Instructional Technology

Most improvement efforts to incorporate instructional technology in the classroom consistently disregard the role of the teacher (Cuban, 2003). However, classroom teachers and instructional designers have access to newly available multimedia production tools that incorporate existing teacher pedagogies and curriculums into the domain of online instruction. Screen-capture instructional technology enables educators to produce in-house lessons for either online multimedia learning or for blended multimedia learning (Figure 2.1.). Screen-capture software enables teachers to create online audiovisual instruction from computer-screen movements with the added capability of capturing audio narration (Folkestad & DeMiranda, 2002). For example, a teacher can record all of his/her writings and corresponding audio from a personal computer application or from a digital whiteboard using screen-capture software. The digital files created from these devices are embedded with the teacher's audio and visual lesson. The ensuing instructional multimedia can be made available for student viewing during class or accessed remotely by students from the teacher's website.

Screen-capture instructional technology can transform traditional teaching methods into instructional multimedia for either online multimedia learning or blended multimedia learning. However, unlike *canned* or prepackaged online lessons, the teacher's content knowledge can be sustained within the lesson. The technology augments a teacher's live lesson into a digital media format. The ensuing multimedia lesson can be made available for viewing over a school's intranet network or accessed remotely from a teacher's website, both inside and outside of the traditional classroom. These online multimedia lessons available for viewing are increasingly referred to by educators as screencasts, video podcasts, or vodcasts (Walker, Cotner, & Beerman, 2011).

Today's use of screen-capture instructional technology has evolved considerably. With the advent of fast high-speed broadband and school network capabilities, textbook companies have begun to incorporate the technology to augment textbook instruction with their own streaming multimedia lessons. As screen-capture technology has become more prevalent in educational settings, teachers are beginning to experiment with their existing instructional materials. Instructors are adding digital notes to images embedded in computer-based lessons and students are utilizing the technology to make notations on screen-capture images for later review (Cox, 2006). In addition, many educational researchers such as Laakso, Myller, and Korhenen (2009) used screen-capture technology to discreetly observe and record their student's onscreen computer activities. Many screen-capture instructional technology applications continue to be discovered by both students and teachers. Teachers are beginning to create their own screen-capture based multimedia lessons as they experiment with new classroom instructional devices, ranging from digital camera projectors, electronic whiteboards, and classroom computers. With the recent proliferation of compatible technologies within the classroom setting, screen-capture instructional technology is poised to take current teaching practices out of the traditional realm and into the world of online and blended multimedia learning.

Online multimedia learning. Online learning provides a platform for instructional multimedia that is not necessarily dependent on a classroom teacher. Unlike past educational software programs preinstalled on classroom computers, online instructional multimedia can be accessed through Internet portals on remote desktop computers and mobile multimedia devices. As stated by Zhao, Lei, Lai, and Tan (2005), "The level of instructor involvement is perhaps one of the most defining differences between traditional face-to-face education and distance education. . . . where the content is preprogrammed and delivered through some technology means without the actual involvement of an instructor" (p. 1846). Rather than rely on the pacing and sequence of a classroom teacher, online instruction offers students the ability to interact with the content (Mackenzie & Jansen, 1998).

Though online learning has become a viable alternative to current teaching practices, K-12 schools have been slow to incorporate the technology within the traditional classroom. Traditional classroom instruction has yet to utilize the inherent advantages of student asynchronous learning. Rather than watch a teacher instruct at the front of a classroom at his/her own pacing, students viewing the instruction in an online format can watch and listen to the instructional multimedia in an asynchronous manner. Asynchronous learning provides control over when, where, and how students watch the lecture. Learner control over the instruction allows a student to use their desired method of learning, at a preferred time, and accessed from a desired location (Smith, 2006). Not only does online format provide students the ability to access content from their desired location and preferred time, the student-centric methodology allows students to match their aptitude as they access content in their own customized sequences (Christensen et al, 2008).

The current implementation of purely online teaching has some major intrinsic instructional deficiencies. The majority of online instruction used by classroom students are not created by the student's classroom teacher, but rather, developed by third party developers including virtual school courseware vendors and postsecondary institutions. According to Picciano and Seaman (2009), most school districts (82.5%) are purchasing online content from a variety of online providers to address the needs of their student requirements. Though teaching content solely from courseware vendors allows for more flexibility, student academic achievement is not necessarily gained. "Distance-learning outcomes were less positive when instructor involvement was low (as in 'canned' applications), with effects becoming more positive, up to a point, as instructor involvement increased" (USED, 2009, p. 53). Without an instructor present to reinforce the asynchronous lesson, many of the online instructional benefits appear unrealized for students.

In summary, the online format appears to be a feasible alternative to traditional classroom instruction. Unlike past media technologies, today's online multimedia offers students the capability to interact with the digital content. In addition, students are no longer dependent on a single classroom teacher for content knowledge. Students are able to acquire instruction online in a manner that allows direct interaction with content and at their own pacing. Though the online and asynchronous platform can be superior for student learning over traditional lecture methods, it appears that the added component of a live classroom instructor to reinforce the material can improve online instruction.

Blended multimedia learning. A student learning from an online curriculum does not necessarily indicate a physical departure from the classroom. Solely online learning and blended learning are two separate forms of instructional models. A blended classroom environment takes advantage of online learning's student-centric pedagogy. According to Christensen (2008), about 80 percent of courses taken in 2024 will be taken online in a student-centric way" (p. 102). When online content is accessed within the blended classroom, students spend more time interacting with the online content. The additional time spent on the instructional material within the blended classroom represents a substantial difference between the two forms of online instruction (Picciano & Seaman, 2009). Rather than rely solely on face-to-face teaching or remote online instruction, blended learning has the potential to utilize the benefits of both methodologies.

With the ongoing technological improvements within K-12 classrooms, teachers can create blended learning environments that integrate online learning's inherent advantages. According to Picciano and Seaman (2009), blended learning combines online and face-to-face instruction so the vast proportion of content is delivered online with a variety of supporting online venues for classroom discussions, thereby requiring fewer face-to-face instructional sessions. Rather than present educational material in the traditional classroom manner, many teachers are attempting to augment their face-to-face lectures by borrowing online asynchronous strategies. This integration of online instruction within the blended classroom provides K-12 learners with the necessary tools to independently slow down or speed up the audiovisual instruction in a manner that accommodates their cognitive ability. These multimedia presentations can also be repeatedly listened and viewed by the students.

Unlike past media technologies including radio, film, and television, today's online classroom multimedia offers learners an entirely different pedagogy. As observed by Wetzel, Radtke, and Stern (1994), interactive video-based instruction eliminates one-way linear communication by enabling user control over the pace and course of the instruction. Blended classroom instruction can incorporate various audio and video media files through district-wide intranet streaming or from *cloud-based* servers. High-bandwidth infrastructure allows for a richer multimedia experience over the low-bandwidth delivery methods most often associated with past one-to-one computing efforts or recent forms of online instruction.

A recent meta-analysis discovered that schools using either online learning or blended learning produce on average higher student learning outcomes than classrooms relying on face-to-face instruction (USED, 2009, p. 18). As noted by Smith (2006), the availability of broadband technology has increased faster than any other recent technology, thus finally permitting online multimedia to be accessible within mainstream K-12 classrooms. Students who participated in these blended learning environment outperformed those learning from the traditional classroom or solely from online instruction. Initial research supports the blended or hybrid model of education that combines face-to-face learning with online instruction (Zhoa, Pugh, & Sheldon, 2005).

The advantage of blended learning over strictly online learning suggests there is an added benefit from the teacher's direct interaction with the classroom students. In addition, students using strictly online instruction outside of the classroom seem to lack the ability to reinforce their online instruction without fellow classmates and do not gain from the additional instruction time available with a classroom teacher (USED, 2009). Blended learning using screen-capture instructional technology replaces the teacher's live instruction with the teacher's online instructional multimedia as the primary delivery mechanism for content. Face-to-face instructional support and the interactive classroom experience are thereby maintained. However, blended learning and screen-capture instruction have yet to be thoroughly studied within the K-12 population. The reasons for student academic achievement in the blended learning environment are not clear (USED, 2009), but results appear to indicate that learners gain from the added instructional time available within traditional classrooms, the ability to utilize additional resources available only within the classroom, and the physical interactions with fellow classroom students.

> Studies using blended learning also tend to involve more learning time, additional instructional resources, and course elements that encourage interactions among learners. This confounding leaves open the possibility that one or all of these other practice variables, rather than the blending of online and offline media per se, accounts for the particularly positive outcomes (USED, 2009, p. 52).

To summarize, a student learning from an online curriculum does not necessarily indicate a physical departure from the classroom. Blended instruction, or hybrid learning, is fast becoming a way for classroom instruction to combine the benefits of online learning with traditional face-to-face instruction. Rather than rely solely on face-to-face teaching or remote online instruction, blended learning utilizes the benefits of both methodologies. In the hybrid-blended learning environment, a substantial proportion of the content knowledge is delivered online and in an asynchronous way. Students in the blended learning environment have been shown to be academically superior to learners from both the traditional classroom and online only instruction. However, the successes of blended learning have yet to be adequately researched or understood.

II. Cognitive Theory of Multimedia Learning

As teachers and instructional designers move classroom practices and curriculum into the digital medium, it is important they understand how a student learns from computer-based instructional multimedia. Rather than simply record audiovisual lessons for student online access, instructors can improve their online teaching practices by incorporating research that explains what strategies have proven most effective for instructional multimedia. The following theme deals with the latest brain research developed to assist curriculum developers and instructional designers as they create instructional multimedia for the hybrid-blended learning environment.

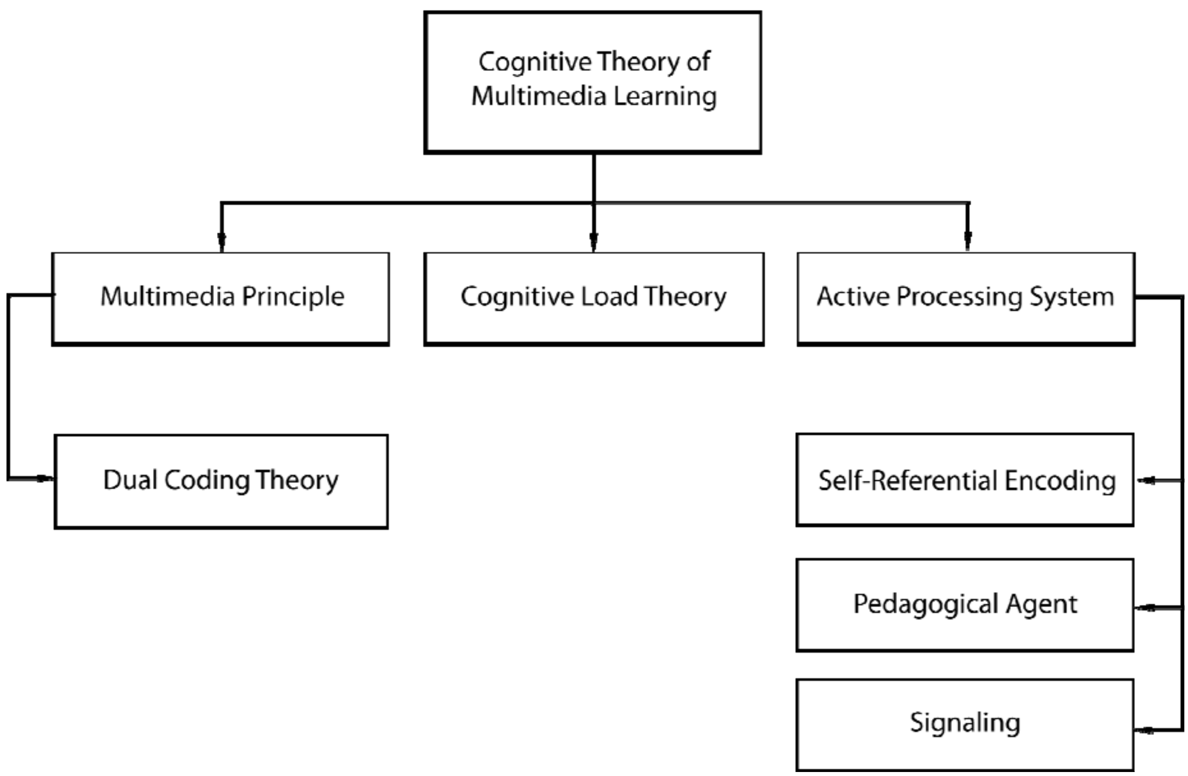

Figure 2.2. Spatial Diagram of Related Literature for the Theoretical Framework.

The cognitive theory of multimedia learning (CTML) provides instructional practitioners strategies on how words, images, and language can be integrated within instructional multimedia. Three areas of study in the CTML include the multimedia principal, which analyzes how the brain separately processes audio and visual information, the cognitive load theory (CLT) that addresses learners' limited working memory, and the active processing system that anticipates a student's active learning capacity (Moreno, 2005). As teachers and instructional designers move classroom practices and curriculums toward asynchronous instruction, CTML can assist practitioners in the development of online and blended instruction.

Cognitive theory of multimedia learning was first developed by educational psychologist Richard Mayer to explain the basic principles of instructional multimedia. The cognitive theory of multimedia learning is divided into three separate components of brain function. "Cognitive theory of multimedia learning assumes that the human information-processing system includes dual channels for visual/pictorial and auditory/verbal processing, each channel has limited capacity for processing, and active learning entails carrying out appropriate cognitive processing during learning" (Mayer, 2009, p. 57). To explain the cognitive theory in multimedia learning, the three components of brain functions are described in this chapter by the multimedia principle, cognitive load theory, and active processing system.

Multimedia Principle

The Multimedia Principle states that humans have separate information-processing channels to acquire verbal and pictorial knowledge. Instructional multimedia is a student-centric approach to learning that provides learners the ability to use various coding systems, such as verbal and pictorial knowledge representations (Mayer, 2009). Mayer asserts that moving images such as animation are processed through the visual channel, while words presented as narration are processed in the auditory channel. This verbal and visual information then becomes encoded in the human brain from working memory (Mayer & Sims, 1994). New information is subsequently encoded into the brain as long-term memory, a necessary component for the recall and transfer of knowledge. To maximize the dual-coding capacity, text should be presented directly to the verbal channel as spoken narration rather than in its written form. By incorporating both moving pictures and audio, instructional multimedia offers a differing approach to the current pedagogy of textbook-based classroom instruction.

Consequently, instructional multimedia can lead to superior learning when compared to learning solely from textbooks. Mayer (2009) discovered that "people learn more deeply from pictures and spoken words than from pictures and printed words" (p. 200). In this light, rather than read text online, learners should be presented with words and concepts that are in the form of images and audio narration. The crux of this argument is that the sole purpose of language is to serve memory (Paivio, 1986). Multimedia information delivered to students as audio rather than text reduces the brain's overall cognitive load. Comprehension occurs in humans when they are able to integrate mentally both pictorial and verbal representations (Mayer, 2009). Rather than delivered in its graphical representational form, content presented as spoken words will increase the brain's ability to code information into memory.

Dual-coding theory. The rationale behind multimedia theory is rooted in Paivio's 1971 dual-coding theory that states auditory and visual information are processed entirely different in the human brain. Audio and visual information are transmitted through separate channels to the brain and then coded separately as memory for later retrieval. "Cognition involves the cooperative activity of two functionally independent but interconnected systems, a nonverbal system specialized for dealing with nonlinguistic objects and events, and a verbal system specialized for dealing directly with language" (Paivio, 2007, p. 33). Unlike direct auditory processing from spoken language, textbook instruction requires words to be recoded in the brain as inner speech and visual logogens. Words that are processed through the auditory channel are coded more effectively then when the visual channel processes the same words (Paivio, 2007).

Processing of new information is enabled by the brain's ability to code material into memory. As described by Sweller (2005), "cognitive load is reduced because the use of dual modality increases effective working memory capacity" (p. 27). Because only half of the brain's processing abilities are utilized when reading, students are limiting their cognitive capability when they read from a textbook. However, instructional tools that incorporate both areas of the brain's processing are rarely present in K-12 school curriculums. Though reading utilizes only half of the brain's coding channel, it is a predominate educational tool. When students read from a textbook, words are recoded in the brain and the use of the auditory channel as a learning device is neglected. Based on the dual-coding theory, instructional multimedia should avoid presenting information only in text and instead incorporate audio descriptions with corresponding graphics.

Cognitive Load Theory

Cognitive load theory (CLT) is based on the notion that the human brain has limited working memory. CLT stipulates that there are three cognitive loads in the brain that need to be accounted for while learning from instructional multimedia. "CLT [cognitive load theory] distinguishes between three types of cognitive load: *intrinsic load, extraneous* or *ineffective load,* and *germane* or *effective load*" (Paas, Renal, & Sweller, 2003, p. 65). Instructional multimedia requires that all three cognitive loads be accounted for during a learner's acquisition of information. Sweller (2005) defines intrinsic load as cognitive load due to the natural complexity of information being processed (p. 27). While extraneous load pertains to unnecessary or redundant information that inhibits learning, germane load is defined as the process by which the brain makes sense of essential material. An overly complex lesson forces the learner's cognitive load and working memory to be overwhelmed. Conversely, if the learner's intrinsic cognitive load is reduced, working memory will not become overloaded (Sweller, van Merriënboer, & Paas, 1998).

CLT is used as a guide to optimize instructional multimedia. When information arrives in the learner's brain, CLT examines the brain's role in processing information. As noted by Sweller (2005), CLT can link the needs of human cognitive architecture with the development of instructional design. CLT asserts that learning can be impaired when the brain's working memory is overloaded while it attempts to simultaneously process information from both the visual and auditory channels. "The theory [cognitive load theory] assumes a limited capacity working memory that includes partially independent subcomponents to deal with auditory/verbal material and visual/2- or 3-dimensional information as well as an effectively unlimited long-term memory" (Sweller et al., 1998, p. 251). When the brain's working memory is subjected to overly complicated or extraneous instruction, it becomes overwhelmed and is unable to process new information into memory. If a student is forced to select, organize, and integrate too much information through one channel, the subject will be unable to learn as extraneous processing overwhelms the brains limited cognitive processing ability (Mayer, 2009).

In light of CLT, a primary goal of instructional multimedia is to reduce extraneous overload while increasing germane cognitive load. According to Sweller et al. (1998), extraneous cognitive load is due to the effort required of learners to process poorly designed instruction, whereas germane cognitive load can be found when learners attempt to construct schemas and make meaning from the information into a mental framework. As defined by Mayer (2009), germane load is the cognitive processing during learning where the brain makes sense of essential material that can be attributed to the learner's level of motivation (p. 81). CLT can be used to assist the construction of instructional multimedia by optimizing curriculum toward essential or germane knowledge.

The central goal of CLT is to anticipate the limitations of working memory. Instructional design must be created in a manner that anticipates the brains working memory as a key component to learning or it will invariably be deficient (Sweller et al., 1998). Cognitive load describes the brain's ability to manage information as working memory. Paas, Renkl, and Sweller, (2003) state that intrinsic, extraneous, and germane cognitive loads are additive in that, together, the total load cannot exceed the working memory resources available if learning is to occur (p. 2). Miller (1956) found that on average the human mind was able to hold around six to seven items simultaneously, "There is a span of absolute judgment that can distinguish about seven categories and that there is a span of attention that will encompass about six objects at a glance" (p. 91). Miller's early work paved the way to much of the foundations for the study of the brain's information processing during multimedia learning activities. Working memory refers to the temporary storage of information in the brain that is critical for learning and reasoning (Baddeley, 1992).

To overcome the limitations of working memory, CLT implies that the brain groups complex information into smaller components. According to Pass et al. (2003), CLT explains that multiple elements of information are chunked into single elements in cognitive schemas to bypass the limitations of working memory (p. 63). Chunking done consciously might involve grouping numbers together, such as 3-0-0-0 into 3,000. Individual numbers are grouped as one number rather than four separate items. Because the human memory span contains a set amount of chunks, increasing the bits of information within each chunk will allow for the storage of more and more information (Miller, 1956).

Active Processing System

The active processing system provides practitioners a framework for transitioning traditional teaching practices toward online and blended instruction. As a student acquires instructional multimedia, the active processing model suggests the brain actively organizes new information by integrating it with existing knowledge. According to Mayer (2009) students are immersed in active learning as they take-in new knowledge and organize the information into mental representations that are synthesized with previously acquired mental representations. In an attempt to organize incoming instructional multimedia, the learner will select relevant words and pictures, organize them into coherent verbal and pictorial models, and build connections between the verbal and pictorial models with prior knowledge. Based in Wittrock's (1992) generative processes of comprehension theory, teaching is the act of directing students toward their generative processes for understanding and the formulation of knowledge. To assist the learner's active processing system, instructional multimedia can deploy various instructional devices including self-referential encoding, a pedagogical agent, and signaling.

Self-referential encoding. A classroom teacher has the unique ability to contextualize content and create self-referential instruction for their learners. Unlike prepackaged computer-based applications or *canned* online instruction, a classroom teacher can incorporate specific current events and locally relevant instruction into a blended learning environment. As suggested by Yong Zhao, each community of learners is different and therefore, all instruction should be approached in a manner that is relevant both locally and individually (Brown &

Cooper, 2009). Additionally, the teacher's ability to create personalized instruction for the students can transform online instruction into an effective classroom learning environment that is knowledge centered, learner centered, and community centered (Bransford, Brophy, & Williams, 2000).

Self-referential encoding is based in research that analyzes how personalizing instruction can affect human cognition and schemas. Humans are more conscious of instruction when they are spoken to directly and they learn more deeply when the words in a multimedia presentation are in conversational style rather than formal style (Moreno & Mayer, 2000). Self-referential encoding is one of the most powerful encoding devices, based on the premise that people learn more when the information being processed relates directly to oneself (Rogers, Kuiper, & Kirker, 1977). In order to form a bond with learners using a multimedia lesson, self-referential encoding can be deployed. "The self-reference effects . . . support the use of personalized conversations in student communications with pedagogic agents as a cognitive tool to promote meaningful learning" (Moreno & Mayer, 2000, p. 730).

Pedagogical agent. Research has demonstrated that a pedagogical agent's on-screen voice can improve learning by navigating learners seamlessly through a multimedia lesson (Moreno, Mayer, Spires, & Lester, 2001). To engage learners effectively in instructional multimedia, online instructional techniques often use a pedagogical agent. As defined by Mayer (2009), a pedagogical agent is an on-screen character whose objective is to interact with the learner. An on-screen agent, such as a video or voice of an instructor, can be used to direct the learner's attention toward relevant information within a multimedia lesson. Acting as a familiar pedagogical agent within his/her own multimedia lesson, an instructor can reduce extraneous cognitive processing. "An on-screen agent points to a relevant portion of the graphic, this may serve to direct the learner's visual attention - thereby reducing extraneous cognitive processing" (Mayer, 2009, p. 261). These instructor's gestures can be embedded into a instructional multimedia in the form of video instruction (see Figure 2.3).

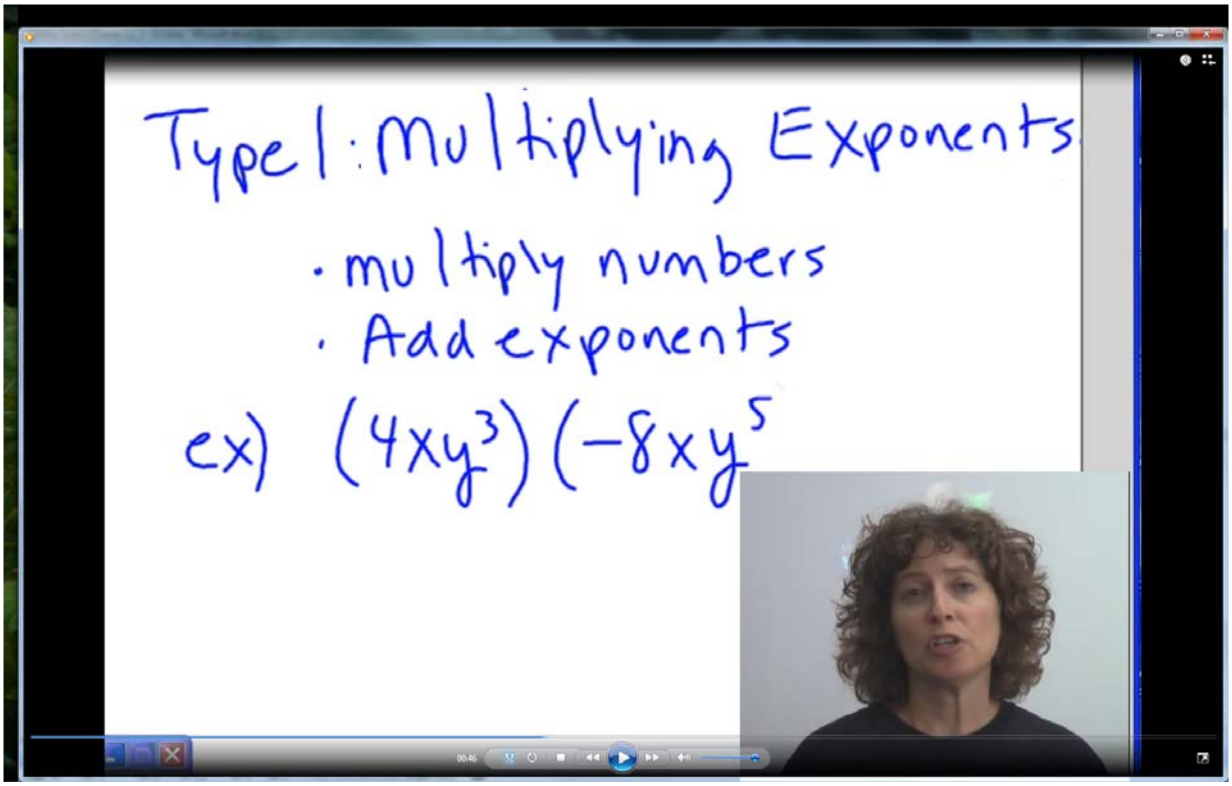

Figure 2.3. A Pedagogical Agent in a Screen-Capture Multimedia Lesson Demonstrating Algebra.

