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The Effects of Flipped Learning on Middle School Students' Achievement with Common Core Mathematics

by

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Abstract

Common Core State Standards (CCSS) has caused K-12 math teachers to search for new pedagogical strategies to instruct their students. This study investigated whether a popular learning environment called flipped learning is a valuable instructional technique to be used with a seventh grade CCSS's math curriculum that emphasizes problem-based learning. Flipped learning is a form of blended learning that combines information and communication technology with instruction that switches the focus of the classroom instruction from one that is teacher-centered to one that is student-centered. Literature is limited with flipped learning being integrated in a K-12 math classroom. However, literature suggests that flipped learning and California CCSS Mathematics Framework share a commonality based on *technology-supported learning, student-centered* instruction,m and *problem-based learning* activities. This study used a quasi-experimental methodology with a repeated measures design to compare the effects flipped learning had on a group of middle school students' academic achievement in a seventh grade CCSS math class. The two cohorts' (control and intervention groups) results from three measures (pre-test and two post-tests) were analyzed using three analyses: t-test, difference in average scaled scores, and Repeated Measures Analysis of Variance to determine if there was a difference in performance. Though the findings show the effects of flipped learning were statistically insignificant, the results from this study still suggest that flipped learning is equally an effective learning environment for student-centered instruction and/or blending other learning environments for K-12 teachers.

Keywords: Common Core State Standards, flipped learning, math, middle school, problem-based learning, repeated measures, student-centered, technology-supported learning

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Chapter One: Definition of Problem

The adoption of the Common Core State Standards (CCSS) in math classes throughout California has redefined how educators instruct their students in the classroom. The new K-12 state standards have caused teachers to look for new pedagogical strategies to instruct their students. According to the California State Board of Education (2013), students are expected to interact with each other and solve real world problems, and teachers are expected to provide learning environments that are student-centered and provide access to information and communication technology (ICT). Students are expected to develop problem solving skills and apply these skills to develop a stronger conceptual understanding of math and mastery of the skills. The issue for today's teachers is that using traditional classroom teaching strategies will not satisfy the learning expectations of the new standards that require teachers to provide instruction and classroom time in order for students to develop a deeper level of understanding of content so that they may develop a stronger mastery of essential math skills (Bergmann, 2013, August 13). Traditional forms of classroom instruction limit the interaction between students, favoring only student-teacher interactions.

Newer forms of instruction, such as problem-based learning, satisfy certain components of the new learning expectations of the standards (California State Board of Education, 2013). Problem-based learning provides a learning environment for students to develop conceptual understanding of math content but requires students to develop new skills to learn it. Additionally, problem-based learning requires students to already possess problem-solving skills in order to learn a lesson's content and does not focus on the procedural skills. Students struggle with learning the content because they lack learning strategies to manage the problem-based activity (Cerezo, 1999). CCSS for mathematics urges educators to search for new instructional techniques to help students develop their problem solving skills, enhance their conceptual understanding, and master multiple procedural skills.

Blended learning offers a solution for the issue, as its practice incorporates well with the new learning expectations defined by the California CCSS Mathematics Framework. Blended learning offers teachers the ability to incorporate multiple instructional strategies to address CCSS's student learning expectations. Blended learning represents more than one combination of pedagogies. "A typical blended learning model may contain two or more techniques with different approaches" (Köse, 2010, p. 2794). This broad definition of blended learning assists teachers with developing a learning environment to address the learning expectations defined by the California CCSS Mathematics Framework. Blended learning does not require educators to focus on using one specific form of instructional technique with their students; rather they can incorporate new teaching strategies with traditional teaching strategies to help students develop problem solving skills and greater mastery of math skills. When educators use blended learning, they have the ability to make adaptations based on the students' learning needs (Garrison & Anderson, 2000; Strayer, 2012).

More popular forms of blended learning incorporate information and communication technology (ICT). According to Spencer (2013), ICT supports blended learning because it creates a link between what is occurring in class and what is occurring at home and vice versa. Several studies on blending ICT with problem-based learning (PBL) concluded that the two complemented each other; furthermore, these studies concluded that blending ICT with other non-problem-based learning pedagogies could either enhance or disrupt the effectiveness of an educator's instruction (Donnelly, 2010; Garrison & Anderson, 2000). Their analysis suggested that educators must find the right combination of technology and instruction to blend in order to be successful with addressing student learning expectations as described by the California CCSS Mathematics Framework.

Flipped learning is a form of blended learning that combines ICT with instruction that is the reciprocal of the form of learning students typically engage in the classroom. Flipped learning, previously called “inverting a classroom,” switches the focus of the classroom from one that is teacher-centered to one that emphasizes problem-based learning (PBL). The *flipping* occurs when the direct instruction and/or lectures are viewed at home through online videos before the lesson. As a result, more time in the classroom is allocated for instructional activities that necessitate student collaboration and application of concepts learned from the online videos. Previous research determined flipped learning was the preferred learning environment for college students when compared to traditional forms of instruction, such as lectures and direct instruction. Strayer’s (2010) mixed methods study found that college students, who were instructed using flipped learning, preferred the instruction because it instigated more innovative thinking and collaboration. Butt’s (2014) survey of flipped learning found that college students, who were taught in flipped learning business classes, believed it was beneficial to their learning. Moreover, Findlay-Thompson and Mombourquette’s (2014) case study interviews revealed that college students in a business class had a better learning experience with flipped learning instruction.

Previous research has demonstrated that flipped learning is an overall preferred learning environment for university students, when compared with traditional forms of instruction. There is a lack of research on flipped learning in K-12 schools. The issue for public school teachers is establishing a learning environment that blends ICT, traditional forms of instruction, and student-centered instruction that work harmoniously with the California CCSS Mathematics Framework and curricula. K-12 teachers are searching for a blend of instructional techniques to improve their students' problem solving skills, enhance their conceptual understanding, and master their procedural skills with their current CCSS curriculum. In particular, previous research is limited in the scope of middle school math and has not determined whether flipped learning blends well with the CCSS curriculum, leaving today's middle school teachers with inconclusive evidence when considering a flipped learning environment in a middle school math classroom.

Purpose of Research

The purpose of this study was to analyze the effects of a currently popular form of blended learning called flipped learning on a population of seventh grade math students. This study investigated whether flipped learning is a valuable instructional technique to be used with a seventh grade CCSS's math curriculum that emphasizes PBL. As previous studies have not investigated whether flipped learning is a successful instructional technique to blend with seventh grade CSSS curriculum, it is crucial to determine whether blending ICT with the problem-based curriculum will function in harmony with student learning or serve as a disruptive element in their learning process. This study provided teachers with a quantitative perspective of the effectiveness of flipped learning and feedback that could help improve their own pedagogy with teaching seventh grade CCSS math curriculum.

Research Questions

The main research question for this study was: What effects does *flipped learning* have on seventh grade students' achievement in mathematics delineated in CCSS? The sub-question of the research was: Do students in a flipped learning environment perform better than students in a non-flipped learning environment with CCSS problem-based curriculum?

Preview of Literature

Chapter Two reviews the literature on three themes: blended learning, flipped learning, and videos as a supportive instructional tool. The purpose of the review of literature is to demonstrate the similarities the three themes share with the California CCSS Mathematics Framework for teacher instruction and explain how the current research with K-12 mathematics supports these similarities. Blended learning combines instruction that engages students in the lesson's activity and encourages them to use problem-solving skills with ICT as a supportive tool (Akkoyunlu & Yilmaz-Soylu, 2008; Donnelly, 2010; Gerbic, 2011; Köse, 2010). Unfortunately, effectively blending problem-based learning instruction with ICT is highly ambiguous (Oliver & Trigwell, 2005). Flipped learning alleviates this issue because it defines how ICT and classroom instruction can work harmoniously with problem-based CCSS curriculum. Previous literature describes the instructional strategies of flipped learning as promoting greater interaction among students and engaging them to use their problem-solving skills (Butt, 2014; Strayer, 2012; Winter, 2013). Additionally, the results from recent studies revealed that students overly preferred flipped learning in K-12 math classes because they have the ability to interact with their peers during a lesson and the instructional videos provide more of an individualized form of learning (Coufal, 2014; Schmidt, 2013; Wiginton, 2013). Videos employing flipped learning can effectively bridge the gaps inherent to direct instruction in the classroom by being available online for students to prepare for a new lesson. Videos can also clarify students' misconceptions before they engage in a problem-based learning activity in the classroom (Lawson, Bodle, & McDonough, 2007).