Social cues from an instructor's image or voice enable students to form an attachment or partnership with a teacher while navigating through a multimedia lesson. Mayer (2005) suggested that social cues in multimedia lessons could prime a social response within learners that will then lead to deeper cognitive processing and better problem-solving outcomes.

> Social cues in a multimedia instructional message - such as the nature of the speaker's voice or conversational style - prime the activation of a social response in the learner - such as the commitment to try to make sense out of what the speaker is saying. This social response causes increases in active cognitive processing by the learner - as the learner works harder to select, organize, and integrate incoming information - which in

> turn leads to a learning outcome that is better able to support problem-solving transfer performance (Mayer, 2005, p. 201).

Signaling. By visually directing or signaling students with a pedagogical agent embedded in a multimedia lesson, an online instructor is able to reduce a pupil's cognitive load. Signaling reduces extraneous processing by directing the learner to the key elements of the lesson (Mayer, 2009). By providing visual and auditory cues, such as pointing to relevant portions in a multimedia lesson, extraneous cognitive processing can be reduced. "A possible way to reduce extraneous load, without reducing the informational richness of animations (e.g. motion and timing), is by focusing the learners' attention on relevant aspects in an animation by cueing them" (de Koning, Tabbers, Rikers, & Paas, 2007, p. 732).

The rationale for an online multimedia instructional strategy that incorporates an instructor's moving video image can be traced back prior to the development of text and language. Man's earliest forms of communication were exhibited in gesture. In early Homo sapiens' settings, humans responded to gestural forms of communication for their survival. Gesture theory states that postures and gestures preceded language as a form of communication (Paivio, 2007). Incorporating gestures with auditory narration in a multimedia lesson is built upon the hypothesis that audio and visual information presented together minimizes the overall cognition load for the learner. As students view instructional multimedia, the learner can be signaled by cues toward relevant information, thereby reducing any extraneous load (de Koning, Tabbers, Rikers, & Paas, 2007). Embedded in the personalized instruction, various signaling principles are employed. By visually directing or signaling students with a pedagogical agent embedded in a multimedia lesson, the instructor is able to provide ongoing engagement that can increase student learning. Yet, "more research is needed to determine the conditions under which the presence of on-screen agents on the screen can foster learning - perhaps through pointing to relevant parts of the screen that the learner might otherwise have difficulty finding" (Mayer, 2009, p. 261).

In summary, the cognitive theory of multimedia learning encourages instructional designers and practitioners to account for the brain's information-processing functions. The theory is broken down into three separate regions of study. Within the first domain, the multimedia principle incorporates dual-coding theory that stipulates auditory and visual information are processed separately by the brain. The second portion states that the human brain has a limited amount of working memory available during the learning process. The third and final component of cognitive theory of multimedia learning analyses is the active processing system that explains how the brain organizes instruction by integrating newly acquired information with previous knowledge.

IV. Literature Review

Studies that analyze online learning and blended instruction in K-12 classrooms are surprisingly sparse. The majority of research studies on online learning, blended learning and instructional multimedia were conducted on college students seeking extra credit coursework. Online research databases were primarily employed in the literature process. Descriptors used in various combinations included: asynchronous instruction, blended learning, computerized instruction, computer-based learning, distance learning, hybrid instruction, multimedia instruction, one-to-one computing, online learning, podcast, screen-capture, and web-based instruction. The search of databases included ERIC, Education FT, CSA, Wilson Web, EBSCO, ProQuest, Emerald, Sage journal online, and Google Scholar.

During the online literature search, it became evident that empirical research on screen-capture instructional technology used to create online learning or blended learning within the K-

12 classroom was essentially nonexistent. Only four articles discussing screen-capture based instruction were located, however, this research dealt with teaching new software applications to college level students. Three dissertations and two peer-reviewed articles were located on the use of screen-capture instructional technology. Unexpectedly, few quantitative research studies were located that compared online or blended learning to traditional classroom instruction within K-12 schools. These findings are similar to those of a 2009 comprehensive U.S. Department of Education's meta-analysis study that found only nine K-12 studies between 1996 and 2008 involving a contrast between blended or online learning with face-to-face (offline instruction) sufficient for a quantitative analysis (USED, 2009).

Research on college level students using online learning and multimedia instruction was available. The search for relevant empirical studies using online or multimedia instruction yielded 117 peer review articles, 4 handbooks, and 6 books. This review will therefore also incorporate online and multimedia studies conducted on college students to fill the void of research on secondary students using online multimedia instruction within the classroom environment. However, as noted by USED (2009), "caution is required in generalizing to the K–12 population because the results are derived for the most part from studies in other settings (e.g., medical training, higher education)" (p. xii).

Themes

When analyzing the 117 peer review articles, 4 handbooks, and 6 books, much of the research deemed not relevant was due in part to their outdated modes of instructional technology. For example, many studies were unable to incorporate relevant online multimedia instructional practices due to past hardware limitations or network constraints that could not effectively measure student cognition. Of the relevant online and multimedia research, themes discovered were organized into four distinct areas: purpose, method, results, and discussion.

Cognitive Load emerged as the first theme from the online multimedia research. Researchers frequently attempted to reduce the learner's cognitive load during an online multimedia lesson. Attempts to reduce the learner's cognitive load were demonstrated as researchers varied instructional technologies, manipulated user control over the pacing and sequence of the lesson, and replaced text and graphics with audio narrations and animations. *Cognitive Tool* was the second theme discovered as researchers attempted to use digital instruction as a cognitive tool. Rather than use online multimedia content to support classroom instruction, researchers used online instructional multimedia as a tool to replacing traditional forms of instruction. *Lack of Oversight* emerged as a theme from the method researchers used to conduct online field experiments. Many of the researchers conducting online multimedia studies questioned the reliability of data from their remote subjects. *Student Engagement* emerged as a theme from the results of the studies. There was a commonly perceived increase in student engagement within the results section when researchers viewed subjects interacting with the online instructional multimedia. Patterns that attributed to this theme of engagement came from the observed increase in viewing time by participants and an increase in the interaction with the content with subjects using online instructional multimedia. *Blended Learning* emerged as the final theme from the authors' discussion. In the discussion sections, there was a common recommendation that the future use of online instruction should be integrated within classroom practices, and not be used solely for remote learning. The following literature review will discuss these four areas in detail.

Cognitive load. Cognitive load emerged as the first theme from the purpose of the studies as researchers attempted to increase student retention and transferability by reducing the learner's cognitive load. Based in Sweller's (2005) cognitive load theory (CLT), Griffin, Mitchell, and Thomson (2009) analyzed the learning experience of college students viewing online audiovisual lectures in a self-paced method. In hopes of investigating efficacy, the researchers analyzed two online multimedia technologies currently available to college students. Ninety full-time science and social science students were randomly divided into two equal groups. Students in an automated group (Group A) viewed fully navigable audiovisual podcasts of an instructor's multimedia presentation. For this group, each learner was given the option, but not the requirement, to pause, rewind, or forward the movie lecture. On the other hand, students in the manual group (Group B) were required to navigate manually through the entire audiovisual lecture. Rather than seamlessly view the movie lecture like the automated group, the manual group students were required to initiate each slide transition and each slide's audio segment. It was hypothesized that when subjects (Group B) were forced to manually transition through each slide and each corresponding audio file, there would be an increase in the learner's cognitive load when compared to subjects viewing an automated lesson with the option, but not requirement, of manual navigation. When both groups completed the single online multimedia lesson, they took an online quiz and survey. Using a chi-square test, the results from Griffin et al. (2009) indicated that the students in the automated group (Group A) significantly outperformed the manual students (Group B). Out of a possible 90 correct answers, the automated group (Group A) from Griffin et al. (2009) yielded 68 correct answers from a test on hot air balloons and sleep disorders compared to 52 correct answers by the manual group (Group B).

Similarly, Tabbers and de Koeijer (2010) tested interactivity using their hypothesis that learners with control over pace and order of a multimedia lesson can decrease their cognitive load and increase transfer performance. Unlike the experiment of Griffin et al. (2009) that forced learners to locate corresponding audio and manually transition through the slideshow, Tabbers et al. (2010) provided subjects with the option to pause, rewind, or forward the automated multimedia lesson while they studied the formation of lightning. To test their hypothesis, the researchers randomly assigned 52 university students into two experimental groups, one with learner control (Group A) and one without learner control (Group B). Two similar multimedia lessons were created for this study. However, the group without learner control (Group B) would view the educational slides in a format that transitioned to the next narrated slide without the learner's ability to control the pacing or sequence of the lesson. Should the other group (Group A) choose, they had the option to pause, rewind, or forward to any slide and without any time restrictions.

To test the students' performance, a prior knowledge test was conducted in a pretest (Tabbers et al., 2010). The same test was conducted on both groups using a posttest after viewing the instructional multimedia. In addition, a cognitive involvement survey was given to each student consisting of 15 semantic differentials that asked students to score their interest and concentration levels on a 7-point Likert scale. The results from the transfer test indicated the difference between groups was significant from a t-test and Pearson's correlation. Participants in the control group (Group A) had higher test scores based on a scale from 1 to 7 over the students with no user control (Group B) ($M = 2.7$ and $M = 2.1$ respectively). The transfer test for the learner control group (Group A) were significant over the non-control group (Group B) ($t\ (50) = 1.177$, $p = .04$, one-sided, $d = 0.05$).

Both Griffin et al. (2009) and Tabbers et al. (2010) demonstrated that a limited degree of user control during a multimedia lesson reduced the learner's overall cognitive load. In both research studies, the control group subjects (Group A) viewed an audiovisual lesson with the option of pausing, rewinding, or forwarding the lesson. However, the other students (Group B) in Griffin et al. (2009) had too much manual control, while the (Group B) students in Tabbers et al. (2010) had too little manual control over the audiovisual lesson. Both groups (Group B) with extremes of manual control fared equally poor, suggesting that extremes of manual control increases the learner's cognitive load. Based in Sweller's (2005) cognitive load theory, the mental effort required to navigate through a multimedia lesson with too many procedures forces an increase in the learner's cognitive load and working memory (Griffin et al., 2009). Similarly, a student without manual control over the pacing of an audiovisual lesson can experience cognitive overload when their working memory is overloaded from too much incoming information (Tabbers et al., 2010).

In another study with patterns leading to the first theme of reducing cognitive load, leading educational psychologist Richard Mayer worked with educational researchers in a K-12 blended learning environment. Harskamp, Mayer, and Suhre (2007) analyzed the effect of Mayer's modality principle as it applies to the teaching of high school science. Mayer's multimedia theory states that people learn better from graphics and narration than from graphics and on-screen text. To test the theory that instruction anticipating dual modality reduces the learner's cognitive load (Mayer, 2005), Mayer and his colleagues conducted field experiments on 27 secondary school students. To test Mayer's previous laboratory findings that recommended multimedia graphics be accompanied by concurrent narration rather than onscreen text, Harskamp et al. (2007) conducted two separate field experiments using web-based multimedia biology lessons. To verify the use of audio narration as a multimedia tool within the classroom, students were provided instructional multimedia based on content from their existing biology textbook. A pretest and posttest containing 20 multiple-choice items were used to measure the results. In the first experiment, the secondary learners proceeded at their own pace with the instructional multimedia. One group used illustrations with narration while the other used illustrations with text.

The results from the first experiment from Harskamp et al. (2007) indicated the retention and transfer rate for the illustrations with the narration group significantly outperformed the illustration-and-text group. Notable in their conclusion, the authors acknowledged the criticism that laboratory studies do not necessarily apply to real world experiments. However, the results of their field experiments on secondary students in the blended learning environment appeared to validate previous multimedia studies conducted by Mayer and his colleagues on college students in controlled laboratory settings. Based on the first themes attempt to reduce the learner's cognitive overload (Griffin et al., 2009; Harskamp et al., 2007; Tabbers et al., 2010), research conducted in this dissertation will also attempt to reduce the cognitive load by providing the screen-capture group the option to manually control the pacing and sequence of their multimedia lesson.

Cognitive tool. Cognitive tool was the second theme that emerged from the purpose of researching multimedia instruction. According to Kong (2011), cognitive tools are computational devices that can guide and mediate the cognitive processes of learners. With the increase in classroom's broadband capacity and the availability of inexpensive mobile computers, it has only recently become practical to use instructional multimedia as a cognitive tool. Kong (2011) investigated the effect on learning with classroom students using one-to-one tablet computers as a cognitive tool. A quasi-experiment was conducted in a field setting consisting of 9 and 10-year-old math students in two classrooms. Both the control group and experimental groups learned fractions over daily 40-minute teaching sessions (455 minutes) that lasted for two weeks. The control group learned math lessons in the traditional lecture teaching approach without the use of one-to-one tablets. A workbook and corresponding school-based activity worksheet were provided to both groups. For the experimental group, a Graphical Partitioning Model (GPM) software application replaced the teacher's live instruction. The GPM appeared as a rectangular bar located on each student's tablet screen. As students learned how to add and subtract fraction problems from the GPM application, the GPM could be manually deployed by each student to provide additional scaffolding. For immediate feedback, students clicked on the GPM rectangle to view an animation of their proposed answer. Similar to Tabbers et al. (2010), a time allocation analysis was conducted on both groups. Time-on-task was considered to reflect the degree of student engagement. In addition, a pretest and posttest were administered to both groups and a questionnaire was answered only by students in the experimental group after the final computer instruction.

A paired *t*-test and ANCOVA indicated a significant increase in learning for primary students using a one-to-one tablet computer with the GPM software application as a cognitive tool. Surprisingly, the mean scores between the pretest and posttest for the control group were not significant, suggesting that learners using one-to-one computers as a cognitive tool required less instructional time for learning than students in the traditional classroom setting. Using video-based observations, it was revealed that the teacher in the control group spent over 182 minutes (40%) of the teaching time leading whole-class answer-checking sessions. The degree of student engagement during these group activities was extremely low. Conversely, the instructor in the experimental group was able to rely on the tablet computer's GPM application for answer checking while the degree of student engagement in the experimental group was significantly higher.

Interestingly, it was revealed the standard K-12 teacher's protocol to check for student understanding during a traditional classroom instruction occupied over 40% of instruction time and dramatically decreased student engagement, while students using one-to-one computer-based checking software maintained their level of engagement (Kong, 2011). A limitation of the proposed screen-capture instructional technology is the inability for the multimedia software to self-check for student understanding. However, unlike the traditional classroom, the teacher in the proposed experiment will be able to check for student understanding on a one-to-one basis without effecting the other learners' ongoing multimedia instruction. Similar to Kong (2011), the experiment conducted for this dissertation will also use mobile one-to-one tablets as a cognitive tool.

CAD pilot study. As noted, there was limited research discovered in the literature review using screen-capture instructional technology as a cognitive tool. In the fall of 2009, a pilot study was conducted to validate the overall effectiveness of using screen-capture instructional technology for computer aided design (CAD) students. Step-by-step teacher instruction was captured from a desktop computer's screen movements. The results of the CAD study demonstrated that the students had a significant increase in transfer knowledge when they learned from a teacher's instructional multimedia when compared to students learning the same content in a textbook. For a possible score of 14.0, total scores on the CAD posttests were significantly higher for students in the screen-capture group (M = 9.71) than those in the textbook group (M = 7.83), $F(1,48) = 4.79$, $p < .05$, partial $\eta^2 = .09$

The 2009 pilot study did not measure the use of screen-capture instructional technology on a traditional K-12 curriculum. One might suggest that the findings from the CAD pilot study are limited to the instruction of software applications that rely heavily on a graphical user interface (GUI). However, a teacher using a lecture-based whiteboard methodology depends on step-by-step graphical representations to convey their instruction. Similar to CAD students, math students are required to understand each step prior to moving onto the next concept. The math curriculum's requirement to build upon the previous day's knowledge and its use of step-by-step instruction is deemed the best suited of the mainstream K-12 curriculums to integrate screen-capture instructional technology. Therefore, the proposed research will be conducted using a high school's math curriculum.

Lack of oversight. The lack of oversight emerged as a theme throughout online research experiments. For example, Figlio et al. (2010) conducted a comparison study on a university introductory microeconomics course between classroom lectures and identical online instructional multimedia. While it can be made nearly impossible for experimental group participants to sit-in on classroom lectures with a live classroom group, individual students in a live classroom group can surreptitiously view the online instruction with the experimental group participants at remote locations (Figlio et al., 2010). Based on the control group's academic proficiency and their extremely low classroom attendance rate, the authors suggested that students in their control group chose not to attend the classroom lectures, but rather accessed the online content from the experimental group's participants.

Similarly, O'Bannon, Lubke, Beard, and Britt (2011), also found it difficult to rely on their subjects when they tested online instruction. In this study, 58 female and 11 male students from four sections of a technology class for a teacher accreditation program participated in the study. The study examined the academic achievement of students (experimental group) using podcasts in place of the classroom lectures (control group) over a semester course. Over the length of the study, students in the experimental group downloaded 12 digital media file lectures from iTunesU and Blackboard. The duration of each podcast was targeted for 10-minute durations to ensure optimal content and communication. In addition to the instructor's audio lecture, students were provided with printouts based on the classroom instructor's corresponding slideshow. At least eight of the participants (22%) from their study (O'Bannon et al., 2011) reported that they did not listen to most of the online instructions, and one third (*n* = 12, 33%) reported that technical problems prohibited them from viewing online content.

Data sources used in the study by O'Bannon et al. (2011) were taken from chapter quiz scores, online survey responses, and podcast journals. On the last day of the study, students completed an online survey that inquired about the amount of time students listened to each episode. Twenty-four (67%) of the participants reported they listened to most of the podcasts, with eight (22%) of the college students unable to view some of the podcasts entirely. Even with this difficulty listening to the audio lectures, the study findings reported no significant difference in the achievement of students who received the podcast instruction versus those who received the live lecture. Surprisingly, a major finding of the study was that a majority of the podcast learners were not comfortable using the podcasts to replace traditional lectures. Many of these college students suggested the digital lectures should be used for supplemental purposes only.

The lack of oversight during online experiments forced researchers such as O'Bannon et al. (2011) to rely on self-reporting for measuring student participation. As a result, data regarding student participation was not very reliable. The problems of measuring online access also created contamination issues. Unlike participants in O'Bannon et al. (2011) who failed to access the online instruction, it was suggested by Figlio et al. (2010) that the control group participants were sharing the online lessons with the variable group participants for the final exam. Less than 90% of the control group participants from Figlio et al.'s study (2010) attended all of the classroom lectures, yet their scores matched the students who were learning from the online classroom lectures. It can be concluded that online course comparison studies conducted with a lack of oversight can easily result in treatment diffusion.

Data that appeared most reliable were comparative studies of instructional multimedia in the laboratory, and not field experiments of online instruction. As with the online field experiments, most of the multimedia experiments were not conducted on K-12 students taking academic courses, but rather conducted on college students in controlled laboratory settings. Of these multimedia studies, educational psychologist Richard E. Mayer pioneered the use of computer-based multimedia instruction beginning in 1989 and participated in no less than 25 research studies. Mayer's ongoing research contained the most reliable data available, and his research continues to fill in gaps in multimedia research. Furthermore, within each of Mayer's studies, a minimum of two separate experiments were deployed to measure multimedia learning. Much of today's online multimedia research replicates Mayer's experimental designs, but adds various modifications. To address the theme of online contamination and student difficulty downloading online content, the proposed experiment will be conducted within a classroom setting using online multimedia content with the added capability to access the day's multimedia lesson as a preinstalled movie file from within each mobile computing device.

Student engagement. Student engagement emerged as a theme from the results of research experiments. For example, Tabbers et al. (2010) summarized that the higher scores were not from the multimedia's dual coding, but rather from the extended time spent on each slide by the engrossed students. Using videotaped observations, Tabbers et al. (2010) reported the average duration for the self-paced students on the instructional content was twice the amount to the students in the automated lesson. Some of these self-paced learners spent three times the amount of time viewing each slide than the students in the automated group, while three of the self-paced participants chose not to use any of the navigation tools. Though the control group had superior transfer results, the authors suggested the improvement in student test scores could be a factor of additional time and not user control. In their discussion, the authors cautioned against generalizing the effect of multimedia instruction's dual coding.

In Harskamp et al.'s (2007) second experiment, subjects could learn at their own pace through the multimedia lesson, but the content was more interactive for each group and the students were required to answer two or three questions with corrective feedback throughout the lesson. The results were not significant, leading to speculation that their level of engagement provided for an extended period to interact with the multimedia lesson, which trumped the modality principal. As a result, Harskamp et al. (2007) suggested that when slower learners are actively engaged in their learning, they benefit from the added instructional time provided from the multimedia lesson.

Blended learning. The recommendations for blended learning emerged as the final theme from the authors' discussion of the research experiments. Researchers concluded that online multimedia instruction should not be used solely for remote learning, and instead be used as a classroom activity. Rather than eliminate the traditional classroom setting, researchers suggest the classroom should be used for more student-centric activities. For example, with the success of online multimedia instruction as the primary delivery method for the coursework, many researchers suggested that the classroom instructor should no longer need to deliver live instructional content to their students, but instead devote classroom time to more student-centered activities. "The instructor is free to devote instructional time to more student-centered interactions" (O'Bannon et al., 2011).

In the theme of blended learning, Griffin et al. (2009) went so far as to question the validity of providing online lessons to students without corresponding classroom activities. The authors acknowledged the pedagogical justifications of "the four Ps," place, pace, peace, and process. *Place* referring to a flexible location, *Pace* for the ability to learn at their own speed, *Peace* for choosing an appropriate learning time, and *Process* for providing students with an alternative means for learning. However, the authors suggested "the four Ps" could just as easily lead to pub, plod, procrastinate, and play. *Place* could just as easily refer to an inappropriate learning location without the encouragement of an instructor or from fellow students in the classroom (*Pub*). *Pace* could slow considerably as the learner worked alone (*Plod*). Rather than provide a peace and quiet for student learning, the learners could just as easily put off studying from the inherent freedom provided (*Procrastinate*). Finally, rather than choose a learning process that is most suitable for oneself, the student may just as easily choose one that is inappropriate for their learning needs (*Play*). Based on their findings, Griffin et al. (2009) argued that online learning should be supported by other types of classroom instruction to enhance the learning process. Griffin et al. (2009) suggested that the ideal use of the online medium would be best suited for a blended learning environment where there is "the thoughtful integration of classroom face-to-face learning practices with e-learning experiences" (p. 538). As a result, the proposed experiment conducted for this dissertation will be held within the secondary blended environment.

V. Summary

In today's educational climate, many public school teachers and administrators are challenged by the requirement to annually increase student academic achievement as mandated by the No Child Left Behind Act of 2001 (NCLB). Online learning can provide an increase in academic achievement that is not dependent on the presence of a classroom teacher. Many schools have begun to utilize solely online curriculums, even though the blended learning environment has been shown to be superior for learners. By incorporating screen-capture instructional technology, instructors can create their own *in-house* multimedia lessons that can create a hybrid-blended learning environment.

The cognitive theory of multimedia learning is divided into three separate components of brain function that include the multimedia principle, CLT, and active processing. The multimedia principle states that humans have separate information-processing channels to acquire verbal and pictorial knowledge. Based on dual-coding research, the multimedia principle states that audio and visual information are transmitted through separate channels in the brain and then coded as memory for later retrieval. By incorporating the dual-coding theory in a multimedia lesson, text should be presented directly to the verbal channel as spoken narration rather than in its written form. By utilizing both channels, learning is increased by the reduction of extraneous processing.

CLT stipulates that there are three cognitive loads in the brain that need to be accounted for within multimedia instruction: intrinsic load, extraneous load, and germane load. CLT suggests that optimal learning occurs with an increase in germane cognition and a decrease in extraneous overload. Similarly, the cognitive load of working memory can become overloaded when the intrinsic or inherent complexity of information is too high. To overcome the limitations of working memory, the learner's brain groups complex information into smaller components. By grouping information, the brain can overcome its inherent working memory limitations.

The active processing system of the brain constructs interpretations of new information and attempts to integrate it with existing knowledge. To assist active processing, multimedia instructional strategies include the use of self-referencing, a pedagogical agent, and signaling. Self-referential encoding includes personalizing a multimedia lesson for the student. A pedagogical agent, such as a video or voice of an instructor, can be deployed to reduce cognitive overload. A pedagogical agent embedded within a multimedia lesson can employ signaling to direct a learner's attention toward relevant information within a lesson. These various strategies developed under the cognitive theory of multimedia learning attempt to reduce the overall cognitive load in the brain with the intent of increasing student learning.

When analyzing the literature, five relevant themes that appeared from online and multimedia research were organized into four distinct areas: purpose, method, results, and discussion. Cognitive load emerged as the first theme due to researchers' attempts to reduce the learner's cognitive load during an online multimedia lesson. Cognitive tool was a theme also discovered as the purpose for using multimedia instruction as a cognitive tool. Lack of oversight emerged as a theme based on the lack of oversight from the online field experiments. Student engagement emerged as a theme from the results of the instructional multimedia and blended learning emerged as the final theme from the authors' discussions.

Based on the findings from the literature review, this research study incorporated intended to incorporate the five themes. To reduce the learner's cognitive overload as demonstrated in these findings (Griffin et al., 2009; Harskamp et al., 2007; Tabbers et al., 2010), research conducted for this dissertation attempted to reduce the cognitive load of the learners by providing the screen-capture group with the option to manually control the pacing and sequence of their multimedia lesson. Resembling the experiment of Kong (2009), this dissertation procured one-to-one mobile tablets to be used as a cognitive tool. Similarly, the teacher intended to check for understanding on a one-to-one basis. To address the theme of online contamination and skewed data from the students having difficulty downloading online instructional content (Figlio et al., 2010; O'Bannon et al., 2011), this experiment was to be conducted in a classroom by students using tablet computers that could also access the day's online multimedia lesson as a preinstalled movie file. Finally, as noted from the recommendations that online instruction be used in the blended learning environment and not remotely (Griffin et al., 2009, O'Bannon et al., 2011), the proposed experiment was to be conducted within the secondary classroom with remote viewing enabled as a support feature.

CHAPTER 3

METHOD

This study used a quasi-experimental research design to measure students' academic achievement on secondary students learning from a teacher's screen-capture instructional multimedia compared to students learning from the same instruction, but presented as a traditional classroom lecture. The four-week experiment incorporated one full chapter from a high school's Algebra II textbook. The research questions for this study were as follows:

1. To what extent, if any, is there a difference in the academic outcomes of secondary Algebra students learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
2. To what extent, if any, do secondary Algebra students prefer learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
3. To what extent, if any, are secondary Algebra students more engaged learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons?
4. To what extent, if any, does the experience of creating and instructing multimedia Algebra lessons developed from a secondary classroom teacher's screen-capture instructional technology change the teacher's instructional practices?

Setting

A convenience sample was drawn from a comprehensive secondary school that was part of a suburban school district located within Northern California. The K-12 public school district also included four elementary schools, one junior high school, a continuation high school, and a small alternative environmental academy. The school was the only comprehensive high school within the public school district and therefore received a great deal of attention from the district office and community. As the main high school within the district, the school did not need to compete with other local high schools for community funding.

Participants

The sample for this study was 56 students from a comprehensive high school serving approximately 1,230 students. The participants were 9th, 10th, 11th, and 12th grade students whose ages ranged from 14 to 18. The ethnicity of the students consisted of 72% White (non-Hispanic) students, 20% Hispanic students, 4% African American students, 2% Asian students, and 2% Indian students. For the 2011-2012 academic school year, the high school's guidance counselor randomly assigned all the Algebra students into classes using Aeries Student Information System Software.

The control (n = 24) and treatment (n = 32) groups were selected from a convenience sample from one of the two high school Algebra II classes instructed by the math department's chair. To address any ethical concerns that could have arisen from the research, this study was submitted for review by the Saint Mary's Institutional Review Board (IRB) and was approved in June of 2011. This study maintained the guidelines from the author's previous math pilot study approved by IRB during the summer of 2010. As with the math pilot study, the site principal and superintendent provided approval for the proposed research in written statements. Parental consent was not deemed necessary by IRB because no new curriculum was introduced and no harm to the research subjects was foreseen. The classroom teacher also completed a consent form prior to the research experiment (Appendix F).

Instrumentation

Teacher Journal. An online journal was created for the teacher in an attempt to discover whether the experience of creating and instructing multimedia Algebra lessons created from the teacher's screen-capture instructional technology might change a secondary classroom teacher's instructional practices (Appendix A). When the Algebra teacher developed her multimedia lessons using the SMART technology, she periodically provided a written assessment of the construction process. Using her Google teacher's account, the Algebra teacher maintained an online journal document that had sharing rights with the researcher conducting this study. As with all of the school district's online documents, the school's director of information technology (IT) also had viewing privileges to the journal documents.

Teacher Survey. After each day's classroom activity during the experiment, the Algebra teacher reflected on the daily instructional practices of each group by using the teacher survey (Appendix A). The teacher rated the effectiveness of both the traditional lessons on the live-lecture group and the online multimedia lessons on the screen-capture group. The teacher's classroom observations were recorded by rating each lesson immediately after each classroom session. The teacher survey was not used as a tool for collecting data on student performance, but rather, it evaluated how the students interacted with each math lesson and assessed their level of engagement. Questions one through six were used by the teacher to self-evaluate the lesson's content and rate the mechanics of her online instructional multimedia. These specific questions were nearly identical in the live-lecture and screen-capture group survey's questions. The use teacher's and students' perspectives was used to analyze the quality of the lessons. Questions seven through nine were used to rate the cognitive engagement of the live-lecture and screen-capture group upon each class meeting. Questions one through nine used a five-point Likert-type rating scale (1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree). IBM's SPSS Statistics 18 software was used to measure her positive and negative responses to each statement. In addition to selecting one answer to each statement provided on the teacher survey, the math teacher answered two open-ended questions. These open-ended questions enabled the teacher to express in her own words any unforeseen classroom events that either helped or hindered the teaching of each lesson.

Student Survey. To determine to what extent, if any, do secondary Algebra students prefer learning from multimedia lessons created from their teacher's screen-capture instructional technology, a student survey (Appendix B) was administered to both research groups after the posttest activity. Unlike the teacher, the students completed their lesson survey only once. In hopes of acquiring the perspectives from both the teacher and her students, the teacher survey (Appendix A) was aligned with the student survey (Appendix B). Both survey statements were worded nearly identical. As with the teacher survey, each student survey statement was individually answered by selecting one integer from a five-point Likert scale.

To determine to what extent, if any, are secondary Algebra students more engaged learning from multimedia lessons created from their teacher's screen-capture instructional technology, additional engagement inquiry questions were added to the student survey (Appendix B) for both the live-lecture and screen-capture groups. According to Reeve, Jang, Carrell, Jeon, and Barch (2004), "Engagement refers to the behavioral intensity and emotional quality of a person's active involvement during a task" (p. 147). Unlike student preference, engagement represents the student's participation and involvement in an activity. Additionally, engagement can be used to predict student achievement and dropout proclivity (Reeve et al., 2004). The ability to measure student cognitive engagement is thus paramount to improving the academic outcomes of all students, but most especially for learners who are a high risk of failure (Appleton, Christenson, Kim, & Reschly, 2006). By incorporating Appleton's et al. (2006) SEI in the student survey, cognitive engagement was assessed. The cognitive questions were specifically developed to measure student levels of engagement as perceived from the perspective of the student. The original SEI questions measured the cognitive engagement of each student within school and not toward a specific curriculum. Therefore, the original SEI questions were modified to represent the level of student engagement in the live-lecture and variable group class setting, rather than measure the student engagement in all the school's classes. Both the live-lecture and screen-capture groups answered 11 questions (7 through 18) that were scored using a five-point Likert-type rating scale (1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, and 5 = strongly disagree). All items were coded so that the higher scores would indicate higher levels of engagement. Questions seven through nine matched the teacher survey questions that were also modified from the SEI.

In addition to selecting one answer to each statement on the student survey (Appendix B), two open-ended questions asked the students to describe anything that helped or hindered the learning of the Chapter 5 math lessons. These questions correspond to the teacher's survey questions. A crosstabulation was conducted to examine the ease or difficulty the students experienced while learning from either the traditional classroom instruction or the online multimedia lessons. Using an *Effects Matrix* procedure (Miles & Huberman, 1994), a chart was created to organize the open-ended questions from the student's survey. Random identifiers were written in a vertical column, located on the left side of a matrix chart. To the right of each identifier, open boxes were created below each open-ended survey question. From the completed role ordered matrix, a separate display device was created to organize the findings into categories, patterns, and themes.

In addition to the student survey, participants in the screen-capture group completed the instructional multimedia survey (Appendix C). This survey examined the screen-capture group's preference and interaction with the teacher's online multimedia lessons. The first eight questions (21 through 28) were developed to compare the student preferences with the teacher's traditional pedagogy to her online multimedia lessons. Five of these eight questions were open-ended. A crosstabulation was used to examine the students' preference to learning from either the traditional classroom lesson or the online multimedia lessons. The last ten questions were designed to rate the mechanics of the online multimedia format (questions 29 through 38). These questions were developed with the math teacher in an attempt to examine the interaction with her online multimedia lessons. These survey questions ranged from how often the students interacted with the lessons to whether the screen-capture group's parents viewed the online math lessons.

Apparatus. The high school's community had recently passed a 42 million dollar bond measure created in part to bring educational technology into the classroom. Fortuitously, as a result of the bond measure, all teachers within the school district were asked by the district's director of technology to apply for any desired classroom instructional technologies. Based on our discussions, the school district's director of technology expressed an interest in the methods and results of the dissertation's research study and was willing to help facilitate the experiment. He had been looking to incorporate mobile computing into the classroom to satisfy the school district's long term goal of one-to-one computing. He was also responsible for acquiring and implementing the school's online recovery curriculum.

Based on the goals written in the application by myself and the math department chair, the teacher conducting the proposed experiment was given a classroom set of Apple iPad tablet computers and corresponding over-ear headphones used for this study and throughout the school year. In addition, a Microsoft Windows 7 touch-screen tablet was also used in this study to give the the teacher the option of creating the multimedia lessons outside of her classroom. The screen-capture group's audiovisual lessons were created prior to the research study by the Algebra teacher using her digital whiteboard's recording capability and the Window's touch-screen tablet. The instructional multimedia was created on both platforms using the district's SMART technologies' screen-capture software. As the math teacher would demonstrate how to graphically solve Algebraic equations on her classroom's SMARTboard or tablet device, the SMART technology's digital software application captured the animated screen markings. A corresponding audio narration was simultaneously recorded using a microphone plugged into the device's USB slot. The SMART technology's embedded screen-capture technology merged each audio and video lesson into one Windows Media Video (WMV) digital file. When the teacher chose to create the multimedia lessons from a remote location, she did so with the SMART notebook software application on her touch-screen tablet computer. For each day's lesson's introduction, the teacher recorded herself using her iPad's front facing video camera or a digital video recorder. Sony VegasPro movie-making software was used to combine the teacher's introduction, lesson titles, and Smartboard WMV lessons into one multimedia file. When the math teacher completed the development of her lesson, she uploaded the multimedia file through the school district's Internet portal.

The school district was embracing *cloud computing* technology in hopes of making all of the school's digital content available from remote servers, rather then through the school's intranet network. With the school district's emphasis on classroom technology, the director of technology transitioned all of the school's email accounts and digital content to Google's free education web hosting services. Unlike the school's traditional computer-based educational software applications that are restricted to a particular device and location, cloud computing enables users with web browser applications on multiple platforms to interact with online multimedia content, either from within the school site or from remote locations. The *roll-out* of the cloud computing for the district's students and staff coincided with the research study's experiment, and thereby provided the screen-capture group participants access to the teacher's multimedia lessons outside of the classroom. The implications of the free cloud computing technology suggests this study's online component could be easily replicated by other school districts.

Using Google's video share option, the math teacher invited each student in the screen-capture group to access her multimedia lessons through an email invitation. As the screen-capture group arrived daily to class, a designated iPad tablet computer with a numerical identifier was distributed to each student. Once each student individually logged in to the teacher's website using their existing school e-mail account and password, they were able to continually access their Algebra teacher's multimedia lesson. The participants in the screen-capture group were able to view the online lesson in an asynchronous manner from their classroom's tablet computer, other school desktop computers, their own Internet accessible multimedia devices, and from home (see Figure 3.1).

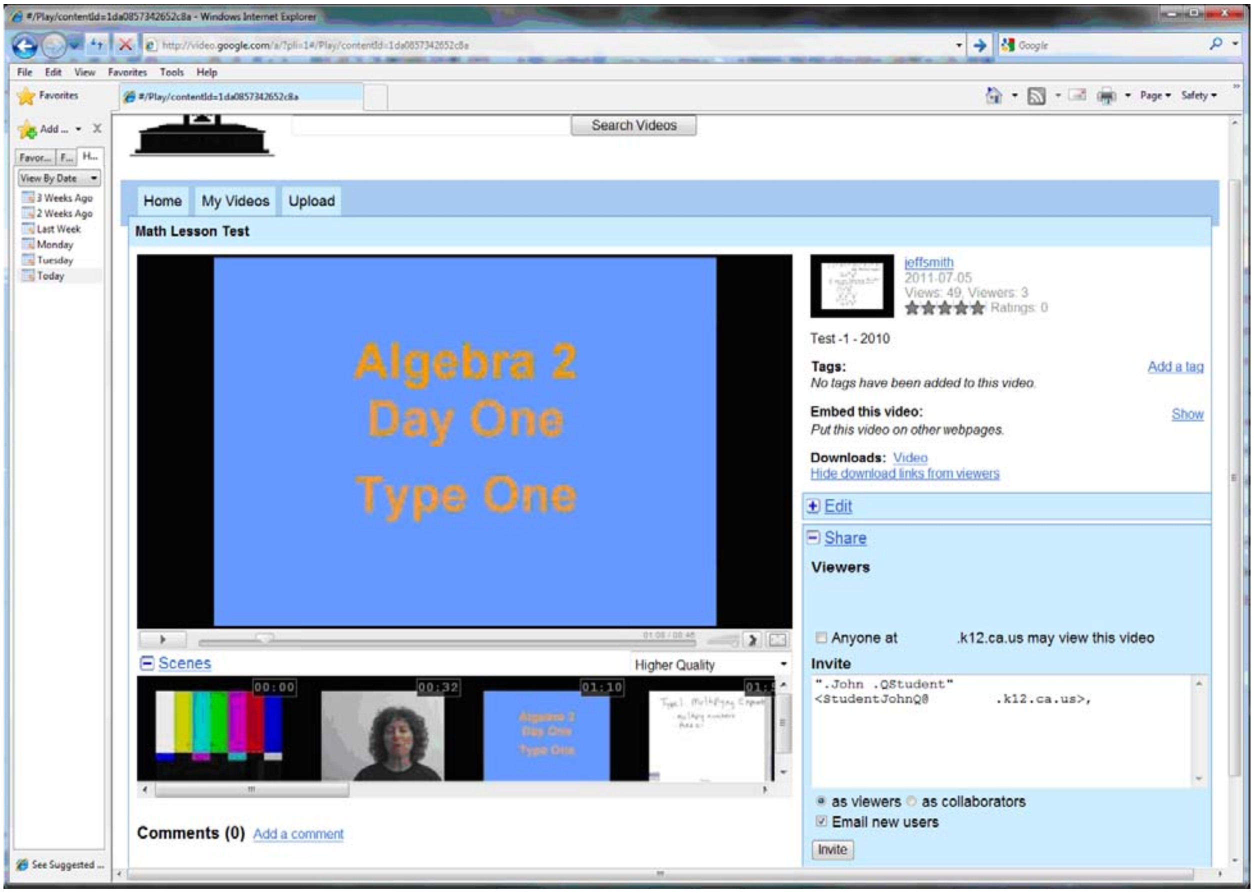

Figure 3.1. Screen-Capture Instructional Multimedia on the Teacher's Online Website Demonstrating the Invite Feature.

If there would have been any difficulty accessing the multimedia file from the teacher's website during the experiment, the students in the screen-capture group were always able to instantly view the multimedia lesson. As a precautionary measure, a backup multimedia file of the teacher's online multimedia math lesson was synced daily to each iPad device. In the event that the Internet connection was inaccessible for an unforeseen reason, the participants in the screen-capture group could have easily continue the day's research study by accessing the multimedia lessons pre-installed on the iPad's Videos viewing application. One limitation to accessing the multimedia videos internally from the mobile device was that the student were not able to read their teacher's or fellow classmates *realtime* comments or add their own questions or comments. After the posttest and completion of the survey's, the comments from the participants in the screen-capture group were amassed and used to rate student level of engagement. In addition, by not logging into their own online accounts to access the daily multimedia instructions, it was feared that the participants in the screen-capture group would have been less inclined to access the online multimedia instructions outside of the classroom.

Design

To answer the question whether there was a difference in the academic outcomes of secondary Algebra students learning from multimedia lessons created from a teacher's screen-capture instructional technology when compared to students who learn from traditional lecture-based lessons, a controlled field study was conducted. A pretest-posttest comparative study relying on statistical data from a live-lecture and screen-capture groups measured the student's academic achievement from the traditional lecture and from the teacher's screen-capture instructional technology. The live-lecture group viewed their teacher's whiteboard instruction describing how to solve Algebraic equations, while the screen-capture group viewed the identical lesson, but prerecorded for the mobile multimedia devices.

Pilot study. A pilot math study at the same high school as this research experiment had been approved by Saint Mary's Institutional Review Board during the summer of 2010. The pilot study was primarily developed to test the technical aspects of the digital whiteboard's screen-capture software and gauge the level of acceptance towards a self-paced learning environment from the school's math department. It was revealed that the SMARTboards were intended to be interactive and not designed to record multimedia files. However, with a slight modification, the technical problems were easily overcome. Unbeknownst the researcher, the math department chair was too afraid to record new instructional content for her multimedia lessons, and instead, chose to record only review material. Her apprehension laid in the fear that the participants in the screen-capture group would not learn from the instructional multimedia and would not test well in the mandated state testing. However, while the math department chair was conducting the pilot study with her review content, she witnessed students pausing and rewinding her audiovisual lessons in an asynchronous manner and became very excited with the technology's educational promise. These multimedia math files were uploaded to the teacher's new website and were used by the screen-capture group as a *dry run* a few weeks prior to conducting the current study. No data was collected from the students during this procedure.

Current study. Students used the California Content Standards for High School Mathematics and school board approved Algebra II textbook materials. This research study did not make any changes to the existing Algebra curriculum, but did change some of the sequence of the Algebra instruction. The teacher did not need to change her existing lecture and whiteboard practice to conduct this experiment. The classroom's digital whiteboard was able to capture this pedagogy as a multimedia file. The live-lecture group and screen-capture group were both taught the same Algebra II curriculum and strategy to solve mathematical equations. For both the live-lecture and screen-capture groups, the Algebra II teacher introduced content from chapter five of *Glencoe's California Algebra II* textbook. The lessons included graphing quadratic functions, solving quadratic equations by graphing, solving quadratic equations by factoring, complex numbers, and completing the square.

All students were informed of their involvement in this research study. No decrease in classroom instruction for either group of students was projected for this study. Based on the literature review and results from the pilot math study, it was anticipated that both the live-lecture and research group participants would learn new Algebra II content during the study.

Students who completed this research study and were in need of additional instruction were able to receive one-to-one instruction from the math department's chair. All student names were removed from the pretests/posttests and were replaced with numerical identifiers provided by a table of random digits. Group identifiers, pertaining to student names from the live-lecture and screen-capture groups, were also removed. The only student information included in this study was the student's demographics, GPA, and prior Geometry grades.

The study only used computer hardware and software available to secondary students and did not subject students to any technology that was not available for the classroom. The instructional technology, including SMART technology's digital whiteboards, iPad tablets with headphones, multimedia editing software, Google's teacher webpage, and screen-capture software had all been approved and purchased under the auspices of the district's school board. All of the instructional tools deployed in this study were owned by the school district and were readily available for other high school teachers within the district.

Procedure

On the first day of the study, both the live-lecture and screen-capture groups were given a pretest activity (Appendix D). Both the live-lecture group and screen-capture group participants met in the teacher's regular classroom. Over the following four weeks, both groups were provided daily new lessons based on the Algebra's textbook and workbook activities. Each day, the Algebra teacher provided the live-lecture group with a live lesson that lasted no more then 10 minutes. In addition to the 10 minutes of new instructional conent, individual student questions were answered as needed. After the lecture, the participants in the live-lecture group worked independently on their Algebra workbook activity for approximately 20 minutes. Students were able to ask for and receive one-to-one assistance from the teacher during the workbook activity. After four weeks of instruction, both groups took a posttest (Appendix D).

The screen-capture group used the same lesson objectives as the live-lecture group, but with the instructor acting as a familiar pedagogical agent embedded within the multimedia lesson. At the beginning of each day's lesson, the screen-capture group's students logged in to the teacher's Google webpage with his/her username and password and begin streaming the day's Algebra lesson on their own iPad. To limit the student's cognitive load, it was anticipated that each lesson would last no more than 10 minutes. Students were permitted to take notes in their spiral notebooks. Rather than perform a live instruction to the screen-capture group, the Algebra teacher proctored her captured multimedia lesson and provided one-to-one assistance as requested from her students. Upon listening and watching the teacher's live instruction or from the iPad's multimedia lesson, both research group students worked independently on a workbook activity for approximately twenty minutes. While the participants in the live-lecture and screen-capture groups solved Algebraic problems from their workbook activity, they had ongoing access to the teacher for one-to-one assistance.

Unlike the participants in the live-lecture group, the subjects in the screen-capture group asynchronously viewed the Algebra instruction from their iPads throughout the duration of the classroom activity and as often as needed. The screen-capture group's participants could access their teacher's multimedia Algebra instruction on other school computers, on their own mobile multimedia devices, and from their home computers. Each day's lesson was built upon the previous day's lesson, where they remained accessible only to the participants in the screen-capture group for the duration of the research study. When a student missed the day's activity, the live-lecture group participants followed standard teaching procedures and made-up the day's lesson during class and after class with the teacher, while the students in the screen-capture group made-up the lesson during class and at his/her own discretion using the teacher's webpage.

Data Analysis Plan

For the assessment, the classroom teacher's DataDirector test scanning software was used. Random student identifiers replaced all student names on the pretest-posttests. To evaluate the extent students learn the Algebra concepts, an analysis of covariance (ANCOVA) was employed using IBM's SPSS Statistics 18 software. An ANCOVA was used as a technique for managing extraneous variables and as a means for increasing the power of the statistical test. By checking for a covariance, data from a student with any potential prior knowledge was statistically negated. Using the SPSS results, the posttest scores were able to be deemed significant when compared to the pretest scores.

The screen-capture group's participants also completed a survey after the posttest that measured the research question whether secondary students prefer learning from a teacher's screen-capture instructional multimedia when compared to traditional lecture-based instruction. This survey was based on Marshall and Rossman's (2006) *Significance for Practice* matrix. "The argument here should rely on a discussion of the concerns or problems articulated in the literature. This will involve citing experts, referencing prior research, and summarizing incidence data" (Marshall & Rossman, 2006, p. 37). The student's survey focused on issues of practice that concerned the students learning from the multimedia instructional technology.

Many students using new technology initially prefer using the new method, only to lose interest shortly thereafter. Students tend to put forth an increased effort or persistence that demonstrate an increase in learning, however, these gains tend to vanish over time as the Novelty effect diminishes when students become familiar with the medium (Clark & Sugrue, 1988). By conducting this study with a full chapter of Algebra that lasted four weeks, the novelty effect should have evaporated. The students' survey results revealed areas for improvement when using screen-capture instructional technology. This information will also be used to assist in the development of improved multimedia content and blended teaching practices.

CHAPTER 4

RESULTS

This chapter will report the results of screen-capture instructional technology for student academic achievement, student preference, student engagement, lesson development, and the teacher's classroom experiences. The results of the students' pretest/posttest, surveys, and online postings will be presented throughout the chapter. Students' favorability ratings and answers to open-ended questions will also be used to reveal their psychometric measurement of cognitive and psychological engagement while they learned from the screen-capture instructional multimedia pedagogy. This chapter also puts forward the results of the teacher's lesson development and her in-depth account as she incorporated the instructional multimedia into her secondary classroom.

Included in this chapter is the analysis of quantitative and qualitative data. Data from an ANCOVA was used to investigate student outcomes based on their pretests scores and previous geometry grades. Student engagement, student preference, teacher lesson development, and the lesson implementation will be assessed by a triangulation of the interrelated findings. This cross verification of data from multiple sources was intended to provide a reliable and detailed assessment of the instructional technology. Screen-capture participants left online comments after viewing the multimedia lessons and both groups of students completed a comprehensive survey at the end of the study. Additionally, the teacher kept an ongoing online journal and responded to daily survey questions during the experiment. After the student's self-rating questions and the teacher rating questions, open-ended questions were deployed to elicit deeper and more reflective thoughts. A teacher interview was also conducted at the end of the research experiment. Finally, both the teacher's rating responses and student's self-rating responses were aligned for analysis. This alignment was developed to provide results that could be used to compare specific facets of the instructional technology from both the students' and teacher's perspective.

A total of 14 themes are revealed within this chapter (Table 2). One theme was developed based on students' academic achievement scores. Four themes were discovered upon reviewing the students' cognitive engagement ratings, five themes emanated from the students' psychological engagement findings, and four themes were identified from the teacher's lesson development revelations. To sufficiently present both the quantitative and qualitative findings, this chapter is arranged into four distinct sections. Based on the research questions and findings, this chapter is organized as follows: I. Academic Achievement, II. Student Preference, III. Student Engagement, and IV. Lesson Development.