Chapter Two identifies three meaningful associations between the California CCSS Mathematics Framework's recommended instructional practices and the instructional practices found in the themes of blended learning, flipped instruction, and the use of videos as an instructional tool. The three meaningful associations are: 1) *technology-supported learning*, 2) *student-centered* instruction, and 3) *problem-based learning* activities. For the purpose of this research, *technology* represents information and communication technology (ICT), which encompasses a wide variety of online communication tools (Voogt, Knezek, Cox, Knezek, & Brummelhuis, 2013). Student-centered instruction requires the teacher to adopt the role of a facilitator, keeping students on point so that they can become active learners through their interactions with each other (Watson, 2008). Problem-based learning (PBL) is a method by which students analyze, collaborate, or debate to solve a multifaceted problem (Cerezo, 1999). It requires students to develop problem-solving skills to tackle these types of problems.

Preview of Methodology

This study used a quasi-experimental methodology to determine the effects of flipped learning instruction on a sample of seventh grade students (n=112) in a CCSS classroom at a middle school in California. The study used a cohort design with repeated measures and was conducted over an eight week timeline. Two cohorts of seventh grade math students were chosen for the flipped learning investigation because they had Internet access at home and the ability to wholly participate in the study using the flipped learning intervention. The two cohorts of students were comprised of four seventh grade math classes. The participants completed a pre-test in order for their pre-test results to establish a baseline and attempt to minimize the difference between the intervention group and the control group. Two of the four classes (n= 59) participated in the flipped learning intervention, while the other two classes (n= 58) were assigned as the control group. However, the sample size would change by the end of the study for analysis. Both cohorts were taught by the researcher the College Preparatory Mathematics (CPM), which was aligned with CCSS. The instructional strategies that the intervention group received included the following: online instructional videos, guided questions, online discussion forum for the guided questions, and a review of the videos and the guided questions at the beginning of next day’s class. The intervention and control groups completed two post-tests. The first post-test was administered after four weeks of the implementation of the flipped learning intervention, and the second post-test was administered at the end of the eight week study. The intervention group’s and control group's pre-test and two post-test results were used for the analysis. As a means to determine the impact flipped learning has on students' learning of CCSS mathematics, three analyses were conducted: (a) initial analysis using difference in average scaled scores (b) an Repeated Measures Analysis of Variance (pre-test, post-test one, and post-test two), and (c) a series of t-tests to compare the two groups' performance on the pre-test and two post-tests.

Significance of Research

The aforementioned research has investigated university students’ preference between traditional, teacher-centered instruction versus flipped learning instruction; however, previous research has not examined the effects of flipped learning instruction with problem-based CCSS curriculum in a middle school classroom setting. This study will add to the growing research on the use of ICT to supplement learning outside the classroom, the adaptability of flipped learning in a middle school classroom with other learning theories such as PBL, and strategies that address the pedagogical expectations described in the California CCSS Mathematics Framework. Furthermore, this study is differentiated from previous studies based on the form of data collected. While the results of the aforementioned research were based on data collected from the students' responses on their learning preferences, this quasi-experimental study's results were based on the impact of the flipped learning intervention on the performance of a population of seventh grade students using a cohort design. This cohort design and two-part analysis investigated the effects the flipped learning intervention has on the participants over time. This is a favorable design to measure the effects of the flipped learning intervention, because influences of the intervention may not be apparent at the beginning of study.

Summary of Chapter

The current CCSS education reforms occurring in United States require educators to shift their pedagogy to address the new level of expectations for student learning (California State Board of Education, 2013). The purpose of the study was to provide insight into a popular pedagogy and determine whether flipped learning harmoniously integrates ICT with CCSS instruction where the focus is on students developing and using problem-solving skills. Current literature suggests that flipped learning is a valuable form of instruction that allows students to gain deeper levels of understanding of the subject matter. What has not been established, however, is whether flipped learning will provide teachers with the ability to give quality instruction based on the California CCSS Mathematics Framework. Chapter Two establishes the platform for this quasi-experimental, quantitative research by connecting characteristics established in previous literature with characteristics found in the California CCSS framework for quality instruction. Chapter Two poses the argument: Positive instructional qualities of flipped learning can be found in both recent literature and in the California CCSS framework, making flipped learning instruction worth establishing its effectiveness within the arena of student learning and CCSS math curriculum.

Definition of Terms

Active-learning - "[A]ctive learning is that the students are engaged, either individually or in groups, and on their own manipulate the information and concepts they have learned in novel ways" (Winter, 2013, p. 6).

Blended learning - Blended learning is the combination of face to face instructional strategies and ICT instruction strategies (Akkoyunlu & Yilmaz-Soylu, 2008; Donnelly, 2010; Gerbic, 2011; Köse, 2010).

CCSS – The Common Core State Standards are the current education content standards for California in K-12 education (California Department of Education, 2013).

CPM- College Preparatory Mathematics is a non-profit educational group managed and staffed by middle school and high school teachers that offers a complete mathematics program for grades six through twelve (CPM Educational Program, 2014).

E-learning- Online or web-based learning (Köse, 2010).

Flipped learning - Flipped learning, previously called inverted classrooms, switches the focus of the classroom from being one that is teacher-centered to one that is student-centered and emphasizes on problem-based learning. The flipping occurs when the direct teaching or lectures are completed at home through various forms of recorded material that students can access online. More time in the classroom is spent with problem-based learning, allowing the students to enhance their level of understanding of a concept that was initially introduced at home for homework (Strayer, 2012).

ICT - Information and communication technology represents a wide variety of communication tools used online (Voogt et. al., 2013).

Passive-learning – "Passive-learning could be described as learning that only involves the recording of information by the student's brain, but no active application of that information" (Winter, 2013, p. 5).

PBL- "Problem-based learning (PBL) is a process by which students encounter ill-structured problems in which they must use knowledge they have, decide upon what additional knowledge they need, and then seek out the answers step-by-step to find a solution to the problem" (Cerezo, 1999, p. 1).

Student-centered- "A shift from lecture- to student-centered instruction in which students become active and interactive learners (this shift should apply to the entire course, including face-to-face contact sessions)" (Watson, 2008, p. 6).

Web 2.0 - "Web 2.0 is the second generation of the Web assembling interactive, online applications and systems that computer users can use to form and share information, communicate with other users and adjust electronic content according to their needs" (Kőse, 2010, p. 2795).

Chapter Two: Literature Review

The transition to common core state standards (CCSS) has caused teachers to adjust their pedagogy and search for new strategies to provide a meaningful instruction that deepens students' understanding of math concepts. The California State Board of Education (2013) considers that math instructional models should consist of techniques that engage students in collaborative learning, develop problem solving skills, and integrate information and communication technology (ICT) tools to assist with their learning. One instructional technique, such as lectures or problem-based learning, will not foster the instructional model recommended by the California CCSS Mathematics Framework. Instead, teachers need to find the right combination of instructional techniques and ICT tools to form a blended learning model that is consistent with instructional recommendations specified in the California CCSS Mathematics Framework, and that enhances students' learning experience in the classroom. This study investigated a popular blended learning model termed as flipped learning that previous literature has determined as a preferred learning environment for students when compared to traditional forms of instruction (Butt, 2014; Fulton, 2012; Strayer, 2012). The primary intention of this study was to determine the impact of flipped learning on student's achievement in middle school CCSS math class. The secondary intention was to compare the achievement of students who partook in the flipped learning environment with the students who partook in the non-flipped learning environment.

Overview of the Context of Literature

The California CCSS Mathematics Framework's recommended instructional techniques parallel the instructional techniques of: *blended learning*, *flipped learning*, and the teaching tool *online instructional videos*. The parallels are *technology-supported learning*, *student-centered instruction*, and *problem-based learning* activities. This chapter will describe how these parallels demonstrate that flipped learning, a specific form of blended learning, changes how the teachers deliver instruction and how it can be adapted with other instructional methods, such as problem-based learning. The chapter will also discuss how online instructional videos can substitute certain instructional practices in the classroom. First, the review of literature will provide evidence in the way *technology-supported learning*, *student-centered instruction*, and *problem-based learning* activities can be blended together as a learning model similarly referenced by the California CCSS Mathematics Framework. Then evidence from the review of literature will provide an argument that flipped learning and online instructional videos can be a viable instructional strategy for educators to support student learning when integrating CCSS curriculum.

Blended Learning

Blended learning is more than a combination of pedagogies. “A typical blended learning model may contain two or more techniques with different approaches” (Köse, 2010, p. 2794). Teachers who use a blended learning model combine *face-to-face* instructional strategies with ICT-supported instructional strategies (Akkoyunlu & Yilmaz-Soylu, 2008; Donnelly, 2010; Gerbic, 2011; Köse, 2010). Students who participate in a blended learning environment experience learning in a traditional *face-to-face* classroom setting and also in an online setting called *e-learning*.

While there are numerous studies about successful *face-to-face* pedagogies, little has been discussed about *e-learning*. E-learning represents the learning experience that occurs when students use an ICT tool. E-learning alone changes the classroom environment strictly to an online learning environment and provides teachers the ability to individualize the instruction, because students can learn the content at their pace (Köse, 2010). Conversely, the disadvantage of *e-learning*-only instruction is that students do not experience the same beneficial social experience normally gleaned from collaborating or interacting with the teacher and fellow students (Köse, 2010). Teachers who combine classroom-learning with *e-learning* increase their choices of pedagogies and tools to use with a curriculum, and are able to continue the classroom learning beyond the limits of the classroom (Garrison & Kanuka, 2004). These options are beneficial for teachers because they can differentiate the instruction and provide a more individualized curriculum for each student.

The issue with blended learning is its ambiguity on what type of instruction is actually occurring (Oliver & Trigwell, 2005). By definition blended learning is a redundant term because it lacks descriptors, such as learning theories, or an instructional design that separate it from other pedagogies. It is difficult to substantiate blended learning instruction from other instructional methods, because of its ability to incorporate other instructional designs. However, blended learning's ability to incorporate multiple instructional designs renders it as a valuable tool for teachers. Its ambiguity allows teachers to morph it into a pedagogy that creates a productive learning environment for students. Teachers are able to incorporate the suggested instructional practice found in the California CCSS Mathematics Framework using a blended learning environment. Researchers do agree that implementing a blended learning model with *problem–based learning* (PBL) activities in class and that integrating *information and communication technology* into the instruction can create a *student-centered* learning environment (Akkoyunlu & Yilmaz-Soylu, 2008; Donnelly, 2010; Gerbic, 2011; Köse, 2010).

The following sections will describe PBL in K-12 mathematics classes, followed by a discussion on blending technology and student-centered learning.

Face-to-Face Instruction in Blended Learning

The malleability of blended learning in a classroom environment allows teachers to incorporate certain instructional strategies that are effective with student learning. Blended learning can be transformed into a learning environment that is conducive to the instructional recommendations of the California CCSS Mathematics Framework. The California State Board of Education (2013) believes that teachers using common core math instruction are expected to create a classroom environment for students to share, debate, and discuss their reasoning. This requires students to collaborate and interact with each other and the teacher, which is not the teacher's focus using traditional classroom math instruction. The teacher is the sole distributor of knowledge in a traditionally instructed math class (Köse, 2010). Common core instruction in a classroom environment has shifted how teachers deliver curriculum. Specifically, the teacher's role has transformed from the role of information deliverer to one of a facilitator, who engages students to interact with each other through debating, evaluating, and sharing their reasoning with the class (Bliuc, Goodyear, & Ellis, 2007; Gerbic, 2011; Köse, 2010). Past research of classroom depictions on blended-learning instruction demonstrate that the face-to-face communication in a blended-learning classroom is primarily student-centered (Bliuc, Goodyear, & Ellis, 2007; Gerbic, 2011; Köse, 2010).

Incorporating problem-based learning (PBL) in the face-to-face facet of blended learning increases the amount of student-centered learning that occurs in the classroom. PBL requires students to take the lead with their learning as the teacher supports their learning process

(Cerezo, 1999). This pedagogy encourages students to collaborate while they undertake a mathematical investigation. Additionally, the California CCSS Mathematics Framework and PBL share the same instructional strategies for student learning. To deepen their understanding under PBL, students must debate and clarify their thinking with other students (California State Board of Education, 2013; Donnelly, 2010; Estes, 1999, August; Garrison & Kanuka, 2004). An issue with PBL is that students need to develop problem-solving skills and socially adjust for PBL to be an effective learning environment (Estes, 1999, August). PBL activities engage students to work in independent groups, solve problems, and then learn the specific problem-solving skills to complete mathematical investigations. This type of self-discovery is difficult for many students without practice. Research on PBL indicates that students need to socially adjust in order to collaborate and benefit from this learning model (Donnelly, 2010; Garrison & Kanuka, 2004). Hodges (2010) also believes, "[m]iddle school students specifically do not come to school equipped with the knowledge and skill set needed to solve problems" (p. 96). Students need time to adjust and build both collaboration and problem-solving skills, and confidence needed to succeed in this type of learning model.

Recent studies on integrating PBL in K-12 mathematics classes confirm the premise of students needing time to adjust to a higher cognitive demand in PBL. While the contexts of these studies on PBL are based on K-12 mathematics, they do not address CCSS or the changes of instruction with the adoption of the new standards within their research (National Governors Association, & Council of Chief State School Officers, 2014). Rodgers (2011) investigated the impact a hybrid model of PBL had on a high school remedial math class. The researcher determined there was no significant effect of PBL on one class of high school students' achievement, when compared to another class of high school students who received traditional instruction in the remedial math class. The students taught with traditional instruction performed significantly better on the assessments than the students who received the PBL instruction. Rodgers accredited this difference in performance to factors that students needed to adjust to this learning style. While this issue with integrating PBL is a concern, other recent research shows positive results with students adapting to PBL instruction in a math class, because of teacher's attitudes towards PBL, how it was implemented, and the teacher's level of experience. According to Boren's (2012) research, teacher's attitude and the design of the implementation were factors to the success of PBL. Boren also found that 2nd grade students were more engaged with their learning in a PBL environment due to the teacher's attitude towards PBL and how PBL was implemented in the classroom. Additionally, Shelvin-Boozer's (2015) research found teacher's experience with integrating PBL was another factor that impacted the success of integrating PBL. Shelvin-Boozer's (2015) research found that middle school students, who were unfamiliar with PBL instruction, struggled with math. However, the middle school teachers who were well versed with PBL instruction were able to meet the needs of the students who were struggling with the PBL lesson because these teachers were able to assess which groups needed interventions and which groups could continue working independently.

Overall, the commonality among these perspectives is that in face-to-face instruction in a blended learning environment the teacher's lecture should not dominate the class time in a math class (Boren, 2012; Rodgers, 2011; Shelvin-Boozer, 2015). Instead, math teachers, who incorporate student-centered PBL activities in a face-to-face blended learning environment, are in fact increasing student interaction and having students investigate real-world problems as described by the California CCSS Mathematics Framework. Additionally, K-12 math teachers need to provide tools that support student learning as recommended in the California CCSS

Mathematics Framework. Blending ICT tools with PBL instruction in K-12math class only strengthens the support system students need to adjust and benefit from this learning environment. “Together they (PBL and technology) can be seen as a formidable combination and this study has shown that they are approaches to learning that are complementary rather than collide” (Donnelly, 2010, p. 358). Additionally, blending PBL and ICT tools closely reflects the instructional practices recommended in the California CCSS Mathematics Framework.