Table 2

Screen-Capture Instructional Technology Themes

Area	Theme
Academic Achievement	Students learning from their teacher's screen-capture instructional technology demonstrated higher algebraic knowledge compared to their peers learning from the teacher's live-lectures.
Student Preference	Students preferred to learn from their teacher's screen-capture instructional multimedia because they found it easier to understand than the teacher's live-lecture.
Cognitive Engagement	Students actively controlled the pacing of the screen-capture instructional multimedia.
	Students reviewed each screen-capture instructional multimedia lesson as often as needed.
	Screen-capture instructional multimedia was more efficient and faster for learning new algebraic concepts within the classroom than live-lectures.

	Students gained independence by being able to watch their teacher's instructional multimedia in class after they missed school, before and after class, and at home.
Psychological Engagement	Screen-capture instructional multimedia enabled the classroom teacher to provide more one-to-one instructional support to students than the live-lecture format.
	Students preferred to watch the online screen-capture instructional multimedia in the classroom with their teacher, rather than at home in a flipped model.
	When students learned from their teacher's screen-capture instructional multimedia in the classroom, they were not disturbed by their classmates.
	Students using the screen-capture instructional multimedia were less afraid to ask their teacher or peers questions in front of classmates.
	Students using screen-capture instructional multimedia were able to receive additional instruction from their parents at home.
Lesson Development	More time was required to develop lessons using screen-capture instructional technology than with the live-lecture methodology.
	Screen-capture instructional technology was a new tool used to analyze and evaluate the teacher's classroom instruction.
	The teacher using screen-capture instructional technology recaptured the initial instructional multimedia lesson in hopes of improving the instruction.
	Screen-capture instructional technology was a new tool used for teacher collaboration.

I. Academic Achievement

This study sought to discover the extent to which there is a difference between the academic outcomes of secondary Algebra students learning from instructional multimedia created from their teacher's screen-capture instructional technology compared to students learning from their teacher's live-lectures. It was revealed that the students' prior geometry grades and pretest scores did not influence the overall students' scores. At the end of the four week study, the results indicated that screen-capture students showed an increase in algebraic performance over the live-lecture students (Table 3).

A one-way ANCOVA was calculated using prior knowledge from the pretest as a covariate (Table 3). Two measures, Partial Eta Squared (partial η^2) and Cohen's *d,* were calculated to measure the magnitude of the effect, of the instructional multimedia. For Partial Eta Squared, 0.0099 constitutes a small effect, 0.0588 a medium effect and 0.1379 a large effect, and for Cohen's *d*, less than .1 is trivial, .1 to .3 is considered small, .3 to .5 is moderate, and over .5 is considered to be a large effect size (Cohen, 1988). Pretest results for the classroom's live-lecture group were not significantly different than that of the screen-capture group, indicating that both groups' prior mathematical knowledge were similar and did not affect the final test results. Though all students' posttest scores improved over their pretest scores, students' posttest scores were significantly higher for the screen-capture students when compared to the scores from the live-lecture group students, even after controlling for their pretest scores, $F(1,53) = 4.86$, $p < .05$, partial $\eta^2 = .08$. A Partial Eta Squared of .08 for the main effect of group membership (screen-capture vs. live-lecture) indicated a moderate effect size.

Table 3

Algebra Pretest and Posttest Results

	Live-lecture (n = 24)			Screen-capture (n = 32)		
Measure	*M*	*SD*	Std. Error Mean	*M*	*SD*	Std. Error Mean
Pretest	26.34	13.31	2.97	20.56	14.50	2.55

Posttest	70.73	20.13	3.65	81.49	15.26	3.15

An additional statistical method of control was performed using the students' previous math grades from their geometry class as an index of prior math knowledge (Table 4). A one-way between-subjects ANCOVA was calculated to examine the effect of the instructional method (i.e., screen-capture vs. live-lecture) after statistically controlling for prior math knowledge, as measured by geometry scores. Geometry scores for the live-lecture group were not significantly different than that of the screen-capture group. The screen-capture instruction was related to posttest scores ($F(1, 53) = 12.98$, $p < .05$, partial $\eta^2 = .07$). The main effect from the instructional technology on the screen-capture students was significant ($F(1. 53) = 4.14$, $p < .05$), with the screen-capture group scores significantly higher than the live-lecture group scores. The ANCOVA confirmed that prior geometry scores did not significantly affect the posttest results, and a Partial Eta Squared of .07 for the main effect of group membership (screen-capture vs. live-lecture) indicated a moderate effect size.

Table 4

Geometry Scores and Posttest Results

	Live-lecture (*n* = 24)			Screen-capture (*n* = 32)		
Measure	*M*	*SD*	Std. Error Mean	*M*	*SD*	Std. Error Mean
Prior Geometry Scores	80.46	9.31	1.90	83.17	10.14	1.79
Posttest	70.63	20.13	3.25	81.56	15.26	2.81

Students learning from their teacher's screen-capture instructional technology demonstrated higher algebraic knowledge compared to their peers learning from the teacher's live-lectures. The results of this study indicated an increase in knowledge acquisition and transfer by students using the screen-capture instructional multimedia.

II. Student Preference

A student survey was used to measure the extent secondary Algebra students prefer learning from their teacher's screen-capture instruction when compared to learning from their teacher's live-lecture (Appendix B). Both the screen-capture students and live-lecture students answered 5-point Likert scale survey questions the following class date after the posttest study, while the teacher responded to survey questions immediately after each class period throughout the duration of the four week study. The first nine survey questions for all groups were based on the same questions and aligned between both groups of student subjects and their teacher. Survey questions one through six compared the satisfaction rate and the perceptions toward the instructional methodology. Each student anonymously self-reported his/her level of satisfaction across domains of understanding, clarity of instruction, lesson pacing, and how well the lessons transitioned from the previous day's instruction.

When the screen-capture students were asked why they preferred the instructional multimedia, they reported that they understood new Algebra concepts at a significantly higher rate than did their live-lecture group counterparts whose mean score was significantly lower than the screen-capture group (Table 5). An independent-samples *t*-test comparing mean preference scores of the screen-capture and live-lecture groups showed a significant difference between the two groups ($t(50) = 2.531$, $p < .05$). The live-lecture group also did not believe the Algebra teaching was clearer and easier to understand compared to the screen-capture students. The screen-capture students had significantly higher mean scores of participants reporting their teacher's instructional multimedia was clear and easy to understand ($t(50) = 3.737$, $p < .001$).

Table 5

Students' Lesson Ratings

Question	Live-lecture Self-Evaluation (n = 22)		Screen-capture Self-Evaluation (n = 30)	
	M	*SD*	*M*	*SD*
1. Students understood all of the new math concepts taught in Chapter 5.	3.68	0.89	4.23*	0.68
2. The Chapter 5 math teaching was clear and easy to understand.	3.64	0.95	4.53*	0.78
3. The pacing of the Chapter 5 instruction was too slow.	2.00	0.98	1.90	0.92
4. The pacing of the Chapter 5 instruction was too fast.	2.71	1.16	2.27	1.11
5. Each day's instruction successfully transitioned from the previous day's instruction	3.73	0.94	4.13	0.73
6. My math teacher was able to answer all my questions during class.	4.05	0.89	4.53	1.04

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). *$p < .05$.

T-tests indicated that the teacher felt both groups of her students had a far better understanding of the math concepts than both groups of students actually reported. An independent-samples *t*-test comparing the mean scores of the live-lecture students and the teacher's rating found a significant difference between the means of the two groups, $t(33) = -3.889$, $p < .05$ (Table 6). When compared to the live-lecture students, the math teacher significantly overestimated the level of student understanding.

When both groups of students responded to whether each day's instruction successfully transitioned from the previous day's instruction in question five (Table 5), a *t*-test comparing the mean scores of the instructor and the live-lecture group also found a significant difference between the mean of the two groups ($t(33) = -2.295$, $p < .05$). The results of survey indicated the teacher thought her daily lessons for the live-lecture group students successfully transitioned from the previous day's lesson while the live-lecture students did not feel they transitioned successfully (Table 6). The mean of the live-lecture group was significantly lower than the mean of the teacher's self-rating.

Table 6

Live-Lecture Lesson Ratings

	Teacher's Live-lecture Evaluation (*n* = 30)		Live-lecture Self-Evaluation (*n* = 22)	
Question	*M*	*SD*	*M*	*SD*
1. Students understood all of the new math concepts taught in Chapter 5.	4.77*	0.59	3.68	0.89
2. The Chapter 5 math teaching was clear and easy to understand.	4.00	1.29	3.64	0.95
3. The pacing of the Chapter 5 instruction was too slow.	2.00	0.00	2.00	0.98
4. The pacing of the Chapter 5 instruction was too fast.	2.77	1.01	2.73	1.16
5. Each day's instruction successfully transitioned from the previous day's instruction	4.46*	0.88	3.73	0.94
6. My math teacher was able to answer all my questions during class.	3.92	0.86	4.05	0.89

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). *$p < .05$.

The teacher's mean scores reporting that her daily instruction was clear and easy to understand were similar with the mean of the screen-capture group. Yet, the math teacher assumed a significantly better understanding of the daily lessons than the screen-capture students reported (Table 7). The math teacher claimed the screen-capture students understood the new math concepts at a significantly higher rate than they professed ($t(40) = -3.348$, $p < .05$). The implications of the teacher's over-estimates for both student groups' daily understating of her instruction will be further addressed in Chapter 5.

Table 7

Screen-Capture Lesson Ratings

	Teacher's Screen-capture Evaluation (n = 30)		Screen-capture Self-Evaluation (n = 30)	
Question	*M*	*SD*	*M*	*SD*
1. Students understood all of the new math concepts taught in Chapter 5.	4.92*	0.29	4.23	0.68
2. The Chapter 5 math teaching was clear and easy to understand.	4.50	0.67	4.53	0.77
3. The pacing of the Chapter 5 instruction was too slow.	1.92	0.29	1.90	0.92
4. The pacing of the Chapter 5 instruction was too fast.	2.00	0.00	2.27	1.11
5. Each day's instruction successfully transitioned from the previous day's instruction.	4.25	0.97	4.13	0.73
6. My math teacher was able to answer all my questions during class.	4.33	0.65	4.53	1.04

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). $^*p < .05$.

When the teacher evaluated her students' daily activity, the pacing of the live-lecture appeared significantly faster when compared to her screen-capture lessons (Table 8). The math teacher did not state that the screen-captured lessons were too fast, while she felt on average the lesson pacing of the live-lecture was faster ($t(23) = -2.627$, $p < .05$). This finding was also collaborated with her statements that the live-lecture lessons felt rushed as revealed later in this chapter. It should be noted that the teacher did not deviate from keeping each group's daily Algebra instruction in unison with the exact same instructional examples and strategies.

Table 8

Teacher Lesson Ratings

	Teacher's Live-lecture Evaluation (n = 24)		Teacher's Screen-capture Evaluation (n = 30)	
Question	*M*	*SD*	*M*	*SD*
1. Students understood all of the new math concepts taught in Chapter 5.	4.77	0.59	4.92	0.29
2. The Chapter 5 math teaching was clear and easy to understand.	4.00	1.29	4.50	0.67
3. The pacing of the Chapter 5 instruction was too slow.	2.00	0.00	1.92	0.29
4. The pacing of the Chapter 5 instruction was too fast.	2.77*	1.01	2.00	0.00
5. Each day's instruction successfully transitioned from the previous day's instruction.	4.46	0.88	4.25	0.97
6. My math teacher was able to answer all my questions during class.	3.92	0.86	4.33	0.65

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). *$p < .05$.

Preference Themes

A role-ordered matrix procedure was used to organize responses from the teacher interview, teacher surveys, teacher online journaling, student surveys, and student online postings (Appendix E). "A role-ordered matrix sorts data in its rows and columns that have been gathered from or about a certain set of 'role occupants'- data reflecting their views" (Miles & Huberman, 1994, p. 124). This display matrix used random student identifiers and teacher survey entry dates in a vertical column located on the left side of the matrix chart. To the right of each name, empty boxes were created below each open-ended survey question located on the top of the page. Individual student explanations to each survey question were written in their corresponding empty boxes. From the completed role ordered matrix, a new role-order matrix was then created to organize the findings into categories, patterns, and themes.

Students preferred to learn from their teacher's screen-capture instructional multimedia because they found it easier to understand than the teacher's live-lecture. A clear theme emerged from the student survey responses and their online postings. When reading their detailed comments, it became evident that the screen-capture group students had developed a strong attachment toward the multimedia pedagogy. The preference theme emerged from both the students' online and survey comments about the instructional multimedia and the mechanics of the instructional technology. The ease of which the screen-capture students learned from the online instructional multimedia can be found in their responses to nearly every survey question. The basis for their preference will also be analyzed further in Chapter 5. It should be noted that when the students were asked what things they liked about the teaching of Chapter 5, the number of screen-capture group responses (78) were nearly double than that of the live lecture group's (46). For example, when the screen-capture students were asked what they like about the teaching of Chapter 5, over a third (21) of the screen-capture comments were directed toward the ease of learning with the instructional multimedia. One student commented “I didn’t worry about copying it down wrong or not being able to read the board.” Another student noted “the lessons were easy” and another stated “the lessons were clear and understandable.” When the students were asked whether they felt the multimedia math lessons improved their learning, a majority indicated it had (Figure 4.1.). Eighty-seven percent of the screen-capture students claimed the technology had improved their learning while 13% reported the lessons had not, even though no student had received any grades from the instructional multimedia.

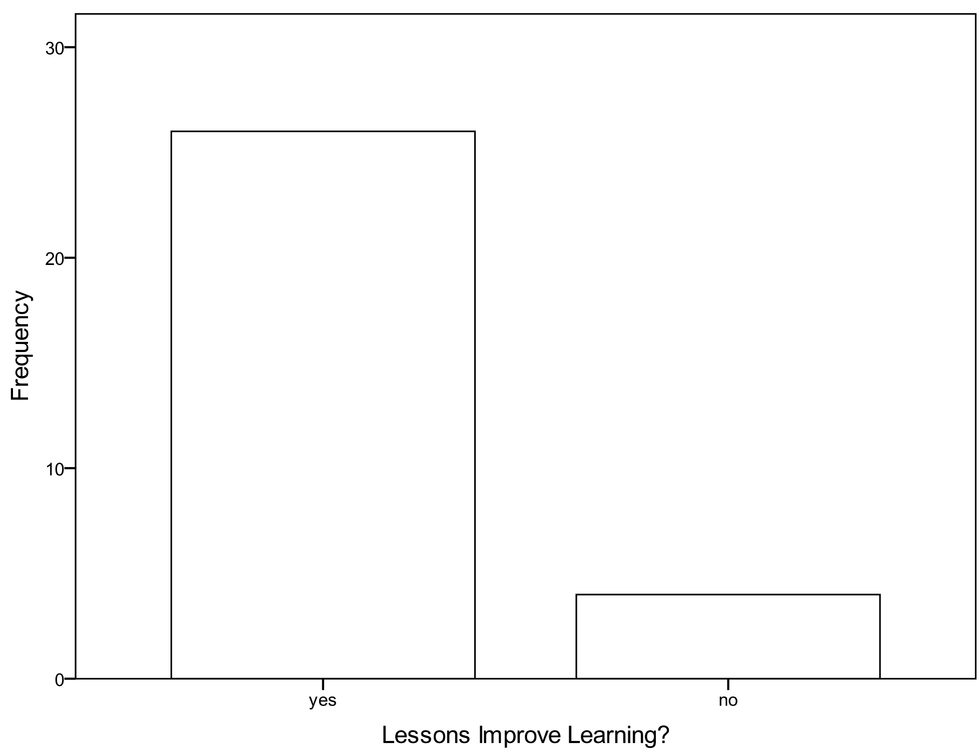

Figure 4.1. “Overall, do you feel the online math lessons improved your learning?”

Note. $N = 30$

There were many negative statements by the live-lecture students indicating their displeasure with the instruction of Chapter 5 and Algebra in general. For example, even though the survey question asked what the students liked about the teacher's instruction, the live-lecture students made many disparaging remarks about traditional classroom instruction. The live-lecture students' negative responses to what they were suppose to like about the teacher's live-lecture instruction varied. One student stated "I don't really care, I handle whatever is thrown at me" while another noted "there was nothing I liked." There were no negative remarks when the screen-capture students were asked what they liked about their instruction. When asked what they did not like about the Chapter 5's instruction, the live-lecture students' responses were less subtle and more direct. One student wrote "COMPLEX NUMBERS HAVE NO RELEVANCE TO LIFE" and another stated "not enough instruction or help." When asked what they did not like, the screen-capture students' negative remarks were sparse and tended to comment on minor technical glitches, such as password problems. Unlike the overwhelming negative responses by the live-lecture group, a majority of the screen-capture students' comments to what they did not like about the instructional multimedia were in fact positive, with responses such as, "I don't have any complaints, I really liked using the ipads," and "learning a new lesson everyday was very successful."

The screen-capture students also explained their satisfaction to the mechanics of the instruction in their answers to whether they felt the online math lessons improved their learning. One screen-capture student commented that it "kept me focused and ready to learn" while another student indicated that in the traditional live-lecture classroom "it's easy to zone out." Other students had positive responses to the instructional multimedia ranging from "I feel it's a new and very good method to learn," to "It kept math exciting." When the screen-capture students explained which method they preferred to learn from in the future, they commented that they liked the instructional multimedia with statements such as, "The system is perfect as is with the live-lectures on I-pad and worksheets on paper." Without being prompted, the screen-capture students continually shared their displeasure with the regular teaching methods of the live-lecture classroom instruction with statements such as, "traditional ways of teaching doesn't really work for me."

When asked in the survey which type of instruction the students would prefer in the future, the screen-capture students overwhelmingly chose the teacher's instructional multimedia in place of the live-lecture teaching methodology (Figure 4.2). Seven percent chose the traditional live-lecture method, while 13% of the students said it depends, and 80% wanted more of the teacher's online instructional multimedia. Of the students that selected *depends*, half failed to leave comments explaining their answer. One student stated that online would be favorable if he/she could stay at home, and the other student indicated he/she would be in favor of the online lessons if they could be used in conjunction with the traditional live-lectures.

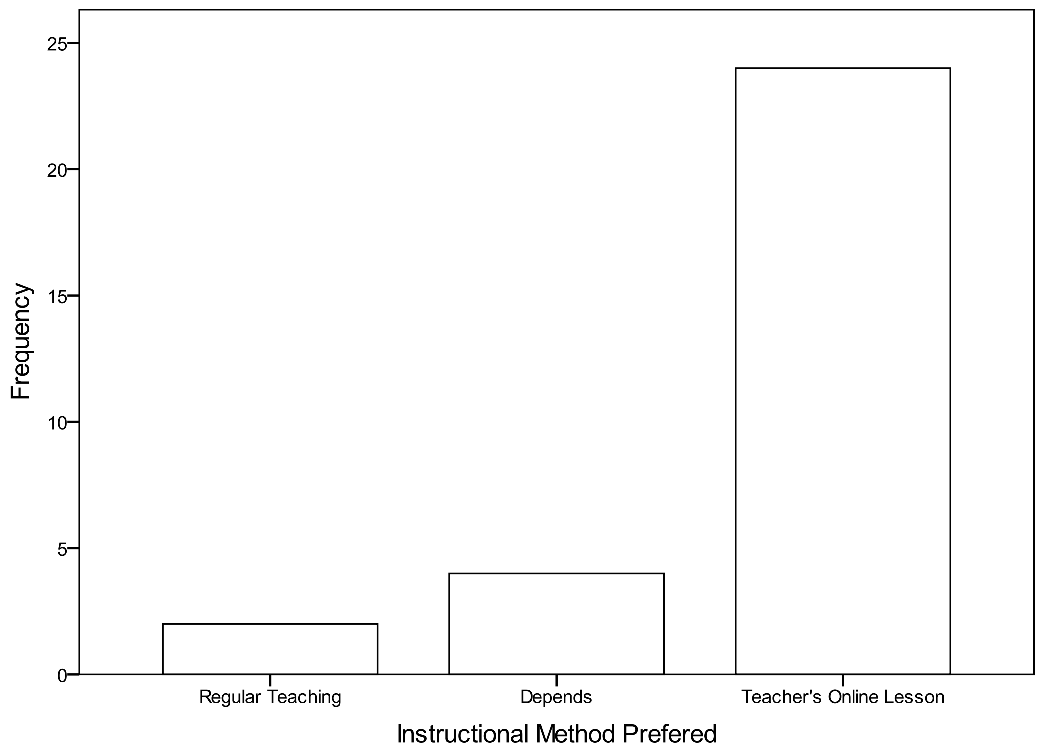

Figure 4.2. “If you had to learn math in the future, which method would you prefer?”

Note. N = 30

Students explained what it was about the teacher’s online lesson they preferred. Learners continually indicated what they liked about the instructional technology with their preference statements, but ease of use remained constant. One student comment claimed, “step by step notes and examples that are very easy to follow and I watch closer.” When the screen-capture students were then asked what they did not like about the live-lecture pedagogy, their statements reflected the difficulty with traditional high school classroom instruction. One student lamented, “sometimes it goes too fast and I get behind, lost” and another bemoaned, “feel less involved in lesson.” Many of the screen-capture students indicated that the teacher’s live instruction used prior to this experiment was difficult to follow. A student wrote it was “hard to focus when she’s talking fast" and another complained that during her traditional math lesson "everyone has to go at the same speed."

When analyzing the screen-capture students' online postings, it was evident that they preferred the screen-capture instructional multimedia and were feeling very comfortable with the pedagogy. The screen-capture students were posting comments to one another about the instructional multimedia. Without leading questions or their teacher's prompting, the students posted revealing comments about math instruction with one another. One student reported "I never really quite understood the things that we are learning, now I can do them with ease" Another student claimed "my lessons are going well and I enjoy listening on the iPad more than taking notes with a teacher talking." Yet another of the student's online postings stated "I think that seeing the lessons the way they are is great and that it is easy to take notes on."

For the final component of the student preference rating, the students overwhelmingly indicated they preferred the screen-capture instructional technology (Figure 4.3.). Students selected the option to have their teacher make more online lessons for another math chapter. To illustrate their eagerness for the screen-capture instruction, some of the student's "yes" responses were followed with multiple underlines, explanation points, and statements such as, "Please!, Please!" written all around the checked box. To this effect, an overwhelming ninety-three percent of the screen-capture students indicated they wanted more of the teacher's multimedia lessons for another math chapter instead of her live-lectures.

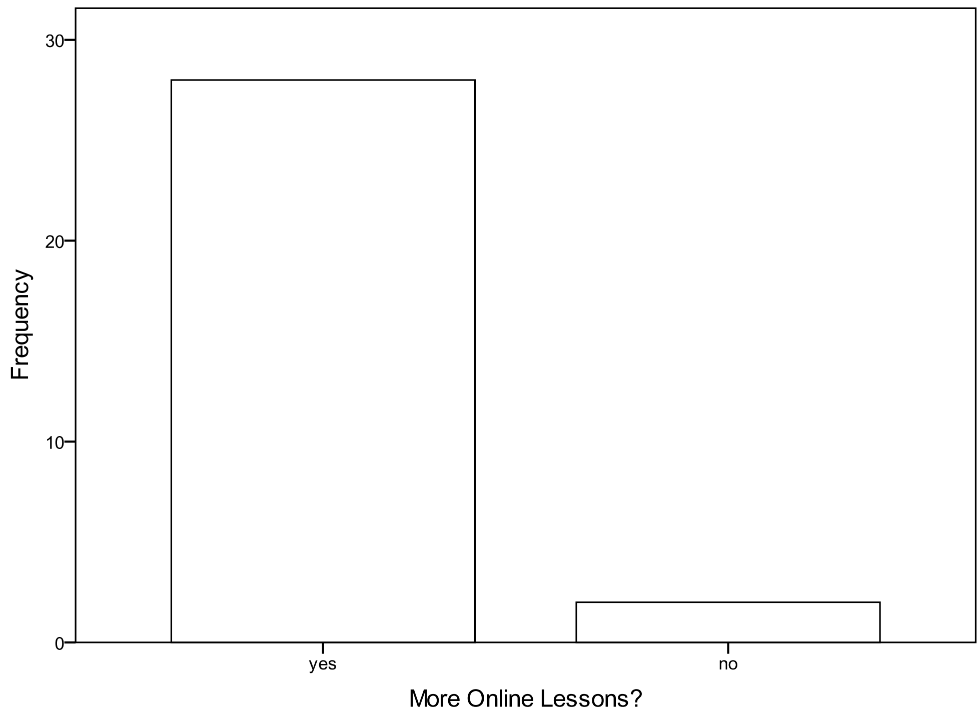

Figure 4.3. “Would you like your teacher to make online lessons for another math chapter?”

Note. . $N = 30$

III: Student Engagement

Surveys for the students and the teacher were developed, in part, to measure the extent secondary algebra students were engaged when learning from their teacher’s screen-capture instructional technology when compared to their peers learning the same content from the teacher’s live-lecture instruction. The teacher’s survey comments and her interview responses were also analyzed for engagement indicators. Student self-rating indicators and the teacher’s daily ratings measured the students’ cognitive engagement and psychological engagement while learning the Algebra chapter. The engagement rating instrument for all the student and teacher responses was based on Appleton et al.’s (2006) *Student Engagement Instrument (SEI)* conceptual model (p.429):

> Cognitive and psychological engagement includes less observable, more internal indicators, such as self-regulation, relevance of schoolwork to future endeavors, value of learning, and personal goals and autonomy (for cognitive engagement), and feelings of identification or belonging, and relationships with teachers and peers (for psychological engagement).