Blending Technology

Blending technology, such as ICT, into a math curriculum also makes the learning more accessible for students. An inferred benefit for teachers who integrate technology into their instruction is that young Americans are truly digital natives. They spend more than seven and one-half hours a day online with some sort of electronic device (Bjorklund, Rehling, Tompkins, & Strom, 2012). Teachers using ICT, such as Web 2.0 applications, can support student-centered and problem-based learning. “Web 2.0 is the second generation of the Web assembling interactive, online applications and systems that computer users can use to form and share information, communicate with other users and adjust electronic content according to their needs” (Köse, 2010, p. 2795). Researchers agree that Web 2.0 tools support learning because they provide an avenue for students to collaborate and share knowledge online (Chen, Hwang & Wang, 2012; Köse, 2010). Web 2.0 tools provide both teachers and students similar instructional strategies and respective student activities as found in the recommended instructional practices described in the California CCSS Mathematics Framework (California State Board of Education, 2013). ICT supports student learning by extending learning strategies that occur both inside and outside the classroom. Spencer’s (2013) research findings concluded that ICT and face-to-face instruction increased student engagement and construction of new knowledge and skills, because it opens up student discussion beyond the traditional classroom setting. The integration of ICT in blended learning extends the *student-centered* learning beyond the scope of the California CCSS framework because the instruction continues online at home.

Blending technology with face-to-face instruction is more than transforming part of the classroom lecture to an online lecture (Donnelly, 2010). Using ICT in a blended learning environment supports the student-centered learning environment in the classroom. According to Spencer (2013), ICT supports blended learning because it creates a link between what is occurring in class and allows it to continue at home and vice versa.

Flipped Learning

There are many different interpretations of flipped learning, but like blended learning, it has evolved to compliment the expectations of 21st century education (Winter, 2013). Previously referred to as "inverted classroom," flipped learning switches the format of a traditional classroom. According to Fulton (2012), "The 'flipped part' of the flipped classroom means that students watch or listen to lessons on video at home and do their 'homework' in class" (para. 1). According to Lage, Platt, and Treglia (2000), "Inverting the classroom means those events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (p. 32). The researcher's depiction of flipped learning shows that flipped learning enables classroom time allocated to student homework, where the students can work independently, have the teacher lead through direct instruction, or collaborate to complete tasks (Fulton, 2012; Lage, Platt, & Treglia, 2000). However, how a teacher uses the classroom time with the students is what defines flipped learning. For Strayer (2012) and Butt (2014), flipped learning occurs when the independent student activities (such a reading or taking notes) or instruction that places the teacher as the source of learning (such as traditional instruction) is flipped. This provides more time for rigorous activities that require students to collaborate and deepen their understanding.

Research is limited with flipped learning in K-12 mathematics; however, three studies on flipped learning in three secondary education mathematics classes support Strayer's and Butt's interpretation of flipped learning. Firstly, Schmidt's (2013) research concluded that students in grades fourth through eleventh preferred the traditional instruction to be placed online, because they were able to review the materials multiple times to create a better understanding and work more efficiently. Classroom time was used for students to collaborate as teachers facilitated learning. Secondly, Coufal's (2014) interviews with eighth grade math students and teachers provided an insight into what they perceived how classroom time should be used with flipped learning. The students appreciated the classroom time because they felt prepared and were given either individual attention by their teacher or given projects that challenged their understanding. The teachers believed that the students were given more opportunities to collaborate. The teachers gave individualized attention to struggling students because they were prepared to ask questions about the concept from the flipped learning videos. Finally, Wington's (2013) mixed-methods study with integrating flipped learning with ninth-grade Algebra I recommended that teachers should include classroom activities that encourage students to collaborate and use their critical thinking skills with flipped learning. All three studies included teachers who used ICT tools to flip the traditional instruction. ICT tools can provide a collaborative environment for these rigorous learning activities.   Köse (2010) stated that technology cannot replicate the level of student interaction that occurs in the class. It is important how teachers interpret flipped learning for their instruction to be effective. How the classroom time is used is what defines flipped learning. Classroom activities that engage students with student-centered, problem-based learning activities that require students to collaborate and deepen their understanding of the lesson content define flipped learning (Butt, 2014; Findlay-Thompson, & Mombourquette, 2014; Strayer, 2012).

Issues with access to technology with flipped learning, the format of the flipped learning pedagogy, and student adaptation to the flipped learning instruction have been noted by past research. Firstly, in a flipped learning classroom, students are required to have home access to the Internet and a computer to complete homework assignments. This can create a digital divide among the upper and lower classes (Findlay-Thompson & Mombourquette, 2014). The digital divide represents the social inequities between those who have access to the Internet and those who do not (Rouse, 2014, June). Secondly, researchers believe there is room for improvement in the pedagogy, such as scaffolding PBL activities, and providing classroom instruction that helps students develop and apply their problem solving skills (Butt, 2014; Strayer, 2012; Winter, 2013). Finally, students have to adjust to the new learning environment. Findlay-Thompson and Mombourquette (2014) stated, "students must overcome their reliance on traditional classroom teaching and be willing to accept the responsibility for self-learning that comes with a flipped [learning] class" (p. 66).

Like blended learning, flipped learning instruction is comprised of student-centered tasks, PBL activities, and ICT as a support tool that blends well with PBL instruction. Student-centered tasks, PBL activities, and ICT represent two forms of learning that take place in a flipped learning model. The current model of flipped learning separates student learning into two forms: active and passive (Butt, 2014; Winter, 2013). Active-learning represents instruction that requires students to collaborate on a PBL activity in the classroom (Butt, 2014; Winter, 2013). Passive-learning takes place at home and only involves the recording of information or memorization of information by students, but no active application of that information (Winter, 2013). The active part and passive part should complement each other in an effective flipped learning environment. The next sections discuss these two forms of student learning.

Active-Learning Instruction in Flipped Learning

Flipped learning instruction requires teachers to rethink the use of classroom time. Unlike other blended learning models, the face-to-face instruction is solely used for *active-learning* activities. Active-learning is student-centered and uses PBL activities to engage students. It also corresponds with the expectations in the California CCSS Mathematics Framework for instructional practices. Researchers Donnelly (2010) and Strayer (2012) believe that PBL activities integrate well with flipped learning. Issues with students adjusting to a PBL can be minimized because passive-learning, such as direct instruction, can be done at home, allowing more time to be dedicated to PBL in the classroom (Butt, 2014). Consequently, students are then prepared for the investigation, and classroom time is not spent on building an initial understanding in order to participate in the investigation. Also, students are more engaged with their learning because class time is dedicated to PBL to develop and hone their problem-solving skills. Researches in the secondary mathematics classes also support the reorganization of active and passive instruction in a flipped learning model. Wiginton's (2013) research found that the active-learning component of flipped learning was more effective in promoting academic achievement than passive-learning strategies with the Algebra I students. Coufal's (2014) interviews of eighth grade math students showed that the students felt prepared when they came to class and were more engaged. Class time was spent on application of the math concepts and skills in the videos that the students learned the day before. This application entailed student collaboration and completing projects during class time, and passive-learning activities and instruction were reassigned outside of the class.

Passive-Learning Instruction in Flipped Learning

Textbook reading, lectures, and direct instruction are all considered instruction that leads to passive-learning (Winter, 2013). Past forms of flipped instruction may have assigned students textbook reading, review of class notes, or complete a worksheet. Today, ICT or Web 2.0 tools are used to create online tutorials or lecture videos for students to access at home. Watching instructional videos at home without active interaction with the teacher and peers may seem ineffective, but students can gain the factual and procedural knowledge necessary for in-depth exploration in the next day's class. According to Winter (2013), "a foundation of facts is vital making passive-learning a necessary step in the learning process" (p. 6). Passive instruction becomes a subsequent prerequisite for active instruction in the classroom (Butt, 2014; Winter, 2013). Coufal's (2014), Schmidt's (2013), and Wiginton's (2013) studies with flipped learning in secondary education mathematics suggest the students felt prepared, more engaged, and created a level of independence with their own learning when compared to using passive instruction in the classroom. Teachers in each of the studies felt they were able to teach every student individually, because each student had personal access to the passive instruction and could access it anytime for reference.

What differentiates flipped learning instruction from other blended instructional models is that technology is used as a passive instead of an active-learning tool. Technology is not considered an extension or a continuation of instruction; instead, technology evolves passive-learning into a prerequisite that, in turn, fosters richer classroom learning results (Winter, 2013). Teachers can disseminate content online for students to view; students then review the content at home and prepare for the class instruction the next day.

Online Instructional Videos

Existing research on various forms of flipped learning has shown that many educators prefer using videos as the main source of delivery of instruction at home (Butt, 2014; Findlay-Thompson & Mombourquette, 2014; Lawson et. al., 2007; Strayer, 2012; Winter, 2013). Videos are considered a supportive ICT tool as stated in the California CCSS Mathematics Framework (California State Board of Education, 2013). Online instructional videos typically represent a recording of a lecture or a tutorial for students to view at home and prepare for the next day's lesson in class. Teachers are able to create a video lesson and provide online access for their students to view using various Web 2.0 tools.

In the past, the instructional videos were controlled by teacher and viewed in the front of the class. Past research demonstrated instructional videos were beneficial to student learning in a math class. Boster, Meyer, Roberto, Lindsey, Smith, Inge, and Strom's (2007) investigation of streaming instructional videos in the classroom from a web-based library to sixth and eighth grade students found that they yielded greater attainment of learning the math skills and concepts by watching the videos. What has changed from traditional video viewing is that students have individual access to the online instructional video and that they can interact with different parts of the video and control the pace and replay of content (Merkt & Schwan, 2014).

In a flipped learning environment, teachers have options with videos they can use with flipped learning. Teachers can assign students instructional videos from an online library, such as videos from the web-based tutorial program Khan Academy; or teachers can create instructional videos and have them hosted on YouTube for students to access. Web-based tutorial program videos are useful, but previous research has shown that they do not always work concurrently with the class lesson (Wiginton, 2013). This can be disruptive to flow of the classroom instruction. Alternatively, the leading trend with integrating instructional videos in flipped learning is teacher-created videos. Current research on flipping K-12 math classes has shown that teacher-created videos are far more effective because teachers can shape the videos to fit with the class lesson (Coufal, 2014; Schmidt, 2013; Wiginton, 2013). Specifically, Coufal's (2014) investigation of students' perceptions of the instructional videos in a flipped learning instructional model found that students perceived the teacher-created instructional videos as valuable to their math education. Students also believed their levels of engagement with learning from the instructional videos were overall higher than from being taught in the classroom through traditional classroom instruction.

Previous research findings demonstrate the benefits of the instructional videos. However, there is still an issue with the instructional videos (Boster's et. al., 2007; Coufal, 2014; Schmidt, 2013; Wiginton, 2013). Wiginton's (2013) interview with Algebra I students revealed that not all students liked the instructional videos because they could not ask clarification questions about the content of the instructional video. Though these videos solely may not reach the instructional goal set by the teacher, other strategies can be integrated with the instructional video to help guide the students when viewing. Merkt and Schwan's (2014) research on interactive (instructional) videos found that students benefited from the videos if they were provided guided questions that coincided with the video sequence. Lawson, Bodle, and McDonough's (2007) study also found that students benefited from watching a video if they were required to answer guided questions that were related to the video. These two studies demonstrated that additional learning strategies need to accompany the videos in order for students to be prepared for the next day's classroom activities.

Connections to Literature

Current research on flipped learning has shown that the learning environment engages students in student-centered activities by blending PBL with ICT, such as online instructional videos (Butt, 2014; Coufal, 2014; Findlay-Thompson & Mombourquette, 2014; Schmidt, 2013; Strayer, 2012; Wiginton, 2013;Winter, 2013). Flipped learning stems from blended learning, which demonstrates that they both share similar qualities. Both flipped learning and blended learning are subject to a wide variety of interpretations. These interpretations make flipped learning an adaptable learning environment. However, empirical studies are limited about flipped-learning instruction's potential in a middle school math class because the current form of this learning model is still in its infancy. Coufal's (2014), Schmidt's (2013), and Wiginton's (2013) research provide a glimpse of the potential of flipped learning, but all the researchers recommend more research to be completed on flipped learning. Additionally, these three studies did not explore flipped learning under the California CCSS Mathematics Framework, but the current literature suggests the two share a commonality based on specific instructional strategies. The blending of active-learning activities with passive-learning activities creates a student-centered learning environment similar to the suggested practices from the California CCSS math framework.

Conclusion

The lack of research concerning flipped learning with middle school math or its effectiveness with CCSS curriculum brings this study to the forefront with studies investigating the implementation of flipped learning in a CCSS middle school math class. However, previous literature has shown that flipped learning can possibly address the issue CCSS has created for teachers who are looking for new strategies to promote meaningful learning in middle school math classes. The student-centered instruction in the flipped learning model can create a meaningful learning environment that requires students to deepen their conceptual understanding. With the aide of online instructional videos, students are better prepared to develop problem-solving skills because classroom time is solely spent practicing these skills. This empirical study investigated the conjectures derived from the current literature on CCSS, blended learning, flipped instruction, and online instructional videos. Chapter Three will describe the quasi-experimental design used to determine the effectiveness of flipped learning on seventh grade students' academic achievement in CCSS mathematics class.

Chapter Three: Methodology

The adoption of the Common Core State Standards (CCSS) in mathematics has created an issue for teachers, because traditional instruction and newer forms of instruction cannot completely placate all of the recommended instruction techniques addressed in the California CCSS Mathematics Framework (Baker, 2012; Bergmann, 2013, August 13; California State Board of Education, 2013). The review of literature in Chapter Two has shown that flipped learning is a promising pedagogy for public school teachers that address the learning expectations explained in the California CCSS Mathematics Framework. The purpose of this research was to examine the effects of flipped learning on a population of seventh grade math students. The leading research question for this study was: What effects does *flipped learning* have on seventh grade students' achievement in CCSS mathematics? Additionally, the study investigate the sub-question: Do students in a flipped learning environment perform better than students in a non-flipped learning environment with CCSS problem-based curriculum?

Chapter three reviews: 1) the quasi-experimental research design, 2) the seventh grade participants, 3) the school setting and the importance of the setting, 4) using the Renaissance Learning STAR math test as the measure to evaluate the effectiveness of flipped learning, 5) the procedures for conducting this study, and 6) analysis process used to investigate the aforementioned research questions. This quasi-experimental study used a cohort design with repeated measures over an eight week period. A sample of seventh grade math students participated as the cohorts for this study at a California middle school. The Renaissance Learning STAR math test was used for data collection. The process for conducting this research began with administering the pre-test to identify the two cohorts from the sample of seventh graders: the intervention group and the control group. Additionally, the pre-test was used as a baseline to determine whether the intervention and control group had similar math skills at the beginning of the study. During the study, the researcher taught the two groups students with a unique curriculum, *College Preparatory Math* (CPM), *Core Connections, Course 2*. The students in each cohort were taught the same CPM curriculum with the exception of the intervention group receiving the flipped learning instruction. The two post-tests were completed by the participants at the midpoint and at the end of the study. The students' test scores were analyzed in three ways: creating a descriptive account of the control and intervention groups with the changes in average scaled scores from each testing time-point, an analysis of variance with multiple measures, and then followed with a comparison of the means of the pre-test and two post-test using multiple t-tests. A Bonferroni Correction was used to limit the probability of a significant result occurring by chance with the independent tests. At the closing of this study, a brief summary of the results and conclusion was given to the participating students and their parents.