Cognitive Engagement Ratings

Both the screen-capture group and live-lecture group students answered 5-point Likert scale questions developed from Appleton's *SEI* self-rating model. Open-ended follow-up questions also measured the student's cognitive engagement using the SEI index. Survey questions seven through nine were aligned with the SEI's self-rating questions that measure student control over their learning and relevance of the school work (Table 9). For the screen-capture and live-lecture students, questions 10 through 14 were also aligned to measure cognitive engagement from student control over their learning and relevance of the school work (Table 12). Questions 15 through 18 were different in that they measured cognitive engagement from the student's future ambitions based on their Algebra education. Of all the SEI Likert scale questions, significant group differences were only aligned in favor of the screen-capture instruction. These group responses can be found in question 7, question 10, and question 11.

Table 9

Teacher Cognitive Engagement Ratings

	Teacher's Live-lecture Evaluation (n = 24)		Teacher's Screen-capture Evaluation (n = 30)	
Question	*M*	*SD*	*M*	*SD*
7. When I do my math work I check to see whether I understand what I'm doing.	3.38	0.87	4.00	0.96
8. After finishing my math work I check it over to see if it's correct.	3.42	0.99	3.83	1.17

9. When I do well in this math class, it's because I work hard.	4.64	0.67	4.67	0.99

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). $^*p < .05$.

Survey question 7 gauged student cognitive engagement by measuring the frequency each student checked for understanding during the math instruction. An independent-samples *t*-test comparing the mean scores of the screen-capture students against the live-lecture students, found there was a significant difference between the means of the two groups ($t(49) = -.121$, $p < .05$). The mean score ($M = 4.03$, $SD = 0.91$) from the screen-capture students checking for understanding was significantly higher ($M = 3.50$, $SD = 0.96$) than the live-lecture group's self-rating (Table 10).

Table 10

Cognitive Engagement Student Self-Ratings

	Live-lecture ($n = 22$)		Screen-capture ($n = 30$)	
Question	*M*	*SD*	*M*	*SD*
7. When I do my math work I check to see whether I understand what I'm doing.	3.50	0.96	4.03*	0.91
8. After finishing my math work I check it over to see if it's correct.	3.14	1.17	3.27	1.20
9. When I do well in this math class, it's because I work hard.	4.14	0.99	4.23	1.07

Mean score comparisons for the teacher's rating of the screen-capture students' overall checking for understanding in question 7 was not significantly different ($t(39) = .121$, $p > .05$) to her rating of the live-capture group (Table 11). Similarly, the teacher's rating for the live-lecture group's checking for understanding was similar to the group's self-rating and was also not significantly different ($t(33) = .354$, $p > .05$). The teacher also viewed more screen-capture students checking to see whether they understood what they were doing than her live-lecture students, but the differences were not significant. These comparisons demonstrated that the teacher's rating of each group's checking for understanding was significantly different for both subjects, but consistently mirroring each group's self-rating response.

Table 11

Cognitive Engagement Ratings

	Teacher				Students			
	Teacher's Live-lecture Evaluation		Teacher's Screen-capture Evaluation		Live-lecture Self-Evaluation (n = 22)		Screen-capture Self-Evaluation (n = 30)	
Question	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
7. When I do my math work I check to see whether I understand what I'm doing.	3.38	0.87	4.00	0.60	3.05	0.96	4.03*	0.90
8. After finishing my math work I check it over to see if it's correct.	3.42	0.99	3.83	0.72	3.14	1.17	3.27	1.20
9. When I do well in this math class, it's because I work hard.	4.64	0.67	4.67	0.49	4.14	0.99	4.23	1.07

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). $*p < .05$.

Questions 10 through 14 were also developed to measure the cognitive engagement from student SEI self-ratings of the curriculums relevancy and to measure student control over their own learning (Table 12). Question 10 was designed to measure cognitive engagement from the students' responses to inquiries about how they value the Algebra class. When both the live-lecture students and screen-capture subjects were asked whether the math class did a good job of measuring what they were capable of doing in question 10, an independent-samples *t*-test discovered a significant difference between the means from their survey responses, $t(50) = 2.075$, $p < .05$. Students in the screen-capture group felt the math class did a good job measuring what they could do ($M = 4.20$, $SD = 0.92$), while the live-lecture group average response was significantly lower ($M = 3.68$, $SD = 0.84$). Neither subjects had information revealing their pretest/posttest scores during the experiment when responding to the survey questions.

Question 11 measured the cognitive engagement of both student groups by inquiring about the relevancy of their Chapter 5 Algebra instruction (Table 12). Student responses exhibited a significant difference in the mean scores as measured with an independent-samples *t*-test ($t(50) = 2.379$, $p < .05$). The screen-capture students rated the information in the math class as more important to know than the live-lecture group's ratings. The screen-capture group's mean score was significantly higher ($M = 3.80$, $SD = 0.10$) than the live-lecture group's response ($M = 3.14$, $SD = 0.90$).

Table 12

Cognitive Engagement Student Self-Ratings

	Live-lecture (n = 22)		Screen-capture (n = 30)	
Question	*M*	*SD*	*M*	*SD*
10. This math class does a good job of measuring what I'm able to do.	3.68	0.84	4.20*	0.92

11. Most of what is important to know you learn in this math class.	3.14	0.99	3.80*	0.99
12. What I'm learning in this math class will be important in my future.	2.60	1.33	3.17	1.26
13. Learning math in this class is fun because I get better at something.	3.23	1.15	3.67	0.88
14. I feel like I have a say about what happens to me in this class.	3.32	1.04	3.67	1.06

Note. Responses were made on 5-point scales, (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). $*p < .05$.

Cognitive and Psychological Engagement Themes

Common words and phrases displayed in the matrix chart that related to the research question were copied under the title *Categories* into a new role-ordered matrix document. As an example, the word *Pace* was frequently used in the first display matrix chart and was therefore written under the title *Categories* on the new document. Additional categories created on the new matrix included: pause, quicker, relearn, choice, independence, one-to-one instruction, cognition, classroom environment, anxiety, and location. Based on this category list, phrases that included words from the category's list were written under a new title named *Patterns*. Each phrase that encompassed the common words was written below the title *Pattern* to provide the context for each word. These patterns included phrases such as, *now I can learn at my own pace*, *regular teaching is slowed by others, I could go back and relearn at anytime, I could choose which lesson to watch, if we missed school we could watch the lesson at home, I could do it on my own, the teacher would be free because she wasn't teaching the lesson, kept me focused and* *ready to learn, there weren't any distractions, and I used to be too afraid to ask teachers questions in front of the whole class because I don't want to look stupid.* Using this pattern list, common phrases were created into single sentences under a new category named *Themes*.

The responses to the open-ended questions in the survey were in alignment with Appleton et al.'s (2006) student engagement indicators. However, unlike the survey questions that targeted cognitive engagement responses, the theme of relationships emanated from the students and teacher's open-ended responses. Therefore, indicators from the student's and teacher's statements were aligned to both cognitive engagement and psychological engagement factors. The open-ended questions revealed themes of psychological engagement as the screen-capture students professed their new found relationships with their classmates, teacher, and parents. Themes that dealt with student engagement were separated into those dealing with cognitive engagement and psychological engagement. These response indicators suggested student cognitive engagement related to self-regulation and autonomy. Indicators also revealed psychological engagement related to student relationships with their classroom peers, teachers, and parents.

Four student cognitive engagement themes emerged from the students learning from their teacher's instructional multimedia related to self-regulation and autonomy. Cognitive engagement was discovered within the patterns list through indicators of self-regulation and displays of autonomy. One theme relating to self-regulation was that the student's actively controlled the pacing of their teacher's instructional multimedia as demonstrated as they paused, sped-up, and slowed down each digital lesson. A theme indicating self-regulation was that students could rewind and review each multimedia lesson as often as needed. Another theme relating to student self-regulation is that instructional multimedia was more efficient and faster for students learning new math concepts within the classroom than live-lectures. Autonomy was found as students described their independence by being able to watch the instructional multimedia from outside of the classroom before and after class.

Four themes dealt with psychological engagement as indicated by the students' relationships with fellow classmates, the classroom teacher, and their parents. The first theme relating to psychological engagement was that the screen-capture instructional multimedia enables the teacher to provide more one-to-one instruction with classroom students when compared to the live-lecture format. Additionally, the students desired to maintain the classroom relationship with their teacher while viewing the online lessons. The students preferred to watch the online instructional multimedia in the classroom with their teacher, rather than at home in a flipped model. The third theme relating to psychological engagement was that the students did not feel anxious when using the multimedia lessons because they were no longer disturbed by their classmates while learning. Another psychological theme was that students using the instructional multimedia no longer felt anxious in front of their classmates when they were asking their teacher questions. The final psychological theme was revealed from the use of the instructional multimedia out of the classroom when it was brought out that students received additional instructional assistance from their parents while at home.

There were more comments made by the students and teacher that can be explored in further research. For example, the teacher's online journal revealed student autonomy as they sought additional strategies from various math websites, without the suggestion or prodding of the math teacher. However, the revelation that her students were independently seeking online solutions to math problems was only found in one statement from the teacher's journal and could, therefore, not be triangulated.

Students actively controlled the pacing of the screen-capture instructional multimedia. When the screen-capture students rated the frequency to which they paused each multimedia lesson (Figure 4.4.), the results indicated they were actively controlling each lesson's pacing. The screen-capture survey results revealed that 6.7% of the students never paused a lesson during viewing, 20% of the students indicated that they paused the lessons once, 20% claimed they paused the multimedia lesson twice, 16.7% reported they paused each lesson three times, and 36.7% of students indicated they paused each online lesson four or more times during the viewing of the online instructional multimedia.

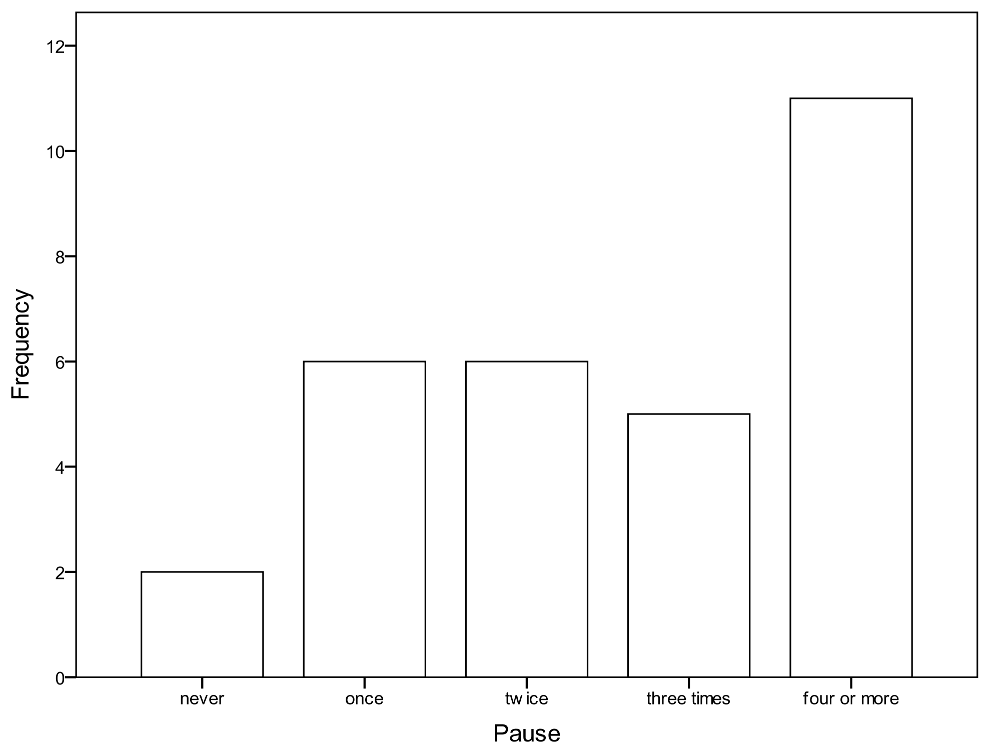

Figure 4.4. "On average, how many times did you pause each online lesson?"

Note. N = 30

When the screen-capture students responded to the things they liked about the teaching of Chapter 5, their responses to the open-ended question supported the first theme of self-regulation through having control over the lesson. Students gained the ability to control the pacing of their teacher's lesson as demonstrated when they paused, sped-up, and slowed down each multimedia lesson. This self-regulated learning with the instructional content demonstrates an increase in student cognitive engagement. The ability to control the pacing of each lesson was the dominate response to what the students liked about the instructional experiment. Nearly a third (31%) of the 61 responses wrote about the ability to control the pacing of their teacher's instruction. For example, one of the screen-capture student's response was "The ipad, I liked being able to take notes at my own pace" and another student stated "when taking notes, I could pause them so I didn't miss anything." Fourteen (25%) of the 56 student responses related their improved learning to the control over the lesson's pacing. One student anonymously stated, "Yes, because I could take all the time I needed to write down my notes." A student also claimed the instructional technology improved their learning through controlling the pace of the instructional technology with the statement, "I think it did because I got to take my time to understand each thing she was saying while taking my notes."

When the screen-capture students elaborated to which method they would prefer for learning math in the future, their responses also supported the first theme of an increase in self-regulation by their ability to control the lesson's pacing. Of the 50 responses, eight (16%) comments related directly to the pacing of the instruction. One of these students stated, "I didn't take notes when she taught regular, thus I never really learned the concepts. Now that I can learn at my own pace, I understand more." Another student claimed "I enjoyed . . . not having to pause and wait because the teacher is going too fast." A screen-capture student went on to state that, "learning at one's own pace should be expanded." Thirteen (27%) of the 48 student responses related their preference of the instructional technology to their ability to control the lesson's pacing.

The screen-capture student's online postings also indicated that they like the ability to pause the online lessons. These postings were not prompted by any specific questions, but rather provided a venue for students to express their thoughts relating to their class and the online multimedia lessons. One student posted, "And listening to these lessons is way better cuz now I can pause it and take notes in class and take my time on understanding the topic :)." A fellow classmate in turn replied, "The lessons are going pretty good, I'm definitely enjoying listening to the topics because I can pause it!!!!!"

Students reviewed each screen-capture instructional multimedia lesson as often as needed. The theme of being able to watch and listen to each lesson as often as needed was supported by the student's survey responses. The ability to review the lesson differs from pacing in that pausing or slowing down the content's delivery assists the active processing of new information in brain's working memory, while rewinding or reviewing the content reinforces prior knowledge from the initial viewing. When the screen-capture students were asked to follow-up on their response to the survey questions, they indicated they like the ability to review and rewind the instructional multimedia with statement such as, "If we didn't understand something we could go back and replay it." Students responded to their ability to rewind and review each lesson with statements including, "I could pause & rewind if I didn't understand something or if I missed something." Another student claimed, "The fact that I could go back and rewatch a video to prepare for my test or if I just didn't remember a lesson." When students were asked to explain what they liked about the teaching of Chapter 5, 10 (18%) of the 59 responses addressed their capability to rewind and review the lessons.

The theme of being able to review the lessons continued to be supported in the student survey responses. A student affirmed, “It really helped me a lot to be able to pause it or rewind if I did not understand what was just said.” The ability to repeat each lessons had the most responses for why the lessons improved their learning with 18 (32%) of the 56 student responses discussing their newfound ability to rewind and replay the teacher’s instruction. “If I needed to, I could just go back and listen to it again and that’s how I learn best, seeing and hearing.” The theme of reviewing the multimedia lessons was also supported in student responses as they defended their selection to which method of learning they would prefer to learn in the future. One student suggested that, “traditional teaching doesn’t really work for me. I usually miss information when I’m giving a speech.” When students responded to what it was about the live-lecture math teaching they did not prefer, six (12%) stated the inability to replay the lesson was what they did not like about the live-teaching method. “If you miss something, you just have to skip it” and “If you get lost or left behind it’s hard to catch up.”

During the interview, the teacher was asked if she thought the multimedia technology was a good fit for most high school teachers. Her response indicated that the screen-capture students were benefiting from the repetitive use of the instructional technology lessons.

> Math needs a lot of repetition of topics. They need to see complex numbers again. They need to see imaginary numbers again. I don’t know that English kind of covers a subject and then they move on, but Math constantly goes back and forth to it. So, the lessons can be used as a review. The lessons can be used to keep reminding yourself of how to do it. It’s a recording of what was taught.
>
> If they don’t understand the notes, they should watch the video again and that, for Math, is available again. It might also work with Science because Science has all that vocabulary, and maybe having the teacher read off the vocabulary is just as easy as you taking notes on what the vocabulary words mean.

The teacher also indicated that a benefit of the instructional technology was the student’s ability to repeat the lessons.

> I'm allowing retakes because it takes a while to learn the concept. I don't expect it to happen right away, which comes upon your, "Well, why don't they watch the video again?" Well, if they didn't take notes, they should have watched the video again. If they don't understand the notes, they should watch the video again and that, for Math, is available again.

Screen-capture instructional multimedia was more efficient and faster for learning new math concepts within the classroom than live-lectures. When reviewing the students' and teacher's survey responses, it was clear that students were able to acquire more multimedia math instruction in a shorter period of time than the teacher's live-lecture. When the screen-capture students manipulated the viewing speed, these actions indicated an increase in cognitive engagement by regulating the teacher's instruction. Even without manipulating or forwarding the screen-capture multimedia lessons, students on average accessed more content in a shorter period of time than their live-lecture counterparts. This was revealed by the students' statements regarding the actions of their live-lecture classmates. A student claimed, "I enjoyed not having to wait for everyone's questions to be answered." Supporting statements that students were able to learn Algebra at a faster rate can be found throughout the screen-capture survey responses. One student went on to suggest that, "when we do regular teaching it is sometimes slowed by others." For example, six (11%) of the 56 student responses explained why they felt the online multimedia lessons improved their learning with statements such as "It made it easier instead of someone asking a question in front of the whole class . . . that takes up time." Students continually wrote about the slower pace of instruction within the live-lecture classroom brought about by their classmates' ongoing interruptions.

When students were asked what they did not like about their regular math instruction, their responses overwhelmingly spoke to their frustration with the teacher's pacing as she was forced to deal with their counterparts. Nearly a third (16) of the 51 responses negatively referred to the pacing of the traditional classroom's live-lecture methodology. One student stated, "When a few people do not understand, the whole lesson is delayed to help them." Another student commented, "Sometimes the teacher has to repeat and explain concepts many times for a few people while others completely understand it already." A screen-capture student went on to say, "When you get something, other people ask questions and you already know the answer." And yet another screen-capture student stated, "I have to wait for the whole class to understand something before we move on." Similarly, six (12%) of the student responses indicated that if they had to learn math in the future, they would prefer the multimedia lessons over the traditional instruction. The increased efficiency of the instructional multimedia was also confirmed with student statements such as, "when she teaches a lesson it takes a lot longer," and "Online is faster, it takes less time due to lack of interruptions." It would appear the students' observations of the live-lecture pacing could be summarized by one brief student statement: "Cater to slowest person."

When the teacher was being interviewed, she was asked to expand on her comment that one student had changed his classroom behavior while using her screen-capture instructional technology. Her response indicated that the instructional multimedia is more efficient and more conducive to moving faster through her math lessons. One student in particular was working through the instruction at an increased rate. The teacher went on to say, "I think it works with Math because some kids are at different places. Some kids can rush through a lesson; get right to the practice problems . . . Billy went through every lesson at such a fast speed. I can't even tell you how fast he went." Additionally, the teacher's survey response alluded to the faster rate by which the students were learning from her instructional multimedia when she said, "This was one of the longer lessons but students finished 15 min. before the end of the period. I got through 2 lessons today. 2nd one was short."

Conversely, the teacher's survey writings for the live-lecture group indicated she was not able to get through most days' lessons and activities nearly fast enough. For example, she stated, "Did not get to check practice problems at end of lesson. . . I checked about ½ students on today's practice problems, not everyone." The teacher's live-lecture survey writings went on to say "I did not get to check their example problems in class. . . Still did not get around room to check notes." Throughout her observations, the live-lecture teacher complained about the lack of time she had to go over material in her classroom. Unlike her response toward the pacing of the live-lecture instruction, she had no comments indicating that she needed more instructional time with her screen-capture students.

Meanwhile, the classroom teacher indicated her multimedia lessons were taking far less time to go through by the screen-capture students as reported in her online journal. She even appeared frustrated by the faster rate of delivery and the subsequent increased idle time.

> The lesson today was too short. They listened to lessons today and . . . thought it was too much but they finished in plenty of time. I don't know if it was because the topic was easy and review or whether they work faster than . . . expected. I have to check the data but the lesson was too short.

When the teacher tried to compensate for the slower delivery speed in her live-lecture classroom as compared to the screen-capture environment, she became frustrated with the results. Her statement went on to claim, "I went too fast and Did [sic] not allow students to absorb it." It would appear that the teacher was unable to successfully match the multimedia's delivery speed and student comprehension when teaching with her live-lecture format.

Students gained independence by being able to watch their teacher's instructional multimedia in class after they missed school, before and after class, and at home. A unique and unexpected indicator of student independence and autonomy occurred when one of the screen-capture students happened to be absent for two of the four week experiment. His absence occurred right in the middle of the research experiment. After the first week of receiving the multimedia treatment, he physically needed to leave the classroom and visit relatives in India. Rather than make-up the assignment as required by state law and school district policy, he was told by the classroom teacher that while he was away, he could watch and respond to the online multimedia lessons being used for the classroom experiment. The student took the teacher's offer. He made online postings while he was abroad that indicated he was not having any problems accessing the teacher's instructional multimedia from the school's Google Docs website. It should be noted that this student traveling abroad scored 40% on the pretest and earned a 100% mark on the posttest. The student had also received a *C*- letter grade from his previous geometry class, thereby suggesting he was not necessarily an outstanding math scholar who would have done well without viewing the screen-capture instruction.

Students also expressed feelings of autonomy with their newfound independence as they described why they felt the online multimedia math lessons improved their learning. A student wrote, "If I didn't get something down, I could watch it at home." Even though neither group had been given their letter grade from the pretest/posttests, students responded that they were learning more from the online math lessons with statements such as, "I can replay a part I don't understand, I can view at home." Students indicated that they could miss instruction and still learn, "If we missed school we could watch the lesson at home." The screen-capture students also indicated cognitive engagement when they explained why they selected their preference to the online instructional multimedia, "If I'm absent I can just go online & watch the lesson." One went on to explain "If I was absent one day I wouldn't be behind." Students also repeated feelings of autonomy when they were asked to explain what it was they did not prefer about their teacher's regular math instruction with statement such as, "If I was absent it was like I didn't miss class because I still could learn the lesson."

The teacher referred to the screen-capture students being able to stay caught-up as a result of their independence when some of her students had missed a class in her daily survey journal. She stated, "Students who were absent . . . had time to make-up lessons." Conversely, the teacher commented on her traditional student's dependence on her for instruction as they were not able to stay caught-up. These students had no ability to be autonomous with the live-lecture lesson. The teacher's commented to the limitation of the traditional live-lecture with her statement "People who were absent (2 of them) were really lost."

Cognitive engagement from the student's autonomy and independence was additionally commented on by the teacher in her interview. The control gained by the students appeared to be lost by the classroom teacher as suggested below:

> But a lot of it is, besides the time to create the lessons – I just thought of this – it's the loss of control. It's a loss of control of the class in knowing that you are not the one who is in front of the class every day.
>
> A lot of teachers like the whole role of being on the stage. They're like an actor or an actress and they're on the stage and they're presenting every day to kids. Well, when you're doing these online lessons, you're not presenting every day. You are in recording and in talking, but you're not in front of the class, performing, and I think a lot of teachers would not like that control.

Screen-capture instructional multimedia enabled the classroom teacher to provide more one-to-one instructional support to students than the live-lecture format. Students' and the teacher responses suggested an increase in one-to-one time with one another. These responses were aligned with internal indicators alluding to a radically different and more intimate relationship between each other. Unlike the traditional classroom experience, the teacher presenting the instructional multimedia had more time to give face-to-face and one-to-one instruction to all her students. The portion of class time required by the teacher to perform a live-lecture in front of all the students was eliminated. The relationship between the students and the teacher thus became less formal and much more personable than the dynamic found in the traditional live-lecture classroom setting. The student responses to this relationship contained some of the most powerful comments to any of the survey questions. One student stated, “It felt like I had a personal teacher.” Another of the screen-capture students claimed, “Seems like you’re the only student.” Students indicated that they were able to have more one-to-one conversations during class with the teacher that was privy from the other classroom students.

When the students were asked to explain whether the screen-capture multimedia lessons improved their math learning, the students’ indicated they had a closer relationship with their classroom instructor because of the multimedia methodology. One of the screen-capture students stated, “I felt I could easier get individual help.” Students responding favorably to the increased availability of their classroom teacher as one of the things they most liked about Chapter 5’s instructional multimedia with statements such as, “If we still didn’t understand it the teacher would be free because she wasn’t teaching the lesson.” Students also expanded to what they preferred with the online math lessons in a manner that suggests an increased relationship with their classroom teacher by stating “If I had any doubts or questions the teacher would instantly come to my aid,” and another claimed, “If you are confused you can still ask the teacher questions.”