Design

This quantitative study used a quasi-experimental cohort design with repeated measures to evaluate the effectiveness of using a flipped learning instruction with two seventh grade CCSS math classes. Two other classes were assigned as the control group. The timeline for this design entailed the researcher having five seventh grade CCSS math classes complete the pre-test to identify the two classes to be used for intervention group and two other classes to be used as the control group. This cohort research design was appropriate for this study because the impact of the flipped intervention is associated with time (Keselman et. al., 1998; Lamb, 2003, February; Taris, 2000). The effect of the flipped learning instruction would not accurately be known at the beginning of this study. Participants in the intervention group needed time to adjust to the new learning environment before the effects of flipped learning might be identified.

Table 1

Control Group's and Intervention Group's Percentile Ranking based on the Pre-Test

Percentile Ranking Distribution	Control Group Students	Control Group %	Intervention Group Students	Intervention Group %
Below 25th Percentile	14	23.7	11	19
25th to 49th Percentile	15	25.4	16	27.5
50th to 74th Percentile	16	27.2	20	34.5
75th and above Percentile	14	23.7	11	19
Total	59*	100	58*	100

Note: The rankings are based information from a Renaissance Learning Software's Summary Report similar to Appendix D, Figure D2. *Two students from the intervention group and three students from the control group were not able to complete the pre-test and were not used in this study.

At the beginning of this study, the control and intervention groups' scaled scores, average scaled scores, and their percentile rankings from the Renaissance Learning STAR math test (see Table 1) were used for identifying the participants for the control and intervention group and for the analysis. The flipped learning instruction was implemented with the intervention group, and then two post-tests were given to both the intervention and control group midway through the study and at the end of the study. A similar quantitative design was used by Malhiwsky (2010) to determine the impact Web 2.0 technology had on student achievement in a college-level Spanish class. Although Malhiwsky's study was a mixed-methods design, the quantitative portion of the study used a Repeated Measure Analysis of Variance (RMANOVA). The focus of the study was to compare four groups of students' academic achievement with a pre-test and a post-test. Two of the groups used Web 2.0 technology in the classroom, and the other groups did not using the Web 2.0 technology. Additionally, Shimazu (2005) used repeated measures in the form to determine the effectiveness of online supplements in a college-level Japanese language class. Shimazu (2005) administered multiple tests over a semester to create greater replication of the data in order to make plausible generalizations from the results. Finally, Winter (2013) used a design similar to Shimazu's and Malhiwsky's quantitative design piece to investigate the effects flipped learning had on a sample of college-level physics students' achievement in the class. Winters's study compared the achievement of one group of physics students taught with traditional lectures to another group of physics students taught with flipped learning instructional techniques. Malhiwsky's, Shimanzu's, and Winter's research designs influenced the experimental process the researcher chose to establish a cause and effect relationship between flipped learning and the students' academic achievement in math.

Participants

Table 2

Control Group's and Intervention Group's Independent T-test Analysis of the Pre-Test

Data	Control Group	Intervention Group
$\bar{x}$	757.02 ≈ 757	772.02 ≈ 772
SD	107.6	89.88
SEM	14.13	11.90
N	59*	58*
CI	95% Confidence Interval of the difference: From -21.66 to 51.66	
p-value	0.41.93	
t	18.504	

Note: $\bar{x}$ = mean or average scaled score from Renaissance Learning STAR math test. SD= standard deviation. SEM= Standard Error of Mean. N= Sample Size. CI= Confidence Interval. P= two-tailed P-value. t= calculated t-test. Adapted from GraphPad Prism [Computer software]. Home – graphpad.com. Retrieved April 2, 2015, from http://www.graphpad.com/ *Three students from each group were unable to complete the pre-test

This sample selection process was based on convenience because the sample of students was selected from the researcher's own student population. The initial sample (n=122) consisted of four seventh grade math classes. The four classes provided an ample amount of data to allow the researcher to draw a conclusion from the results and reveal whether using flipped learning instruction with the seventh grade CCSS math classes was an effective pedagogy. Determination of the control and intervention group from the four math classes were based on (a) the most experience with the CCSS curriculum and the classroom procedures in the researcher's math class, (b) students had daily access to a home computer or a mobile device with Internet access, and (c) the similarity of the student's academic math levels based on the percentile rankings and the t-test analysis of the group averages from the pre-test (see Table 1 & Table 2).

The researcher chose the four classes because the four classes had the most students that had been enrolled in the researcher's class since the beginning of the school. These four classes had the most experience with the CCSS curriculum and the classroom procedures. They were trained at the beginning of the school with group roles, specific strategies to develop problem-solving skills, the daily structure of the textbook, and the format of the class, such as homework and taking notes. The first two classes of the instructional day were chosen as the intervention group based on the fluidity of instruction. Though the content did not vary between the control group and intervention group, the instruction did vary. It was important that both intervention and control group received similar quality instruction. Pairing the first two classes as the intervention group and the next two classes as the control group ensured there was consistency in the instruction as the researcher transition from the flipped learning instruction to the control group instruction.

Along with four classes having the most experience with the curriculum and the classroom procedures, the researcher was able to determine Internet access at the beginning of the school year because students were required to review with their parents the syllabus for the seventh grade math class, respond on the syllabus whether or not they had Internet access at home, and return the syllabus with the response to the researcher. Within the four classes, 98.65 % of the 122 students had home access to the Internet, and access to laptop, a desktop computer, or mobile device, such as a tablet or smartphone.

The nature of this study and the minimized risks to the students allowed the researcher to include all students from the sample to participate in this study. After administering the pre-test, five out of the 122 students in the four classes did not complete the pre-test. The five students did participate in the study, but their scores from the two post-test were not included in the analysis. The reasoning for not including these five students is discussed in Chapter Four. The sample was established as 117 participants. Additionally, the intervention group and control group were identified from the student's math percentile ranking scores from the pre-test: Renaissance Learnings STAR math test (see Table 1) during the initial part of this study. Table 1 showed the disparity between the two groups' percentile ranking distribution. The *Below 25th Percentile* rankings was a difference of three students, *25th to 49th Percentile* rankings was a difference of one student, the *50th to 74th Percentile* rankings was a difference of 4 students, and *75th and above Percentile* was a difference of 3 students between the intervention and control group. Furthermore, the average scaled score from the pre-test was 772 for the intervention group and 757 for the control group. An independent t-test was used to determine if the average scaled scores were statistically different and whether the four classes were a good match for this study. Based on the results of the t-test the two average scaled scores were not statistically significant ($t = .81$, $p = .42$, see Table 2).

Demographics

The intervention group consisted of 58 participants (28 females, 30 males), and the control group consisted of 59 participants (29 female, 30 males). The social and academic demographics for the participants in the intervention and control groups were heterogeneous (see Appendix A for entire group demographics). These demographic criteria were based on the Base Academic Performance Index (API), which is the California academic report used to assess and rank schools-based state assessments (California Department of Education, 2014). The criteria school districts use to categorize students into subgroups for analyses were: (a) students with disabilities, (b) socioeconomic status, (c) English learners (EL), and (d) ethnicities. The participants who received special education services due to a physical or learning disability represented students with disabilities. They made up 6% of the participants for both the intervention and control groups. Also, 3% of the participants qualified as EL's in the intervention group and 4% were EL's in control group. Students were identified as English language learners based on the results on the California English Language Development Test (CELDT). The socioeconomic status of a student was based on whether the student's parents indicated to the school district that they did or did not receive a high school diploma, or requested their child to receive a free or reduced price lunch program from the school district. The student's parents that indicated that they did not receive a high school diploma or requested their child to receive free or reduced lunch at the student's attending school qualified as socioeconomically disadvantaged. The control group included 53%, and the intervention group included 64% of students qualified as socioeconomically disadvantaged.