During the teacher’s daily survey response after the screen-capture lesson, she made numerous comments regarding the added one-to-one instructional time that was helping her daily classroom teaching. She stated, “I got to check more students for practice problems than in other class due to students were at different places of lesson at different times." Her comments included, "Helping kids one-on-one as they had questions," and, "Walking around checking for understanding." The teacher's online journal also indicated that she was answering more individual questions and providing more one-to-one instruction when compared to her traditional classroom.

> I went around the room checking their work for correctness. This is a very effective technique. I got more question than in the previous day. This is where I was able to give a lot of one-to-one attention. Even after they got their points, they had questions they wanted to confirm they were doing right, very powerful. The problems that I required them to do from the lesson, I did walk around and check for accuracy.

During the interview, the teacher discussed her new role working individually with the students while they accessed the instructional technology in the classroom when compared to the live-lecture format.

> I have a lot of energy. I go around to all the kids. I can make it around 32 kids in 20 minutes, you know? You have to move. You have to get up. I don't know how many teachers actually walk and look at students' work every day. I think in the long run, it makes you much more active. When I'm doing the teaching in front, I'm spending more time teaching in front than actually working with the individual students.

During the interview, the teacher gave an example of how one of her struggling students who had never asked questions before the treatment was now willing to ask her questions. She went on to state that the student was benefiting from the increased one-to-one instruction enabled by the classroom's instructional multimedia.

> But all of a sudden people like Jonny, who had never asked a question yet, is having trouble on imaginary and complex numbers and now is asking more questions. . . He had not been asking questions. He's in the iPad class and he had not been asking questions. . . Jonny has a very low 'C' and needs to ask the questions. He has to ask. He has to clarify and he hasn't been, but I noticed that with the lessons [screen-capture], he's started asking more. He was not someone who was asking for me to check. . . Jonny was finally able to say, 'I really don't understand this. Can we go over it?'

Students preferred to watch the online instructional multimedia in the classroom with their teacher, rather than at home in a *flipped* model. Even though the screen-capture students indicated previously that they like being able to view the lessons at home, these students indicated that they did not prefer to watch the online lessons as homework, but rather they wanted to view the lessons with their teacher in the classroom (Figure 4.5.). Only four of the screen-capture students (13.3%) indicated they preferred to have the multimedia lessons viewed as homework rather than in the classroom, while 26 (86.7%) would rather view the lessons in the classroom with their teacher and peers.

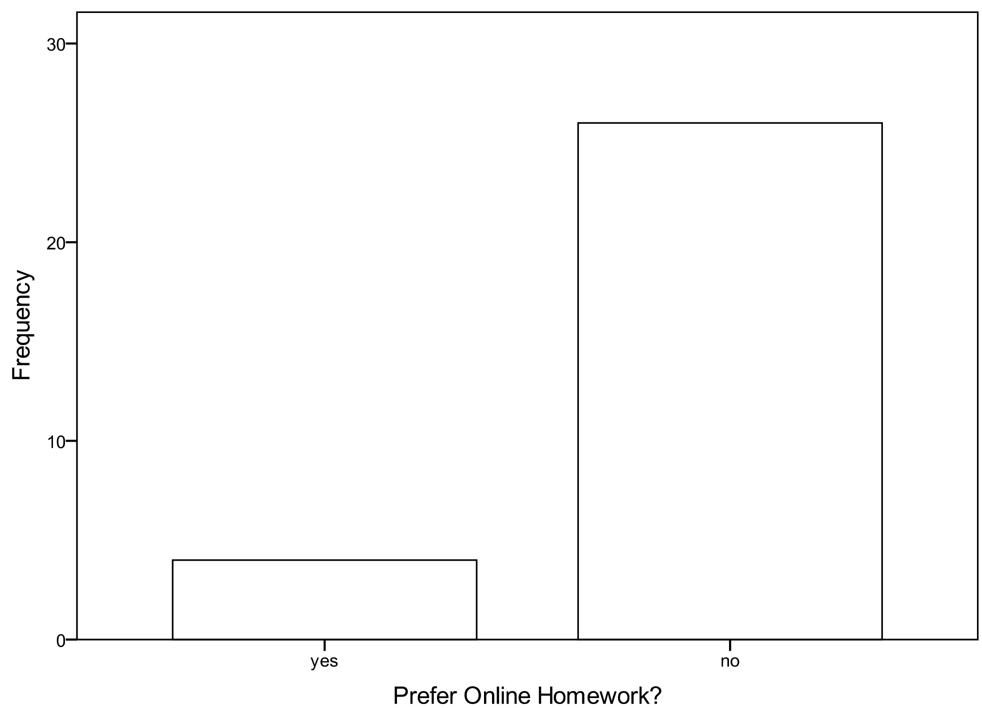

Figure 4.5. "Would you prefer to have watched all the online lessons as homework instead of as class work?"

Note. N = 30

Students indicated that they did not prefer to watch the online lessons as homework. Though the students reported they did like being able to review the online instructions at home throughout the survey, it was revealed that they wanted the added benefit of their teacher's face-to-face explanation to their individual questions in responses such as, "Because if I have a question I can just ask in class and you cannot do that @ home if you are listening to the video." The math teacher was able to provide one-to-one instruction in the blended classroom, but was unavailable to assist the students online while they were viewing the lesson as homework. A student commented, "I feel like watching them in class is better so if you have questions you're able to ask." The screen-capture students also responded with statements such as, "We could ask questions right away if the videos had something we didn't understand." The students went on to state their opposition to the flipped model with arguments such as, "I would forget my questions," if they were to wait until the next day for their teacher's assistance.

One reason why the students preferred using the online teacher's instruction in the classroom rather than at home was from the lack of distraction found within the blended classroom environment compared to their home. One student suggested, "Sometimes home can be a distracting environment and I only have a very limited amount of time on the comp so I feel rushed, it made class more enjoyable." In addition, accessing the teacher's instructional multimedia within the classroom kept the students focused on learning the math lesson as illustrated by the comment "I enjoy watching them in class because it does not take time away later in the day." The screen-capture students also described the types of distractions they encountered while at home when accessing instructions from the internet, "When you are online at home you would go to other websites." Students stated they were far more distracted at home when watching and listening to the math lessons.

The teacher also commented on the lack of success when using the instructional multimedia as homework when compared to the classroom delivery method in her following statement:

> I did a flip lesson. For homework, I assigned the students a lesson to listen to . . . I told them they had to comment on the lesson and then I would know if they listened to it. Some said the internet went out. A few said they never saw the assignment.

When students learned from their teacher's screen-capture instructional multimedia in the classroom, they were not disturbed by their classmates. A few days after completing the pretest/posttest, students responded to the survey questions. Students revealed that when the screen-capture instructional multimedia was incorporated into their learning environment, the relationship with their peers changed. One student pronounced, "If I didn't understand something I would go back and check without disrupting the pace of others." Within the screen-capture learning environment, students reported that they were no longer inhibited by the disruptions of their classmates as found in their traditional live-lecture setting. As stated by one student, "No distractions! Just me and my iPad." One student also suggested, "We can pause & ask questions without disrupting everyone else." Their responses demonstrating this new learning environment can be found in their comments of what they liked most about the teaching of Chapter 5 with comments such as, "It kept the class room quiet making it easier to focus," and "The I-Pads made class a lot quieter because everyone was working."

When the learners were asked to explain their selection for which method they preferred to use in the future and what it was about the teachers online lessons they liked, they responded with statements such as "Everyone can learn and ask questions without interfering with others." One of the screen-capture students went on to state, "Not hearing side convo's so you can't pay attention (focus)." When students replied to what it was they did not like about the regular math teaching classroom, the theme of being disturbed by the other students was also found in statements such as, “People are loud making it hard to hear.” Another student affirmed what occurred in the live-lecture classroom by recounting, “Everyone talks and disrupts the class, so it takes longer.” The screen-capture students went on to reveal the disruptions in the live-lecture classroom with statement such as, “Can’t hear well all the time.” Another student described the traditional classroom environment as, “Too much people talking and not watching.”

The teacher’s survey question for the live-lecture group indicated that the teacher was also having difficulty with student behavior and disruptions, unlike the screen-capture group’s students.

> Many students seemed amazed that we were doing this and there was lots of complaining. Student A is very chatty. Doesn’t focus on my Lesson. Kicked her out to the hall. She was Distracting to other students in my opinion.

The teacher’s online journal comments also revealed a different classroom environment while the students were using the screen-capture instructional multimedia with statements such as, “No behavior issues,” and, “It was dead silent in the room as they listened” The teacher also made a comment that the less distracting environment was beneficial for her academically challenged students:

> If they were sitting there with headphones on – the lower kids who are so distracted, who can’t focus – if they had headphones on and had to listen to a lesson instead of listening to me and some kids screaming.

Students using the screen-capture instructional multimedia were less afraid to ask their teacher or peers questions in front of classmates. As demonstrated by this psychological engagement theme, the screen-capture students improved their relationships with their peers and teacher while using the instructional multimedia. One student revealed, “Too afraid to ask teachers questions in front of whole class because don’t want to look stupid”

The student responses suggest the classroom instructional multimedia enables discreet conversation and individualized instruction with the live classroom teacher with statements such as, "I use to be nervous to ask a question in front of everybody." The basis of the more intimate relationship can be found throughout the written remarks as a student described what occurred in a live-lecture environment with comments such as, "Absolutely nothing, I never learned anything, no questions of mine were answered w/ out me feeling stupid." Though the survey did not directly ask the students if they were feeling less anxious, a few of the screen-capture students reported they were far less nervous asking for help in the multimedia classroom environment. One student went on to state, "Feel a little weird raising hand, hard to ask questions during lesson." Student's psychological indicators were found throughout their responses to what they did not prefer about the regular teaching.

When the teacher was being interviewed, she was asked to expand on her comment that one of her students had changed his relationship with his classmates when using the online medium. The teacher revealed in her reply that one of her students who had accessed the day's lesson prior to the class period was discussing his workbook activity with his classmate.

> He also listened to many of the lessons ahead of time. He came to class with the practice problems done, many of the lessons ahead of time, and during the lessons Sam constantly turned to Billy and said, 'Did I do this correct? Am I doing this correct?' I loved that. I loved that.

Students using screen-capture instructional multimedia were able to receive additional instruction from their parents at home. Psychological engagement indicators were also revealed by students in the screen-capture group as they reviewed the multimedia lessons with their parents at home. Students indicated that they were viewing the lessons at home with their parents (Table 13). Nine students (30%) reported they had viewed the online lessons with their parents. In addition, a student indicated that while viewing the lesson at home, the parents were helping them solve Algebra problems based on the teacher's instruction. If the parents had been made aware that their child's Algebra instruction was available for viewing at home, more parents may have viewed the lessons with the screen-capture students. Even though nearly a third of the students' parents were reported to have viewed the online lessons, it may have been prudent to send home a note to the screen-capture parents indicating that the math lessons were available online for their viewing.

Table 13

"How many times parents viewed the online lessons?"

	Frequency	Percent
never	21	70.0
once	9	30.0
Total	30	100.0

Note. N = 30

IV. Lesson Development

To ascertain how creating and instructing with the screen-capture instructional technology may change teaching practices, the classroom teacher was asked to write her reflections in an online journal and maintained a daily survey (Appendix A). In addition, the Algebra teacher was asked specific questions relating to lesson development and implementation in an interview conducted shortly after the completion of the posttest (Appendix E). The teacher's responses were compiled using the Miles and Huberman's (1994) role order matrix. When reviewing the teacher's responses to the interview questions and reading her online journal and survey responses, words such as *time*, *think-ahead*, and *rerecord*, were found throughout the teacher's statements. These words were then turned into a category list and then moved under a new area titled *Patterns* that included statements such as: *The amount of time it took was a lot, I had to think ahead, The lesson needed to be rerecord.* Based on the statements from the pattern list, common phrases were created into single sentences that became themes.

Lesson Development Themes

The first lesson development theme was created from the teacher's statements that revealed there was a major amount of time required by the classroom teacher to develop the multimedia lessons compared to the traditional live-lecture preparation. Another theme discovered was that during the initial phase of screen-capturing a math lesson, the teacher had a new tool to analyze and evaluate her instruction. The third lesson development theme created from the pattern list is that upon self-evaluating her screen-capture lesson, the teacher recaptured each lesson to improve the quality of the instructional multimedia. The forth and final theme discovered from the teacher interview was that the screen-capture instructional technology can be used as a new tool for teacher collaboration.

More time was required to develop the multimedia lessons than the live-lecture methodology. This theme was discovered when the teacher was asked in the first interview what stood out the most from creating and instructing the online multimedia lessons. The teacher's immediate reaction was to discuss the amount of time required to construct the multimedia lessons. Without hesitation, the teacher stated that a lot of time was required to develop the screen-capture instructional multimedia. In the interview, the teacher stated:

> The amount of time it took to make them was enormous. I find that the amount of time it took to put into it, it was worth the outcome of what happens.
>
> The amount of planning that went into it was a lot, but watching the kids listen to the lesson and knowing that that day, that they were listening to the lesson, I really didn't have to instruct was really beneficial.

In the final interview question, the math teacher also commented to the theme of development time as she responded to the question inquiring what changes would be required to implement the online multimedia technology at her site and school district.

> Time for the teacher. . . . Number one thing is time for the teacher. The teacher needs time to create the lesson. The teacher needs time to record the lesson. The teacher needs time to listen to the lessons and evaluate how well the material is coming across. . . But I think the big issue is just time.

It is worth noting that the increased time requirement was not necessary, but rather, it was self-imposed by the teacher's overwhelming desire to recapture each lesson after her later viewing, so as to improve the quality of her Algebra instructional content.

Screen-capture instructional technology was a new tool used to analyze and evaluate a teacher's instruction. The theme of analyzing and evaluating the teacher's instruction emerged from the interview as the teacher responded to questions about how creating and watching her own multimedia lessons affected the lesson development. The Algebra teacher reported that she found herself able to evaluate her lessons prior to teaching the material to her students. Part of the teacher's response can be found below:

> So, I had to think ahead of time of how I was going to teach it. . . So, what happened is, I had to think ahead of time of how I was going to present the lesson.
>
> It enabled me to look at the lesson and say, with the exponents, that it needed some more work on it. The lessons that I did for the parabola section, I felt, were good but it required me to think ahead of time of what I did.
>
> Some of it was creating another way of doing it to be more organized because I couldn't change what I wanted to say in the middle of the lesson. I had to know exactly what I was going to say because the kids couldn't ask me halfway through, 'Wait! Do you mean that you wanted this done?' They couldn't ask that, so I had to make sure that when I did the lesson, it was very clear.

Prior to using the screen-capture instructional technology, the only way for the teacher to evaluate her lessons was after the Algebra chapter had been taught. Based on the students' scores, the teacher would evaluate the entire chapter's lessons. When asked if there was anything from the experience of creating and instructing the online lessons that could be used to change her teaching practices, the teacher spoke to the ability to analyze and evaluate her lesson:

> I realized that I also have to get more organized in looking at a chapter ahead of time. I tend to go section by section. 'Oh, tomorrow I'm teaching this. What do I have to know for this?' And then – boom – that night or early in the morning, I'm preparing for that lesson. By doing a whole chapter ahead of time, it got me organized. It got me looking back and going, 'This is what I have to do. I have to get organized to do it.'

Prior to the experiment, the classroom teacher relied on students' test scores to assess the quality of her instruction. The teacher had never viewed the content of what she was teaching, and there appeared to be no simple mechanism to evaluate her instructional content. Because the whiteboard was now seamlessly capturing her lessons, she had an easy method to view and assess the quality of her instruction. With her instructional multimedia available for repeated viewing, the classroom teacher felt compelled to spend additional time in developing and improving the quality of her instruction. When asked in a follow-up question whether she would have analyzed the lesson development in such detail for her live-lectures, she indicated below:

> I would not have had to think ahead of time, 'How do I want to present this? What is the easiest way to present this?' In the wrap-up lesson, the putting it all together, I had to think, 'Okay, what have I done through the whole thing that now I'm going to summarize?' I am not a very good closer-of-the-day-type person. I don't summarize at the end of the day. 'This is what we learned. This is what we did.' I don't spend time on review.

The teacher was later asked again in the interview if the lesson development ideas would have come about if she was just teaching using her past practices. She replied:

> No. Well, in a way, as I was doing quadratic formula I might stop and say, 'Oh, let's do an example of what happens if there's a negative under the square root,' and I would stop and just add it. Now, I have to think about, 'Well, is it a better way to teach it this way or should I do it the way I did it?' And I kind of think it's better to do imaginary numbers a different way.

The teacher was asked what changes would be required to implement the online multimedia technologies at her site and district. When the teacher was asked what she would need to make the screen-capture multimedia a standardized instructional practice, she responded as follows:

> The teacher needs time to listen to the lessons and evaluate how well the material is coming across. I found that I had recorded some things three weeks ahead of time and I had to go back as I was getting ready to do the homework and see, 'What did I say in the lesson? I don't even remember what I recorded,' and go back and look at the lesson and see, 'Okay, this is what I recorded. Does this homework match?'

Surprisingly, the teacher also suggested that after incorporating her multimedia lessons in the blended classroom, she was still thinking about ways to improve the lessons. When the teacher was using the live-lecture format in years past, she had no sense of the lesson's pacing or flow. Though she may have covered the same materials, she was able to see the value of rearranging the sequence of her instructional content. For students to understand new math concepts, it was deemed necessary that the content be rearranged so it could build upon concepts taught immediately prior.

> One slide helped me think about how I presented the lesson, and I think even if I go back I might move the quadratic formula to later on and do imaginary numbers first and do quadratic formula that included imaginary numbers because now that we have recorded lessons, I have to go back and teach imaginary numbers as part of quadratic formula. So, the order of the lessons, though it's changed from the book, I still think I might change the order of the lessons again.

The teacher using screen-capture instructional technology recaptured the instructional multimedia lesson in hopes of to improving the instruction. The theme of recapturing each lesson was discovered as the teacher spoke of analyzing and evaluating her multimedia lessons. The teacher revealed her strong desire to recapture her screen-capture lesson when asked how creating and watching the multimedia content affected her lesson development. Though the teacher had over fifteen years of Algebra teaching experience in the high school, she was not satisfied with her lessons. The teacher could just as easily have kept the same instruction from years past, however, she felt obligated to improve the instruction for her students by recapturing the instructional multimedia using her digital whiteboard.

> In dealing the exponents first as a trial, I realized that in the exponent lessons, I have to go re-back and re-teach a couple; present another video that was more detailed. . . And the first couple sections, needed to be rerecorded a couple times because I didn't like the way it was being presented.

In the following question, the teacher was asked if she would have analyzed the content of her lesson if she had not been using the instructional technology. She again discussed her need to recapture the math lessons prior to implementing the study.

> This chapter, I had to put it all together. It helped me with my errors and doing my math that I went back and made changes to the answer keys, but it helped me putting it all together.

The teacher's strong feeling to recapture her lessons was surprising. In the past, the Algebra teacher was not concerned with the structure of the lesson, but rather, she was more concerned with covering as much material as possible to satisfy state and federal testing requirements. When the teacher was asked in a follow-up question if she could have presented her lessons to the students without recapturing the lessons, she replied:

> No, I have to rerecord because when I did quadratic formula, I did not put any imaginary numbers underneath the square root. My imaginary lesson is good, but now I need to go on and do imaginary numbers under the quadratic formula. I didn't cover that enough as I was doing it. I also found that a couple times, I did the lesson but I didn't look at the homework that I was assigning.

When the teacher's online journaling was reviewed, it was found that on more than one occasion, she had decided to recapture her lesson due to perceived errors in the content. Her online journal was full of notions to recapture her lessons as follows:

> Prerecorded the answer key so all the answers were visible to the students. It seems I had 2 wrong answers so I have to rerecord the answers. Then there was an error on the answer key so that is the 2nd day where I have to dump the answer key and rerecord it. Practice makes perfect or closer to correctness.
>
> I have to spend time this weekend writing a lesson that will allow them to see the translation of parabolas on that program. So much more cooler then the graphing calculator.

Screen-capture instructional technology was used a new tool for teacher collaboration. The final theme emerged from the teacher's discussion on how she analyzed her multimedia lessons. The Algebra teacher in this experiment indicated that she had sought help from a fellow Algebra teacher at her school site. To help evaluate the Algebra content, the teacher showed her fellow math teacher the content of her instruction through the online format. Not only did she have her fellow teacher provide feedback upon viewing the online multimedia lesson, but the other math teacher independently used the screen-capture instructional technology to demonstrate her own techniques for improving the Algebra lesson. The teacher indicated her collaboration in the following statement from the teacher interview:

> It's time and collaboration. It's time of saying, 'Okay, I'm going to do chapter five, Algebra II teacher . . . you do chapter six. I watched your chapter six. I like the way you did chapter six.'

When the teacher was asked whether her lesson development was the same when she was creating them for her live-lecture methodology, she also indicated she had an entirely new method to collaborate with her peers.

> Now, I have to think about, 'Well, is it a better way to teach it this way or should I do it the way I did it?' And I kind of think it's better to do imaginary numbers a different way, and this was also in talking to another Algebra II teacher and she said, 'Oh, no. I did quadratic formula last, after imaginary numbers.' So, it has to do with the collaboration of the Algebra II teachers.

It should also be noted that the colleague who collaborated with this study's teacher simultaneously created online multimedia lessons using the screen-capture technique developed for this study in her classroom. The colleague used the screen-capture instructional technology to collaborate with this study's math teacher and for her own Algebra students. She had to be asked to remove her online lessons from the school's Google Docs website prior to the experiment, so as not to inadvertently confuse the screen-capture students in the research study. The colleague had no previous experience using the screen-capture instructional technology and solely learned the technique from collaborating with the experiment's subject in the months leading up to this study.

Summary of Results

Students demonstrated an increase in academic achievement as found in the mean scores from the screen-capture students pretest/posttest ANCOVA results. Based on the results of the survey and online postings, it was evident that the students preferred learning Algebra from the screen-capture instructional multimedia rather than the teacher's live-lecture. Using Appleton's et al.'s (2006) student engagement instrument (SEI) as an analytical tool on the students' survey results and the teacher's writings, it was also revealed that the screen-capture students demonstrated a higher level of cognitive engagement while they learned new algebraic concepts from the teacher's instructional multimedia when compared to the live-lecture students. Appleton's et al.'s SEI index was used to decipher the students' surveys responses and online postings and was also applied to the teacher's daily surveys, online postings, and her final interview. It was also revealed that the screen-capture students were demonstrating a higher level of psychological engagement as they interacted with their classroom peers, classroom teacher, and their parents. Finally, the teacher's lesson development process suggested the screen-capture instructional technology could be used as new method to analyze and improve a teacher's instruction and could also be used as a tool to collaborate with colleagues. Upon reviewing these results, the themes of Chapter 4 were further refined to become a new and more concise *Propositions* category. These propositions will be explored in more detail within Chapter 5.

CHAPTER 5

SUMMARY OF FINDINGS

Computer-based instruction is rapidly expanding for secondary schools in the United States. School districts throughout the nation are incorporating new instructional technologies, such as online classes, with little assurance student learning will increase (Figlio et al., 2010). As purported by the U.S. Department of Education's meta-analysis, educators and policy makers contemplating the integration of computer-based and online learning within K-12 sites need to base their decisions on rigorous research applied to varying subject matters and student ability (USED, 2009). However, as noted by Mayer (2009), multimedia learning research is still in its infancy.

The purpose of this study was to examine whether screen-capture instructional technology was a viable teaching tool for the secondary classroom. As the research study developed, Algebra II was selected as the curriculum's area of focus, based on the subject's conduciveness to screen-capture technology and the rigorous state and federal high school math requirements. Additionally, Algebra comprehension is considered a barometer for long-term student success and it is a foundation subject required for the modern workplace (National Council of Teachers of Mathematics, 2009a). The classroom teacher's experiences developing the screen-capture lessons and her first-hand observations implementing the online instructional multimedia were also investigated.

To measure the impact of the instructional multimedia within the secondary classroom, this study measured academic achievement, psychometrics measurement of cognitive and psychological engagement, preference, and the classroom teacher's experiences while developing and implementing her instructional multimedia. Student academic achievement was measured using a 2-group experimental pretest-posttest experiment conducted on secondary students enrolled in two Algebra II classes. Each student's preference toward the instructional methodology was sought. The student's level of cognitive and psychological engagement was also self-rated using a student engagement instrument (SEI) survey (Appleton et al., 2006). The effectiveness of the teacher's lesson development and teaching practices were assessed from daily surveys, online postings, and interview.

Based on the themes discovered from this experiment in Chapter 4, a new *Propositions* category was created. Propositions were developed from the answers to research questions which inquired whether academic achievement would improve with the instructional technology, if the classroom students were engaged while learning from the online instructional multimedia, if the students prefer the new type of instruction, and what effect the lesson development and classroom experience had on the classroom teacher. Three overreaching propositions emerged upon analyzing themes from student achievement, student engagement, student preference, and lesson development. The first proposition relates to an increase in cognition, the second proposition relates to student engagement, and the third proposition addresses the new capabilities discovered by the teacher with lesson development. This chapter is divided into six sections; the first is comprised of the three propositions, then lesson development, the limitations of the study, implications for practice, an implementation plan, and a final conclusion.