Safeguards

The flipped learning intervention and the data collected from the pre-test and post-tests were normal educational practices the researcher used to assess the students' learning (see Appendix D, Figure D1). Furthermore, the instructional techniques, CCSS curriculum and the instrument used for the repeated measures were commonly used by other teachers in the school district that the study took place in. Also, there was minimal risk to the participants in this study because the instructional techniques were advocated by the California Department of Education's Mathematical Practices (2013). The instrument used to measure the effects of flipped learning on the seventh grade participants was used by the school district as a benchmark test to monitor students' performance with the new CCSS curriculum. The instrument, the Renaissance Learning STAR math test, was used throughout the year by all middle schools and administered to all middle school students in the school district. Teachers could also use the instrument to monitor their students or class growth throughout the year. The students have the ability to take the Renaissance Learning STAR assessment every two weeks. There was no personal data stored on the Renaissance Learning server. The data collected for this study did not include any students' names or personal information.

Setting

The study took place in a California middle school over an eight week period. The middle school resided in a middle class community. However, the school served students from multiple local communities surrounding the middle class community. Additionally, under the Elementary and Secondary Education Act, students outside the school boundaries could attend the middle school because the school was not considered a Program Improvement (PI) school

(California Board of Education, 2004). PI is part of an accountability system, called Adequate Yearly Progress (AYP), which ensures all groups of students in a school were making progress based on the State's education standards. The school's progress was assessed on yearly-statewide assessment. The students' performances on the State's 2012 - 2013 assessment at the middle school met the State's AYP goals. This caused an influx of students thereby increasing the number of teachers needed at the school. The total student enrollment in the previous 2013 - 2014 school year was 1,262. The School Accountability Report Card (SARC) for the 2011-2012 school year provided the student demographics for this California middle school. SARC showed that nearly half of the parent population (48.1%) ranked themselves as having low-socioeconomic status (SES). Also, the ethnicities of student population was comprised of Latinos (45.8%), Whites (38.4%), and African Americans (3.8%), Asians (4.3%), American Indians (0.3%), Filipinos (1.3%), Pacific Islanders (1.7%) and mixed races (4.3%) making up the balance of the population. Sub-populations receiving various academic supports consisted of students receiving support as English Learners (24.5%) and students receiving academic support based on established disabilities (14.2%).

Researching flipped learning at this middle school was beneficial for the researcher because of the school's focused interest on integrating technology into the curriculum. The middle school incorporated a technology movement called Bring Your Own Device (BYOD), in which students may bring a mobile device and access the school's wireless Internet service. The purpose of the BYOD movement was to provide teachers with a platform to integrate ICT tools into their lessons (Cochrane, Antonczak, Keegan, & Narayan, 2014). BYOD has prompted many teachers at this middle school to blend ICT tools with their curriculum. Additionally, integrating ICT tools into the student's learning environment is encouraged by the school district. The middle school resides in a school district where the goal is to reach a one-to-one ratio of laptop-to-student in all middle schools (students are provided with a laptop instead of a textbook to take home and/or use at school). These circumstances prompted the researcher to investigate the integration of flipped learning in a middle school CCSS math class.

Instrumentation

The Renaissance Learning STAR math test was used to determine whether the flipped learning instruction had a significant impact on a sample of seventh grade students' academic math achievement. The Renaissance Learning STAR math test was used for repeated measures because of its unique features: its regular use by teachers in the school district in which the study took place, and its validity and reliability of the test scores. For this cohort study, Renaissance Learning's STAR math test was used to identify the intervention and control group and used for analysis with difference in average scaled scores, a Repeated Measures Analysis of Variance and multiple independent t-tests.

STAR Math Test

According to Renaissance Learning (2014), the STAR math test was a norm-referenced test that provided a secure way to monitor and measure student progress for both the intervention and control groups. The test provided various scores that determined the school-grade equivalency of each student's academic comprehension of math (see Appendix D, Figure D2). According to Renaissance Learning (2012), the STAR math test was an adaptive test that increases or lowers the level of difficulty to approximate the student's ability. Each student's test was individualized, and the students never re-took the same test. The Renaissance Learning software's ability to individualize each student's test made this instrument an important tool for this study to monitor the student's performance and possible growth. Each student in the study was measured based on their individual abilities in math versus being measured by teacher-created criterion test that could have questionable validity, and contain only a small set of criterions to measure the student's math skills. The questions from the Renaissance Learning STAR math test were based on five domains directly linked to the domains in the seventh grade CCSS, geometry, ratios and proportional relationships, the number system, expressions and equations, as well as statistics and probability (Renaissance Learning, 2014). These domains were assessed each time the student took the test.

The scaled scores were used as the basis to determine how the intervention and control groups were compared for this study. According to Renaissance Learning (2012), "The scaled score is also important because we use it to establish statistical relationships that tell us more about a student's learning" (p. 4). Using those scaled scores created norm-referenced scores, such as the percentile ranking score, to identify the participants in the intervention group and the control group. The scaled scores were calculated based on the student's responses to the test questions. The Renaissance Learning STAR math test constantly adjusted the difficulty of the question based on the student's response to the previous question in that domain (Renaissance Learning, 2014). The level of difficulty of each question was related to the number of points the student received for answering the question correctly. The student's performance on the test translated into a scaled score that reflected their ability. The scaled score also prompted the Renaissance Learning software to make adjustments to the student's next STAR test based on each student's previous performance. Additionally, this allowed teachers to monitor implemented interventions to determine the intervention's impact, including flipped learning.

The school district used the Renaissance STAR math test as a benchmark test to monitor the students' progress of math skills throughout the year. The test was administered to provide a benchmark by the school district at least four times per year at all middle schools to measure students' progress with their math skills. Furthermore, teachers had discretionary permission to administer the STAR tests up to the point where the STAR test could be taken by the students every two weeks.

Reliability and Validity of STAR Math Test

Renaissance Learning used a large sample size (n= 1,213) of seventh graders to determine the internal consistency ($\alpha \geq 0.9$) of the STAR math test as being a reliable test (Renaissance Learning, 2014). The validity of the Renaissance Learning STAR math test was based on multiple correlative studies such as (a) the teacher ratings of their students' math skill, and their test scores on the STAR test; (b) the scores on a wide variety of published tests with established reliability and validity, and (c) the correlations with State accountability tests (Renaissance Learning, 2014). The correlation from these studies ranged from 0.55 to 0.80 which was moderate to strong. For seventh grade math, there were 29 studies with an average correlation of .64. This demonstrated that the Renaissance Learning STAR math test had a high validity of reflecting a student's performance similarly to other assessments.

Procedures

The researcher was the participants' math teacher for this study. The procedural steps for this study were chosen based on three similar studies conducted by Malhiwsky (2010), Shimazu (2005), and Winter (2013). These researchers used a multiple measures design with their study.

Hence, the framework for determining the effectiveness of the flipped learning instructional interventions with the seventh grade students' mastery of CCSS math skills required the researcher to: (a) inform the participants and their parents about flipping their math class, (b) use the pre-test's results to determine academic similarities and a baseline between the intervention and control groups for comparative analysis of both groups of participants, (c) plan and implement the unit of study from the CPM curriculum, (d) plan and implement the flipped learning instruction, (e) have both groups from the study take the two post-tests at four weeks midway into the study and at the end of the study, and (f) provide feedback from the findings to the parents and students. These steps were implemented to maintain a systematic means to evaluate the impact of the flipped learning intervention on the participants' academic achievement in math.

Parents and Students Informed

An information letter was given to the students in the intervention group to take home for their parents to read over the weekend before the study begun. The information letter was translated into Spanish and was photocopied front-to-back with both translations (see Appendix D, Figures D3 and D4 for the parent letters). An email was also sent to all the parents of students participating in the intervention group on the same day the letter was given to the students to take home. The email contained the same contents as the letter, and the letter was attached to the email as well. The purpose of the letter was to inform the parents that there was a change in the structure of assigned homework, how students were accessing that homework, and the expectation that their child must complete the flipped learning homework. Additionally, the letter explained that the students had access to the computers in the school library before school or afterschool, and could review videos at lunch with the classroom laptops. In the final section of the letter, parents were given the teacher's website containing more information about flipped learning and how to contact the researcher.