Propositions

The first proposition is that secondary students demonstrate an increase in cognition from their reduced cognitive load and show an increase in cognitive engagement when learning from their teacher's screen-capture instructional multimedia. The first research question explored the effects of screen-capture instructional technology on student cognition. This study's initial directive sought to discover the extent to which there was a difference between the academic outcomes of secondary Algebra students learning from multimedia lessons created from their teacher's screen-capture instructional technology compared to students learning from the same teacher's live-lectures.

Cognition. When analyzing overall scores, the screen-capture students were shown to have significantly higher posttest Algebra scores than their counterparts learning from their teacher's live-lecture. The screen-capture students' Algebra test scores improved one full letter grade (11%). Results from this experiment indicate that secondary Algebra students can significantly increase their retention and transfer of new math concepts when using screen-capture instructional multimedia within the blended classroom environment. The findings are aligned with research on instructional multimedia that is based in the theoretical framework of Mayer's (2001) cognitive theory of multimedia learning (CTML). Strategies developed under Mayer's CTML theoretical framework were integrated within this study to reduce the brain's overall cognitive load for the learner, as demonstrated by the screen-capture participant's increased level of academic achievement scores and their cognitive engagement indicators. One aspect of CTML is that the brain interprets new information by integrating the instruction with existing knowledge through the active processing system. This screen-capture instructional technology experiment incorporated the active processing system with self-referencing, a pedagogical agent, and signaling. Self-referential encoding was established in this experiment by personalizing the multimedia lessons with the student's familiar classroom teacher. The teacher introduced each Algebra lesson with her moving image and maintained an audio connection with her students throughout each lesson. Acting as a pedagogical agent within each math lesson, the instructor employed signaling that directed the learner's attention toward relevant formulas and procedures to solve algebraic equations. The teacher's ability to maintain an onscreen relationship with her students, in part, minimized the learner's overall cognitive load.

Cognitive load theory was developed to provide guidelines to assist instructional multimedia development that optimizes intellectual performance (Sweller, 1998). As information is encoded into working memory, knowledge is limited in capacity and duration (Miller, 1956). Students in this experiment commented on the ease of use while following the teacher's screen-capture instructional multimedia and also reported the multimedia lessons made it much easier to stay focused with very clear instructions. Rather than learn from the teacher's live audio and visual instruction, the screen-capture group had control over the instructional multimedia. It is noteworthy that the content of the instructions and teacher's explanations were nearly identical for both groups, suggesting that the student's control over the instruction made the content clearer and not necessarily the instructional multimedia per se. The screen-capture group participants were thereby able to minimize their cognitive load with control over the lesson's pacing. This finding was well supported in the themes that emerged from the literature review and the students' survey responses.

Throughout the initial phase of the literature review, it was discovered that researchers experimenting with instructional multimedia consistently referred to Sweller's (1998) cognitive load theory. Researchers throughout the literature review were attempting to reduce the learner's cognitive load by manipulating user control over the pacing and sequence of the lesson. Tabbers et al. (2010) tested interactivity using their hypothesis that learners with control over pace and order of a multimedia lesson can decrease the learner's cognitive load and increase transfer performance by expanding research from Mayer and Chander (2001). The resulting interactive principle summarized in the literature review and confirmed in this study was based on the premise that learners who control the pace and order of instructional multimedia decrease cognitive load.

Students also using the instructional multimedia wrote antidotal statements indicating their learning improved within the quieter and less distracting environment. Pass et al. (2003) stated, intrinsic, extraneous, and germane cognitive loads cannot exceed the working memory resources available for learning to occur. Comparison to the live-lecture participants in this study revealed the learning environments in traditional live-lecture classrooms were full of distractions, including repetitive student questions and ongoing student outbursts. This study's live-lecture group participants were no different as demonstrated with a decrease in their learning outcomes. Rather than work to listen and view their teacher's live instruction over the noise and disruption of their other classmates, the screen-capture students were able to minimize extraneous stimulus in their information-processing channels. In relative isolation, the students were easily able to focus on their teacher's instructional multimedia.

Cognitive Engagement. Cognitive engagement can be used to predict student achievement and dropout proclivity (Reeve, 2004). The ability to measure student cognitive engagement is thus paramount to improving the academic outcomes of all students, most especially for learners who are at a high risk of failure (Appleton et al., 2006). The third research question inquired whether secondary Algebra students were more engaged learning from multimedia lessons created from their teacher's screen-capture instructional technology when compared to students learning from traditional lecture-based lessons. By incorporating Appleton's et al.'s student engagement instrument (SEI) into the student survey, cognitive engagement was assessed. Cognitive engagement questions were developed to measure levels of student engagement as perceived from their perspective. The SEI questions were modified to reveal student engagement from both the live-lecture and screen-capture classroom settings, but not the overall school environment.

When reading the detailed comments from the students, it became evident that the screen-capture participants had developed a strong attachment to the multimedia pedagogy. However, student preference and engagement with computer-based instruction does not necessarily improve understanding. To increase knowledge, interactivity with computer-based instruction must be consistent with how people learn and in a way that minimizes cognitive load (Mayer & Chandler, 2001). The interview from this experiment revealed that the teacher believed her lower performing students using her screen-captured instructional multimedia were more engaged and demonstrated an increased level of algebraic understanding than when she had taught the same students in the previous chapter using her live-lecture pedagogy. This premise is consistent with Mayer's (2005) statement that lower performing students increase their academic achievement when learning from instructional multimedia.

Students in this research experiment reported an increased level of cognitive engagement as they interacted with the teacher's online instructional multimedia. Unlike student preference, engagement represents the student's participation and involvement in an activity. According to Reeve et al. (2004), "Engagement refers to the behavioral intensity and emotional quality of a person's active involvement during a task" (p. 147). For example, Tabbers et al. (2010) suggested that the improved scores from students using instructional multimedia was from the additional time each student spent on the media, and not necessarily the multimedia's dual coding benefit. Unlike this study that used self-reporting survey responses, Tabbers et al. used videotaped observations that discovered the average duration for the classroom students using the instructional technology was twice that of the students who did not have the capability to control the lesson's pacing.

Tabbers et al.'s time on task findings are consistent with the survey findings from this experiment which indicated students viewed each lesson nearly two times (1.9) within the classroom. Paradoxically, even though the screen-capture students in this experiment spent nearly twice as long viewing the teacher's instruction than the live-lecture group participants, the screen-capture learners still managed to move through each lesson at a faster rate. This seemingly contradictory occurrence for Tabbers et al. (2010) resulted from the teachers attempt to check for understanding with the entire group of learners, either through question and answer sessions or by working individually with each student. As indicated by Kong (2011), a teacher checking for whole-class understanding in a lecture-based classroom can easily add 40% more time to the overall instruction. Unlike the inability for the teacher in the live-lecture group to check for understanding with each individual student in a single class period, the teacher from the screen-capture group spent the entire class period moving from student to student.

The increased level of student engagement resulting from control over instructional multimedia can be an effective and easy-to-implement methodology to enhance student understanding (Tabbers, 2010). Enabling students to replay and pause their instructional multimedia minimizes the amount of information being presented in the learner's visual and auditory channels. Students using their classroom teacher's screen-capture instructional multimedia demonstrated an increase level of cognitive engagement and understanding from watching and reviewing each lesson. The learner's ability to pause and revisit the instruction as needed allows for an overall reduced cognitive load. Still, as suggested by Harskamp et al. (2007), student active engagement with the instructional multimedia may provide the learner added instructional time with the lesson enabled by the viewing technology. When student engagement is combined with instructional multimedia that addresses the learner's cognitive load as suggested in the results of this study, an increase in academic achievement is possible.

Psychological Engagement. The second proposition is that student's psychological engagement increased within the blended classroom as learners developed a one-to-one academic relationship with their classroom teacher and peers. This experiment demonstrated that the blended classroom could be used effectively to combine the strengths of a teacher's face-to-face instruction with the student's control over online content when using screen-capture instructional multimedia. The recommendation that online instruction be used in the classroom also emerged as a theme from the literature review. It was recommended that online instruction should be integrated with classroom instruction, and not for remote learning. As Griffin et al. (2009) suggested, the ideal use of the online medium is best suited for blended learning environment with a thoughtful integration of classroom face-to-face practices and the online learning experience.

Teacher relationships. Though students reported they liked being able to review the online instructions at home, they preferred the teacher's direct one-to-one assistance in the classroom over the traditional stand and deliver classroom experience. Christensen et al. (2008) estimate that the available one-to-one instruction in the live-lecture classroom is less than 20% of the instructional time. Responses from both the teacher and students suggest a dramatic increase in the amount one-to-one time spent within the blended classroom. Both the teacher and screen-capture students stated that they enjoyed the increased one-to-one instruction available within the blended classroom enabled by the teacher not having to perform a live-lecture. These responses were aligned with SEI internal indicators that suggest a more intimate relationship between the students and teacher had occurred. Anderson (1993) suggested, the greatest improvement in learning is not by reducing class sizes, but is associated with one-to-one tutoring. Unlike her reports of the live-lecture classroom, the teacher presenting the instructional multimedia in this experiment was able to have considerably more one-to-one instructional time and develop face-to-face connections with each student. In fact, one-to-one tutoring was the primary role of the classroom teacher in the screen-capture environment. As a result, the blended classroom teacher was able to address specific questions from each student as they interacted with the instructional multimedia.

Peer relationships. Students responding to open-ended survey questions discussed how the instructional multimedia had changed the relationship with their peers. Though the literature review did not address the interaction between students with one another in the blended classroom, this study's findings suggest a decrease in animosity toward peers and an increased level of collaboration with one another in the classroom. Students using instructional multimedia in the blended classroom stated they were not disturbed by their classmates as had occurred in their traditional live-lecture classes. Students' relationships with their peers improved because there was a decreased in animosity without the classmates' ongoing disruptive classroom behavior. In addition, students no longer had to compete with one another for the teacher's assistance. Students reported they were not annoyed by having to wait for their classmates to comprehend the instruction commonplace in the live-lecture classroom. In fact, students discreetly worked with one another to improve their understanding of the multimedia lesson, without disrupting the other classmates. When the teacher was asked if she thought the online multimedia technology was a good fit for most high school teachers, she directed her comments to the interaction of her students as follows:

> I also noticed in our lessons that when we got to topics that were new to the kids, they started working together after listening to a lesson or talking to each other more than when they were doing the topics of factoring and quadratic formula.
>
> The things that they knew how to do was not something that they turned to their neighbor and said, ‘Hey, I need help with this.’ I heard it more when we got to complex numbers and imaginary numbers and checking your answer against somebody else than I did at the beginning review topics. So, maybe you can pause, but I have to think about this. So, maybe my concept of the question is that, Is the lessons better to do with new topics that kids have never seen before and then turning to their neighbor and saying, ‘Hey, this is what I got. Did you get this, too?’

When asked in a follow-up question if the instructional technology lends itself well to group activities, her response was more specific toward paired collaboration.

> To paired. I don’t know that it does group, but I know it does paired because in a group, you’re all at different places, but you kind of look at your neighbor in a pair and say, “Oh, they’re almost done and then I can ask them.” But if you’re in a group of four, are you rushing? Are you rushing because that person finished first?
>
> I think they wanted to ask their neighbor because they didn’t want to get checked by me. With the practice problems that were at the end of each lesson, I don’t know that they wanted to get checked by me until they had verified that they did it correct.

The teacher’s daily journal also reported that her students were independently engaged in obtaining peer assistance as written below:

> I saw students helping other students with practice problems. Students were checking with each other if correct.

Lesson Development

Cognitive Tool. The third proposition states that screen-capture technology enables teachers to self-assess their teaching and collaborate with other teachers to improve their instructional multimedia prior to implementing the coursework with their students. The forth research question inquired how the experience of creating and instructing Algebra multimedia lessons developed from a secondary classroom teacher using screen-capture instructional technology changed the teacher's instructional practices. With the backdrop of ongoing state and federal pressures to improve academic proficiency of secondary students and the corresponding acquisition of prepackaged online instruction by K-12 institutions, this investigation demonstrated that a teacher using screen-capture instructional technology can effectively develop an algebraic multimedia curriculum for secondary classroom students.

The discovery of a cognitive tool was initially discovered in the literature review, as researchers used computer-assisted instruction as a primary teaching tool. According to Drijvers and colleagues (2010), technological tools offer the promise of redefining traditional instruction of Algebra by providing students and their teacher's new ways to engage with the subject. Rather than support classroom instruction with online computer-based content, researchers attempted to use online instructional multimedia as a tool to replace traditional classroom instruction. The concept of instructional multimedia being used as a cognitive tool was first suggested by Mayer and Moreno (2001).

A key component of the screen-capture's cognitive architecture is in the ability to maximize the learning rate with individualized instruction, whereas a teacher in the traditional classroom looses the majority of students as he/she attempts to meet the education needs of one or two students Anderson (1993). Not only can the teacher's instructional multimedia be saved and viewed later, but the instruction could easily be translated into other languages and made available for all students modified from the teacher's screen-capture multimedia lesson. The audio portion of the multimedia lesson can also be presented as subtitles or in foreign languages, so as to accommodate a broader group of learners in the classroom. This capability to translate instruction *on the fly* or transcribe audio into text that corresponds with visual instruction was a readily available online resource found in websites such as Google's YouTube free video-sharing website or from video editing software similar to the one used for this experiment. Unlike the pilot math lessons, the instructional multimedia in this experiment was not modified with subtitles or alternative languages because all learners in this experiment were fluent in English. Additionally, both subjects did not require any significant accommodation requirement for academic success as stated in their Individualized Education Plan (IEP) or 504 documentation. There was also concern that if the students needlessly used the subtitles in conjunction with the audio instruction, they could risk cognitive overload to the detriment of their academic success.

To determine if the experience of using screen-capture instructional technology as a cognitive tool changed the teacher's practices, the classroom teacher wrote her reflections in an online journal, maintained a daily survey during the four week experiment, and participated in a final interview. When the teacher was asked in the first interview question what stood out the most from creating and instructing the online multimedia lessons, *time* was her first reply. It was revealed by the teacher that far more time is required to develop the multimedia lessons than with the live-lecture pedagogy. However, the time required for a teacher's lesson development of the screen-capture instructional multimedia could be offset. A teacher is not required to capture a lesson prior to instruction. Screen-capture instructional technology can be constructed during a live-classroom instruction and paused by the capture software as needed. Furthermore, the time and effort put into the lesson development for a single instructional multimedia lesson could be rewarded for the classroom teacher with less lesson planning and repetitive classroom lecturing over the short-term period and even more so over future academic years.

A single subject high school teacher typically teaches the same subject and curriculum to different groups of students daily. Public secondary school teachers in the United States are often required to instruct up to four or five classes of the same subject daily. It is not uncommon for a typical high school math teacher to instruct the same subject to over 150 students daily. To ensure consistency between classes and reduce lesson development time, many teachers instruct using the same lessons for each class; continually writing and erasing each lesson.

It is important to note that each multimedia lesson in this study was viewed three and a half times as revealed in the student survey and the teacher's statements. One instructional multimedia lesson, developed for one day's class, could easily surpass 500 viewings from students, parents, and administrators. As a result, the aggregate viewing of one online multimedia lesson over the span of a teacher's career could easily approach many thousands of viewings. It is reasonable to envision a school environment where each teacher has their own bank of instructional multimedia lessons that are accessed by students, colleagues, parents, and administrators from year to year. Taken further, a secondary school could easily have students acquiring their entire teaching staff's instructional multimedia from a student's personal multimedia device, taken to and from each classroom and home.

Teacher Collaboration. As reported in chapter four, screen-capture instructional technology was discovered as a new tool for teacher collaboration. A theme discovered from the teacher interview was that the screen-capture instructional technology could be used as a new tool for teacher collaboration. Unexpectedly, the Algebra teacher in this study sought the assistance of another math teacher for help in creating curriculum content as she began to develop her multimedia lessons. This action is not unreasonable with both teachers employed by the high school to teach Algebra at the school site and encouraged to work with one another by the school's administration. Rather than sharing strategies in the live-lecture blackboard technique, the teacher, who was the subject of this experiment, uploaded the multimedia lessons to the teacher's Google doc's website and provided access for the other teacher. The screen-capture instructional technology was the perfect tool for teacher collaboration. Not only was the teacher able to record what she considered her *A-game* lesson, but the collaborating teacher viewed the exact lesson that the students would potentially access. As the teacher reported:

> It's time and collaboration. It's time of saying, 'Okay, I'm going to do chapter five, Algebra II teacher . . . you do chapter six. I watched your chapter six. I like the way you did chapter six.'

When the teacher was asked whether her lesson development was the same when she was creating them for her live-lecture methodology, she indicated she had an entirely new method to collaborate with her math department.

> This was also in talking to another Algebra II teacher and she said, 'Oh, no. I did quadratic formula last, after imaginary numbers.' So, it has to do with the collaboration of the Algebra II teachers.

As the teacher's collaboration grew, both teachers began to use their digital whiteboard's screen-capture technology in the same methodology developed for this experiment. Because the screen-capture technology on the digital whiteboard was simply activated by clicking the recording icon on and off to capture instruction, very little training, if any, was required. With the teachers sharing a USB audio adapter on their classroom's electronic whiteboards, both teachers began to create individual multimedia lessons for their own students and for one another. There was so much collaboration occurring between the two teachers on the schools Google doc's website, the other teacher was asked to remove her multimedia lessons, so as not to confuse the researcher in this study and possibly the students in the research experiment. It should also be noted that after this research experiment, both teachers briefly modified their daily teaching practices to incorporate the screen-capture instructional technology.

Limitations of the Study

This investigation provides insight into the impact of multimedia/screen-capture instruction over the course of one month with 32 secondary students. A lengthier and broader investigation may provide greater understanding into the potential utility of this type of online instructional multimedia. An expanded experiment could include a larger sample size, expanded age groups of K-8 students, and varying types of curriculums. For example, it would be worthy to test if students demonstrated learning gains from instructional material that is not as graphically intensive as Algebra, such as in the social sciences or with a language curriculum. One might also suggest a novelty effect as the screen-capture students worked harder as a result of the new technology. As discover by Clark and Sugrue (1988), students may initially demonstrate an increased effort, but the novelty effect reduces rapidly as students become familiar with the medium. As a result, any improved academic performance relating to the new computer-assisted instruction would have been minimized due to the month long duration of the study. In addition, the live-lecture students were also using the iPads, but for graphing purposes. Rather than use the devices to stream multimedia, the iPads were also used by the live-lecture students as enhanced graphing calculators; none of these students had access to the teacher's online instructional multimedia or the audio headsets. Another concern of this type of pretest/posttest experiment is that the live-lecture students may have experienced a potential interactive effect, enabling them to remember the pretest exercise; however, the complex nature of the testing material should have had a minimal impact on the research study (Gay, Mills, & Airasian, 2009).

This study only measured blended instructional multimedia in comparison to live-lecture instruction and not solely online instruction versus blended learning or live-lecture. It would also be valuable for future blended instruction to determine the level of teacher interaction required for the secondary students to maintain their relationship with the classroom teacher. Though this study relied on the teacher's recorded moving image to introduce each lesson with her following audio narration, it would be noteworthy to determine the extent to which the teacher is needed as a pedagogical agent. Additionally, a limitation of the screen-capture instructional multimedia was the inability for the software to check for student understanding or monitor for student activity. However, unlike the traditional classroom environment or remote online learning, the teacher in the experiment was able to check for student understanding on a one-to-one basis without affecting the other learners' ongoing instruction as she continually walked throughout the classroom.

Implications for Practice

Teacher Evaluation. The teacher in this study found that upon creating her own instructional multimedia lessons, she was easily able to have her peer evaluate the strengths and weaknesses of her algebraic lessons before introducing them to her students. Aligned with current national practices, an evaluation of classroom teachers can be done by school administrators formally entering the classroom. Many of the standard teacher evaluations are measured using satisfactory to unsatisfactory ratings. Historically, the standard determination of a classroom teacher's effectiveness has been measured by how well the teacher manages the classroom instruction time and how effectively the teacher raises student achievement within that period of time (Leinhardt & Greeno, 1986). In the live-lecture group, the students demonstrated typical classroom disruptions where the screen-capture room was reported by both the students and teacher to be a quieter and more conducive learning environment. It was also stated by the students and teacher that the instruction in her live-lecture classroom was not terribly efficient.

This experienced teacher's use of instructional time in the live-lecture classroom was typical. Stigler and Perry (1990) stated that less than half (46%) of a typical classroom instruction is spent on instruction. The use of the screen-capture instructional multimedia directly addressed both teacher evaluation measurements as demonstrated by the teacher's effective classroom management system and for the students' improved academic achievement within a shorter duration of time.

Using screen-capture instructional multimedia, a math teacher's instruction could easily be evaluated prior to the instruction actually taking place, not only by the teacher and peers, but by school administrators. At the high school site of this study, an evaluator sits in on a live lesson. The following feedback, intended to improve instruction, occurs only after the live-lecture teaching has occurred. Additionally, teachers being monitored could have far more control over what was being evaluated using the screen-capture technology than from an administrator's visit. A live observation might also lead the classroom teacher to feel uncomfortable and even threatened. Screen-capture technology could be used to evaluate the content of the teacher's lessons and instruction in a far less imposing manner. The technology could then be used as a tool to provide teachers with specific content suggestions and strategies before the instruction takes place, and thereby actually improving teaching practices and overall student learning.

Student-Centric Activities. The use of self-guided learning has come full circle with the constructivist-learning model that promotes student self-direction and inquiry (Dewey, 1934). As revealed in the literature review, many question the role of the classroom teacher using online instruction. Even though this study demonstrated that a teacher's role dramatically changes to that of a one-to-one tutor, the teacher and student were able to move faster through the instruction and in a student-centric manner. Because the students were able to move through the lessons on their own and did not have to wait for their fellow students' questions to be answered, the time required to view each lesson drastically decreased compared to the live-lecture format. In addition, the average duration of each day's lesson was no more than 10 minutes for each 55 minute class period.

With a faster delivery rate and the student-centric nature of the instructional multimedia, the screen-capture classroom can be more conducive to other student-centric activities that also require greater autonomy and independence. The classroom teacher's role as demonstrated in this experiment was no longer one of a live orchestrator in front of the classroom delivering rote information. After the instructional multimedia has been *pulled* by students, the remaining class time can be available for the classroom teacher to incorporate activities that reinforce the math instruction. The literature review findings suggested that the classroom instructor using online technology should no longer deliver live-lecture content to their students, but instead devote classroom time to more student-centric activities. "The instructor is free to devote instructional time to more student-centered interactions" (O'Bannon et al., 2011, p. 1891). Christenson's et al.'s (2008) bold statement, "Given the current trajectory of substitution, about 80 percent of courses in 2024 will have been taught online in a student–centric way" (p. 102), has been interpreted toward the inevitable elimination of the classroom teacher. However, if the online courses used in Christenson et al.'s statement were based on the classroom teacher's screen-capture instructional multimedia, the statement would be in concert with this research experiment. Taken a bit further, a *student-centric way* could also include activities used by the blended teacher to support his/her online instructional multimedia.

As revealed in this study, screen-capture instructional technology enables math instruction to be acquired by students in the classroom at a faster rate and in a need-to-know manner. Because mathematics is comprised of varying topical strands including Algebra and geometry that are highly interconnected (The National Council of Teachers of Mathematics, 2009b), students would have more time to work on applied projects and could also access information from other math subjects from their teacher's library of online lessons. Using the instructional procedure in this study, students working on projects that build on prior knowledge would be able to acquire their teacher's online mathematical equations and instruction at any given point in the class period. In addition, the instructor would be free to provide one-to-one guidance as needed as the student worked on the projects.

According to Anderson (1993), once declarative knowledge has been acquired by the learner, information needs to be coded in the mind as procedural memory when the learner becomes actively involved in turning the declarative knowledge into skill. In this research experiment, the declarative knowledge was acquired from the teacher's screen-capture instructional multimedia. In Anderson's model, not only should declarative knowledge be reinforced with procedural knowledge from a one-to-one instructor, but the declarative knowledge is further reinforced as contextual and experiential knowledge. Using Anderson's theoretical framework, the knowledge acquired from instructional multimedia (declarative knowledge) should be reinforced as procedural knowledge and contextual knowledge. As stated by The National Council of Teachers of Mathematics (2009a), "Currently, many students have difficulty because they have difficulty because they find mathematics meaningless. Without the connections that reasoning and sense making provide, a seemingly endless cycle of reteaching may result" (p. 6). The idea of applying Anderson's (1993) declarative knowledge as contextual knowledge can also be found in the theoretical framework behind California's high school career and technical education (CTE) programs.

As stated by Common Core State Standards for high school Algebra that is to be adopted nationally, "The Mathematical Practice Standards apply throughout each course and, together with the content standards, prescribe that students experience mathematics as a coherent, useful, and logical subject that makes use of their ability to make sense of problem situations" (National Council of Teachers of Mathematics, 2010, p. 15). The use of the screen-capture instructional multimedia would facilitate the additional use of applied learning as required by the upcoming national Algebra standards. Rather than learn from a live-lecture classroom, students using their teacher's instructional multimedia in a hyper-blended environment would access their teacher's screen-captured instructional multimedia as needed for experiential learning.

Implementation Plan

As stated by Cuban (2003) improvement efforts to incorporate instructional technology in the classroom consistently disregard the role of the teacher. As this study was being conducted, school districts across the nation were turning to their information technology (IT) departments and not their classroom teachers to implement instructional technology for students, based on the notion that IT employees who maintain network servers and run wire throughout the schools are qualified to understand instructional technology. Surprisingly, K-12 IT department managers and technicians are not required to have studied computer science or related subjects from four-year academic institutions or to have taken basic teaching courses. In fact, IT managers responsible for choosing and implementing entire high school online curriculums receive scarcely any post-secondary education. According to Rendell and Zirkle (2005), employees who are IT certified receive little or no formal education beyond high school and have "significant limitations based on their focus on transient knowledge and skills related to vendor-specific technology" (p. 292).

Though not having a comprehensive post-secondary education is not necessarily a detriment for teaching, the practice is not accepted within the K-12 public education system as mandated by No Child Left Behind (2001). A classroom teacher is only recognized as highly qualified once a teaching credential has been awarded (NCLB, 2001). The reliance on the K-12's IT department to come up with online instructional solutions is a scenario not dissimilar from hospital administrators asking their IT department employees to practice medicine, an investment company turning to their IT department for stock recommendations, or asking a grounds crew at a sporting complex to coach their team to the Super Bowl. Epistemology matters.

To implement a teacher-developed digital pedagogy, a paradigm shift is required throughout the entire K-12 landscape. As discovered from the literature review, most researchers and educators perceive computer-aided and online instruction as prepackaged applications that can be dropped into any classroom, regardless of the competency of the classroom teacher. A dramatic change in the relationship between the classroom teacher and computer-based instruction needs to occur. Computer-based and online instruction needs to be taken out of the hands of third-party vendors and embraced as a cognitive tool for the classroom teacher. Rather than look externally for instructional technology solutions, current teachers can be trained with the use of proven computer-based educational practices. Teacher preparation colleges could easily train teachers on how to use screen-capture instructional technology for producing their own in-house content that infuses their speech with dynamic illustrations of enhanced graphics and moving images, rather than the current teaching college curriculum that assist teachers on how to support their live-lecture instruction with slide presentations, web-based activities, and online blogs.

When viewed through the lens of Christensen et al.'s (2008) disruptive innovation theoretical framework, screen-capture instructional technology is viewed as a threat to the current trajectory of the established industry. As a result, the industry does not want and can't use the innovation; in this case the screen-capture instructional technology. If implemented across the board and institutionalized at all secondary sites, screen-capture technology would displace live-lecture teaching practices and even the rapidly growing for-profit online curriculum industry. Just as personal computers were first rejected by the dominant mainframe computer industry channels of the early 1980's (Christensen et al), online instructional multimedia developed by the secondary classroom teacher has yet to be taken seriously as an accepted teaching practice. As a result, the technology will only gain acceptance in areas where the traditional live-lecture methodology can not accommodate. Under the disruptive innovation model, once the screen-capture instructional technology becomes accepted in these areas that traditional live-lecture teaching can not serve, only then will it permeate into mainstream teaching practices. Using the disruptive innovation model, once screen-capture instructional technology gains a foothold, it will forever change the established industry and ways of practice.

There will be a sequence of events necessary for screen-capture instructional multimedia to become ubiquitous in secondary education. The instructional technology will first need to fill a void where the classroom teacher's live-lecture instruction can not occupy. Using Christensen et al.'s (2008) disruptive innovation model, the steps to incorporate screen-capture instructional technology into the school environment are as follows. The first step to make screen-capture technology an accepted teaching practice within secondary education is to fill live-lecture's void of one-time only instruction. Each teacher would be required to use screen-capture instructional technology to capture all their live instruction and upload the digital files to web-based servers. The teacher's classroom instruction would thereby be available to their students outside of the classroom. In this initial phase, the teacher would not need to replace his/her live-lecture teaching practice. The second void in live-lecture teaching is with the students' inability to make-up their teacher's face-to-face instruction later in the classroom. This second step would allow students who missed a class to view the teacher's online instructional multimedia inside the classroom using multimedia devices. Once the first two steps have been successful and accepted by the teaching staff, school administrators, and community, the third void of replacing all live-lecture could be addressed.

As discovered in this research experiment, a teacher's online instructional multimedia delivered into the blended classroom can improve student cognition by providing students the ability to control the pacing and sequence of their instruction. Step three of the implementation plan would be to replace the entire teacher's live-lecture instruction with one-to-one instructional multimedia. Because step one and step two create the online infrastructure required for one-to-one computing, the procedure for implementing step three would only require the additional procurement of multimedia devices to establish a true hyper-blended learning environment. In addition, the teacher's classroom instructional multimedia would be readily available for students, fellow teachers, and parents as needed. As demonstrated in this experiment, once a hyper-blended learning environment has been established, an increase in student academic achievement can occur.

Conclusion

It has been estimated that "almost one-third of all public high school students in America fail to graduate" (Bridgeland, Dilulio & Morison, 2006). To overcome these deficiencies, enormous pressures from the state and federal governments are being placed on the K-12 public school system. Secondary schools throughout the United States continue to look for external solutions such as online curriculums and off-the-shelf instructional applications to solve their educational problems. In hopes of finding a quick and easy solution to this systemic problem, online instruction has been cast as education's new *silver bullet*, similar to past predictions of the radio, film, and television (Cuban, 2003). However, unlike these technologies, new schools are being built solely around online instruction practices, while traditional brick-and-mortar schools are replacing and reducing the role of the classroom teacher. Online instruction has been embraced as a solution to dramatically improve underperforming schools in the United States. Three quarters of K-12 school districts (74.8%) across the nation have introduced online curriculums and more than half of the remaining districts (15.0%) are planning to use some form of online instruction in the near future (Picciano & Seaman, 2009). Yet data demonstrating an increase in K-12 student achievement from canned online instructional content has not been forthcoming. In fact, The National Education Policy Center (2011) found considerable achievement gaps for students enrolled in the emerging sector of online schools (27.4%) when compared to students in traditional brick-and-mortal schools (58.4%) as indicated by their Adequate Yearly Progress (AYP) rating for meeting state standards.

Unlike the USED (2009) meta-analysis from a small corpus of studies that suggested an increase in academic achievement from blended learning over solely online instructional materials may be due to the additional learning time in the classroom and supplementary instructional elements, this study controlled for these variables. This experiment incorporated a hyper-blended learning model where all of the teacher's live lessons were entirely transformed into instructional multimedia and delivered online into the classroom. The students in this study were provided with the same amount of classroom time, with the only variable being the instructional delivery method and increased one-to-one assistance. It was revealed by the screen-capture students and the classroom teacher that the improved learning resulted from a more efficient use of the students' time from their ability to control the lessons pacing, rather than additional instruction time. When placed in the context of accountability requirements for secondary educators, this study suggests that capturing a student's familiar teacher as an online pedagogical agent can be used toward establishing a blended learning environment without radically changing current teaching practices.

However, the notion of the students in this experiment improved their learning due only from their ability to control the teacher's instructional multimedia might be somewhat simplistic. This study revealed there was far more than one factor responsible for the improved student comprehension and engagement from the screen-capture instructional multimedia. For example, the development of the instructional multimedia incorporated CTML, encompassing the multimedia principle, cognitive load theory, and active processing system. The CTML was most evident as the teacher became an audio and visual pedagogical agent within the students' instructional multimedia. In addition, prior to implementing the instructional technology in the classroom, the teacher had a new tool to improve the content of her instructional multimedia. Self-assessment was easily available to the classroom teacher from the screen-capture instructional technology and she was also able to receive feedback on her instructional multimedia by collaborating online with her fellow teacher.

Not to be dismissed, 93% of the students indicated they wanted more of the multimedia Algebra lessons, which were developed by their teacher using the screen-capture instructional technology. Once the experiment was implemented into the classroom, the screen-capture students frequently commented on the lack of disruptions by their classmates, thereby facilitating an easier environment for the classroom learners to focus on the instructional multimedia. Also, the students found their new blended classroom a less threatening atmosphere. Students were able to have discreet face-to-face conversations about the instructional content with their teacher and peers. In addition, the classroom teacher was constantly available for face-to-face assistance. And just as important, the screen-capture students were able to view each lesson before and after class, while receiving additional instruction at home from their parents as needed.

As discussed throughout the previous chapters, there is little reliable data that demonstrates off-the-shelf or canned online instructional multimedia can be used in the secondary classroom to increase student cognition. Ill-informed and technologically stolid policy makers, academic administrators, and IT departments are rushing to purchase online packages and computer application packages to be accessed on multimedia devices with ever decreasing public school funds in the delusion of meeting and surpassing state and federal testing requirements. Without sufficient data measuring K-12 student academic achievement with these new technologies, secondary schools are incorporating online instruction as an alternative to the traditional teaching practices of classroom teachers. With little to no regard for their skill-set, many classroom teachers are being relegated to passive observers and proctors in computer labs devoted to providing third-party online instructional materials.

Instead of purchasing computer-based instructional materials, local school administrators and academic policy makers can look to improve academic achievement by investing in their current teachers and instructional resources within their academic institutions. This study has demonstrated that capturing the teacher's lesson in a manner that reduces the student's cognitive load from a digital whiteboard combined with the instructor's voice and image as a pedagogical agent, is an effective cognitive tool for classroom instruction. The introduction of classroom instruction based on screen-capture instructional technology would enable teachers to improve student academic achievement by expanding their pedagogy into the online and blended realm. Readily available hardware, such as electronic whiteboards, wireless modems, and mobile multimedia devices, can be used to support this cognitive tool. By incorporating screen-capture instructional technology, the collaboration of content knowledge and instructional strategies from the site's staff and academic administrators could be brought into a teacher's curriculum for the purposes of improving student learning.

The transition for teachers to incorporate screen-capture instructional technology as a cognitive tool is far more than the pen to word processor analogy. The change from the live-lecture format to instructional technology is most similar to transitioning from scribbling instruction in sandy shores to teaching from a textbook. Secondary classroom teachers, such as the teacher is this study, are overly dependent on the live-lecture format's use of a whiteboard, only to erase their instructional markings moments later. When teachers transfer their live-lecture into instructional multimedia, they, in turn, transform themselves into pedagogical agents within the students' online instruction. Once teachers have augmented their traditional classroom live-lecture methodology into the digital realm, students will have empirically proven cognitive tools necessarily to compete and succeed in the twenty-first century global workforce.

Technologically savvy students have grown accustomed to accessing information instantaneously and repeatedly on their own terms. For teachers and academic administrators to reach the current and next generation of secondary students, they must begin to see the world from the students' perspective. Fortunately, screen-capture instructional technology works in tandem with this generation's desire and ability to constantly acquire information from their personal electronic devices. Rather than ignore their students determination to be perpetually *plugged-in*, screen-capture technology can bridge the digital divide between educators and students, all the while improving students' academic achievement. Considering the students' improved math scores, their increased level of cognitive and psychological engagement, and their overwhelming preference toward the teacher's multimedia curriculum, academic institutions and policy makers can successfully reach secondary students in the digital world they inhabit by incorporating screen-capture instructional technology into secondary education.

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Appendix A

Teacher Daily Survey **Yellow = Period 2 / Blue = Period 6** **October ___, 2011**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

1. Today's lesson successfully demonstrated all the new math concepts I intended to teach my students.	1	2	3	4	5
2. The instructions given in today's lesson were clear and easy for my students to understand.	1	2	3	4	5
3. The pacing of today's lessons was too slow.	1	2	3	4	5
4. The pacing of today's lessons too fast.	1	2	3	4	5
5. Today's lesson successfully transitioned from the pervious lesson.	1	2	3	4	5
6. I was able to answer all individual questions from my students during class.	1	2	3	4	5
7. When my students were doing their math work, they checked to see whether they understood what they were doing.	1	2	3	4	5
8. After finishing their math work, my students checked their work over to see if it was correct.	1	2	3	4	5
9. Students were working hard.	1	2	3	4	5

10. Things I liked about the teaching of today's lesson were:

A)

B)

C)

11. Things I did not like about the teaching of today's lesson were:

A)

B)

C)

Appendix B

Student Survey - Chapter 5

Directions: Please take your time and read each question carefully. Circle the number that best describes how you feel about each question. **Please answer all the questions**.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

1.	I understand all the new math concepts taught in Chapter 5.	1	2	3	4	5
2.	The Chapter 5 math teaching was clear and easy to understand.	1	2	3	4	5
3.	The pacing of the Chapter 5 instruction was too slow.	1	2	3	4	5
4.	The pacing of the Chapter 5 instruction was too fast.	1	2	3	4	5
5.	Each day's instruction successfully transitioned from the previous day's instruction.	1	2	3	4	5
6.	My math teacher was able to answer all my questions during class.	1	2	3	4	5
7.	When I do my math work I check to see whether I understand what I'm doing.	1	2	3	4	5
8.	After finishing my math work I check it over to see if it's correct.	1	2	3	4	5
9.	When I do well in this math class, it's because I work hard.	1	2	3	4	5
10.	This math class does a good job of measuring what I'm able to do.	1	2	3	4	5
11.	Most of what is important to know you learn in this math class.	1	2	3	4	5
12.	What I'm learning in this math class will be important in my future.	1	2	3	4	5

Student Survey - Chapter 5 (continued)

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

13. Learning math in this class is fun because I get better at something.	1	2	3	4	5
14. I feel like I have a say about what happens to me in this class.	1	2	3	4	5
15. Going to school after high school is important.	1	2	3	4	5
16. This math class is important for achieving my future goals.	1	2	3	4	5
17. This math education will create many future opportunities for me.	1	2	3	4	5
18. I am hopeful about my future.	1	2	3	4	5

19. Things I liked about the teaching of Chapter 5 were:

A)

B)

C)

20. Things I did not like about the teaching of Chapter 5 were:

A)

B)

C)

Appendix C

The following questions are asking about your Chapter 5 online lessons

Please take your time and answer each question carefully. Please answer all the questions.

21. Overall, do you feel the online math lessons improved your learning?

Yes ☐ No ☐

22. Please explain your selection:

A)

B)

C)

23. If you had to learn math in the future, which method would you prefer?

Regular Teaching ☐ Depends ☐ Teacher's Online Lesson ☐

24. Please explain your selection:

A)

B)

C)

25. What is it about the teacher's online lessons you prefer?

A)

B)

C)

26. What is it about the teacher's online lessons you do not prefer?

A)

B)

C)

27. What is it about the regular math teaching you prefer?

A)

B)

C)

28. What is it about the regular math teaching you do not prefer?

A)

B)

C)

29. Would you prefer to have watched all the online lessons as homework instead of as classwork?

Yes ☐ No ☐

30. Please explain your answer:

A)

B)

C)

31. Did you have any problems that made it difficult to learn the online lessons?

Yes ☐ No ☐

32. If there were problems that made it difficult to learn from the online lessons, what were they?

A)

B)

C)

33. Would you like your teacher to make online lessons for another math chapter?

Yes ☐ No ☐

Directions: *Please take your time and answer each question carefully. Circle the number that best answers each question. Please answer all the questions.*

Never	Once	Twice	Three Times	Four or More
0	1	2	3	4

34. On average, how many times did you pause each online lesson?	0	1	2	3	4
35. On average, how many times did you re-watch each online lesson to solve the workbook problems?	0	1	2	3	4
36. On average, how many times did you use your notes to solve the workbook problems?	0	1	2	3	4
37. For Chapter 5, how many times did you post an online comment?	0	1	2	3	4
38. For Chapter 5, how many times outside of school did you watch the online lessons?	0	1	2	3	4
39. For Chapter 5, how many times while at school did you watch the online lessons before or after class?	0	1	2	3	4
40. For Chapter 5, how many times did you watch the online lessons on your own mobile device?	0	1	2	3	4
41. For Chapter 5, how many times did your parents view the online lessons?	0	1	2	3	4
42. How many times did you re-watch part of the online lessons to study for the final test?	0	1	2	3	4
43. How many times did you use your notes to study for the final test?	0	1	2	3	4

Appendix D

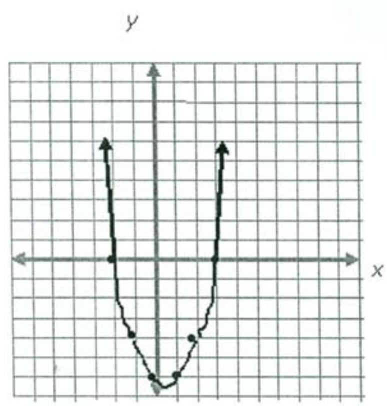
Name: ________________________ **Period:** __________________ **Grade level**_________

Repeating Algebra 2 circle one Yes No

Algebra 2 Chapter 5 test **No Calculator** **No Notes** **Form A**

Multiple Choice

Identify the choice that best completes the statement or answers the question.



____ 1.

Use the graph to determine the solution(s) of $x^2 - x - 6$

A. 3, -2
B. .5, -6.25
C. -3,-2
D. -3, 2

____ 2. *Which ordered pair is the vertex of* $f(x) = x^2 + 6x + 5$?

A. $(-1,0)$
B. $(-3,-4)$
C. $(-2,-3)$
D. $(0,5)$

____ 3. *Write a quadratic equation with the given roots. Write the equation in the form* $ax^2 + bx + c = 0$, *where a, b, and c are integers.*

–5 and 2

A. $x^2 - 7x + 10 = 0$
B. $x^2 + 7x + 10 = 0$
C. $x^2 - 3x + 10 = 0$
D. $x^2 + 3x - 10 = 0$

____ 4. *Write a quadratic equation with the given roots. Write the equation in the form* $ax^2 + bx + c = 0$, *where a, b, and c are integers.*

$-\frac{3}{2}$ and –3

A. $2x^2 + 9x + 9 = 0$
B. $2x^2 - 9x - 9 = 0$
C. $x^2 + 9x + 9 = 0$
D. $x^2 + 9x - 9 = 0$

____ 5. *What are the roots of the quadratic equation* $2x^2+3x-14=0$?

A. $\{-4, -\frac{7}{2}\}$
C. $\{-4, 7\}$
B. $\{-\frac{7}{2}, 2\}$
D. $\{2, 7\}$

____ 6. *Simplify* $(2i)(-3i)(4i)$

A. -24
C. $24i$
B. $-24i$
D. 24

____ 7. Find the x-intercepts for the equation. $x^2+2x-3=0$

A. $\{-3, 1\}$
C. $\{-6, 1\}$
B. $\{-6, 2\}$
D. $\{-1, 3\}$

____ 8. *Find the exact solution of the following quadratic equation.*

$x^2-8x=20$

A. $\{-10, 2\}$
C. $\{-4, 20\}$
B. $\{20, 28\}$
D. $\{-2, 10\}$

____ 9. *What are the solutions to the equation* $x^2+2x+2=0$?

A. $x=0,\ x=-2$
C. $x=0,\ x=-2i$
B. $x=-1+i,\ x=-1-i$
D. $x=-1+2\sqrt{2},\ x=-1-2\sqrt{2}$

____ 10. Consider the quadratic function $f(x)=-2x^2+2x+2$. Find the *y*-intercept and the equation of the axis of symmetry.

A. The *y*-intercept is 2.
The equation of the axis of symmetry is $x=-\frac{1}{2}$.

B. The *y*-intercept is $\frac{1}{2}$.
The equation of the axis of symmetry is $x=2$.

C. The *y*-intercept is 2.
The equation of the axis of symmetry is $x=\frac{1}{2}$.

D. The *y*-intercept is $-\frac{1}{2}$.
The equation of the axis of symmetry is $x=-2$.

____ 11. *What are the roots for the quadratic equation* $2x^2+7x-4=0$?

A. $x=\frac{1}{2};\quad x=-4$
C. $x=8;\quad x=1$
B. $x=-\frac{1}{2};\quad x=4$
D. $x=4;\quad x=-1$

____ 12. Jenny is solving the equation $x^2 - 8x = 9$ by completing the square. What number should be added to both sides of the equation to complete the square?

A. 2
B. 4
C. 6
D. 16

____ 13. What are the roots to the following equation $x^2 + 6x + 10 = 0$?

A. $x = 6 \mp 2i$
B. $x = -6 \mp 2i$
C. $x = 3 \mp 2i$
D. $x = -3 \mp 2i$

____ 14. What is the product of the complex numbers $(-4+4i)(-3-3i)$?

A. $16+12i$
B. $12+0i-12i^2$
C. $24+0i$
D. $12+0i+12$

____ 15. *Simplify* $\dfrac{3}{6+7i}$

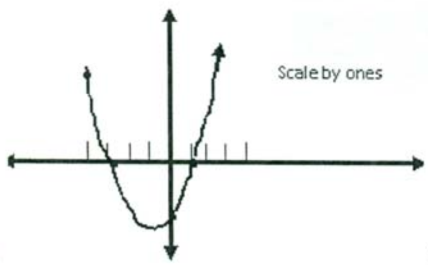
A. $\dfrac{18}{85}+\dfrac{21}{85}i$
B. $\dfrac{6}{85}-\dfrac{7}{85}i$
C. $\dfrac{18}{13}+\dfrac{21}{13}i$
D. $\dfrac{18}{85}-\dfrac{21}{85}i$

____ 16. *Simplify* $(7-4i)-(-3+6i)$

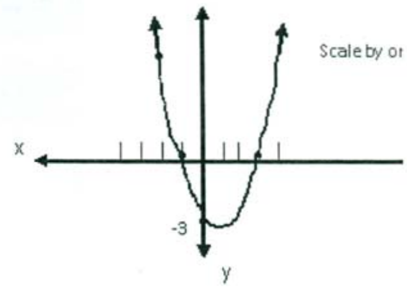
A. $4+2i$
B. $3+30i$
C. $4-10i$
D. $10-10i$

____ 17.

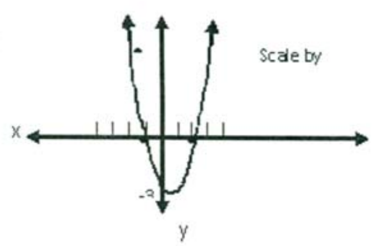
Which of the following represents the graph of: $y = x^2 + 2x - 3$
Note: Graphs are sketches except for x-intercepts



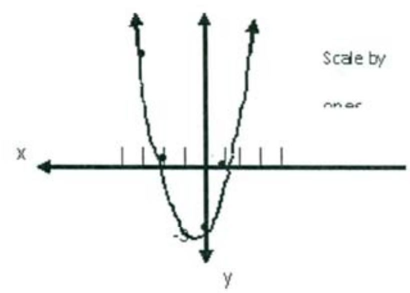
A.



C.



B.



D.

____ 18. *Simplify* $(11+i)+(3-15i)$

A. $14-14i$
B. $-4+4i$
C. $12-12i$
D. $14+16i$

____ 19. *Solve the following equation* $x^2+3x-28=0$

A. $\{-4, 7\}$
B. $\{-7, 4\}$
C. $\{4, 7\}$
D. $\{-4, -7\}$

____ 20. *What are the solutions to* $3x^2+3=7x$?

A. $x = \dfrac{7 \pm \sqrt{85}}{6}$
B. $x = \dfrac{-7 \pm \sqrt{85}}{6}$
C. $x = \dfrac{7 \pm \sqrt{13}}{6}$
D. $x = \dfrac{-7 \pm \sqrt{13}}{6}$

Appendix E

Final Teacher Interview

I want to thank you again for all your help in assisting me with my dissertation; I cannot begin to tell you how fortunate I am to have such a great participant. I am going to ask you a few questions about the study. None of your comments or answers will be associated with you in any way and you will remain completely anonymous. It is important that you answer the questions honestly. And please do not worry about offending me, as the information you provide is intended to be used to improve instructional practices.

1. What stands out the most from creating and instructing the online multimedia lessons?

2. During this study, how has creating and watching your multimedia content effected your lesson development?

3. During this study, how did your teaching experience differ with the control group when compared to your online class?

4. Was there anything from the experience of creating and instructing the online lessons that may change your future teaching practices?

5. Do you think this online multimedia technology is a good fit for most high school teachers?

6. What changes would be required to implement the online multimedia technology at your site and school district?

Appendix F

Teacher Interview Consent Form

I. Purpose

Jeffrey G. Smith has received permission from the Institutional Review Board (IRB) at Saint Mary's College of California to conduct the research study entitled, Screen-Capture Instructional Technology: A Cognitive Tool For Hybrid-Blended Learning

II. Participation in the Study

You have been asked to participate in this research study between the dates of October 4th and November 4th 2011. Participation in this study is voluntary.

III. Confidentiality

All information is confidential and will only be used for research purposes. Anonymity is assured as neither you or your students' names will not appear in any written reports that stem from data collected from the researcher.

IV. More Information

If you have questions or concerns about this study, please contact _Dr. Sawako Suzuki_ e-mail: ss12@stmarys-ca.edu and phone: 925.631.4465. If you have any questions about the human rights as a research participant, contact Ms. Emily Hause at irb@stmarys-ca.edu.

V. Informed Consent

If you have read and understood the information above and agree to participate in this research interview, print and sign your name below.

______________________________	______________________________
Name of Teacher (Please print)	Name of School
______________________________	______________________________
Teacher Signature	Grade Level/Subject
______________________________	
Date	