Pre-test

The pre-tests in a repeated measures design were used to determine the similarity of the control and intervention groups and establish a baseline to compare the results with the two post-tests (Mertler & Charles, 2011). This study used the Renaissance Learning STAR math test as a pre-test to identify the intervention and control groups from the researcher's five seventh grade CCSS math classes, attempt to establish academic similarities between the intervention and control groups, and establish the pre-test's results as a baseline to compare with both post-tests' results.

The students were given a 48 minute period to complete the pre-test via a laptop. According to Renaissance Learning (2012), the test generally takes a student 20 minutes to complete the test. Students who required more time or were absent the first day of testing were allowed to complete the assessment the next day. Students took the test on laptops in their classroom and were required to log onto the Renaissance Learning website to take the assessment. Students were required to work independently on the assessment. Cheating was not an issue during testing because the Renaissance Learning STAR math assessment is an adaptive test. As stated before, each student's test was an individualized assessment that assessed computational skills based on the following CCSS domains: geometry, ratio and proportional, relationships, the number system, expressions and equations, as well as statistics and probability. These skills were then reassessed in following two measures of this study. The participants completed the Renaissance Learning STAR math pre-test two days before the flipped learning interventions were implemented.

The College Preparatory Mathematics Curriculum

The adoption of CCSS in mathematics and the College Preparatory Mathematics (CPM) differentiates this study from previous studies, because previous research only compared traditional instruction with flipped learning instruction. This study investigated flipped learning with a curriculum that was already integrated with CCSS. It was important to demonstrate the classroom learning environment in which the flipped learning intervention was integrated. The classroom setting for both the intervention and control groups only varied based on the flipped learning interventions. The concepts taught to both the control group and intervention group were from Chapters 4 and 5 in Course 2 of the CPM curriculum. The lessons in Chapters 4 and 5 addressed the following CCSS domains: expression and equations, ratios and proportional relationships, and statistics and probability. These standards and the CPM lesson objectives expected the seventh grade students to learn how to simplify expressions through combining like terms, use of linear diagrams to compare a parts-to-whole through ratios and percent, investigate experimental and theoretical probability, and learn how to use a problem solving process called the 5-D process (Deitiker et al., 2013). There were a total of fourteen lessons, with each lesson requiring one to three days to complete. The College Preparatory Mathematics (CPM), seventh grade, Course 2 program encompassed: (a) the teacher's role in the classroom, (b) cooperative and problem-based learning activities, (c) *Review and Preview* homework, (d) *Homework Help*, and *Checkpoint Materials*, and (e) math notes.

The teacher's role in class. The teacher's role for this study as delineated by CPM curriculum was to be a facilitator. Each CPM lesson had a teacher's guide that provided suggestions for structuring the lesson, to assist with instructional strategies that would promote group collaboration and build conceptual understanding of the lesson's topic. The teacher's most significant role is to monitor and intervene when instructing a CPM lesson (Deitiker, Hamada, Hoey, Kysh, & Sallee, 2013). Though direct instruction is not the emphasis in the CPM lessons, common sense dictates its use in order to clarify a point or redirect a misconception when the majority of the students require support. Also, teachers should provide closure to each lesson to reinforce the mathematical concepts, allowing students to deepen their understanding of the concept (Deitiker et al., 2013).

Cooperative and problem-based learning activities. Students sat in groups of three to four and were assigned specific roles to increase interaction to solve various problems. These roles included a group facilitator, who led the group discussions; a task manager, who kept the other group members on the lesson's task; a recorder reporter, who took notes for the group and reported the group's decisions to the class; and a resource manager, who was in charge of materials. Student groups were expected to lead, debate, share, and support each other as they attempted to solve the problems from the CPM textbook (Deitiker et al., 2013). CPM lesson-problems were structured in a way for the students to develop an understanding of the mathematical concepts, develop or learn problem solving strategies, and practice these skills. Each lesson was designed to work cohesively with previous lessons to build a conceptual understanding of the mathematics and/or link the conceptual understanding within the process of solving math problems, and ultimately teach the vocabulary and the procedural skills related to the concept. For example, the first two lessons of Chapter 5 expected the students to work in their groups to either develop or learn a problem solving strategy to use with identifying part and whole relationships. The students applied their understanding and skills (learned from Chapter 2) to convert a fraction to a decimal and to a percentage to represent a part-to-whole relationship. Groups who needed extra support received scaffolding questions from the lesson and then worked through the questions teaching the use of a linear model to identify part-to-whole relationships and its correlation to fractions, decimals, and percentages. Subsequently, the students use their problem solving strategy with part-whole relationships in Chapter 7 and apply it to solve percent increase and decrease problems, simple interest, and other application of percent (Deitiker et. al., 2013).

Review and Preview homework. The CPM Review and Preview homework was assigned to both the control and intervention groups at the end of a lesson, or was broken up over a two-to-three day lesson. The CPM Review and Preview assigned mixed and spaced practice math problem to the students. Wherein “mixed and spaced practice” is a skill system strategically placing a variety of practice math problems from previous chapters or previous grade levels in the homework practice throughout the chapters. The purpose of the Review and Preview homework was to give students time to practice and retain the understanding of the concepts taught in past lessons, along with building a conceptual understanding for future lessons (Deitiker et al., 2013). Students received either a photocopy of the Review and Preview homework or accessed the document online and were expected to complete the problems from the Review and Preview homework in a spiral note book.

Homework Help and Checkpoint Materials. CPM’s online website, Homework Help, provided support for students to complete the Review and Preview homework at home. The online Homework Help website provided either multi-step hints and/or solutions to the Review and Preview practice problems. The Checkpoint Materials provided answers and additional practice problems for the students to develop a concrete understanding of the math concept. Chapter 4 of CPM did not have any Checkpoint Materials, but Chapter 5 reviewed the order of operations.

Math notes. Interspersed throughout most of the CPM chapters, the math notes consolidated definitions, explanations, or processes to solve a math problem for that chapter (Deitiker et al., 2013). Examination of the topics Chapter 4, lesson 4.3.3 and all of Chapter 5 lessons included: (a) distributive property, (b) equivalent ratios, (c) part-to-whole relationships, (d) independent and dependent events, (e) probability models for multiple events, (f) solving problems with the 5-D process, and (g) consecutive integers. Photocopies of the math notes were given to the participants in the intervention and controlled groups. The participants were expected to attach their math notes into their spiral notebooks. The participants had an option of summarizing the math notes in their own words, explain the process, or create a word problem and provide a solution. These math notes were quick references for the participants during a lesson or while completing the Review and Preview homework.

Flipped Learning Intervention

The flipped learning intervention's primary tool was the instructional videos that supported the CPM curriculum. The delivery, the preparation of the intervention group, and the ancillary activities that supported the instructional videos were all elements of the flipped learning intervention. The instructional videos were created using *Vittle* software. Vittle can be used to create multimedia presentations. The videos were uploaded to Google Classroom, a learning management system, for the students to access. The contents of the instructional videos were based on the CPM curriculum and the prerequisites skills students needed for the upcoming lesson. For example, in Chapter 1 the seventh grade students were introduced to experimental and theoretical probability, and in Chapter 5 the students learned how the relationship between experimental and theoretical probabilities for an experiment adjusts as the experiment is performed multiple times (Deitiker et. al., 2013). Instead of using class time to review with the students with what they learned from the lesson in Chapter 1 on experimental and theoretical probability for the upcoming lesson, an online video was provided for the students in the intervention group to view and take notes for the upcoming lesson on theoretical and experimental probability. Subsequently, the topics of the videos for Chapters 4 and 5 consisted of reviewing previous mathematical concepts and strategies, or reinforcing new concepts from previous Chapter 4 and 5’s lessons to prepare the intervention group for the next day’s lesson (see Appendix B, Table B1 and B2). Implementing the instructional videos with the intervention group required the researcher to: (a) train them how to access and use the learning management system, (b) familiarize them and their parents with the structure of flipped learning, and (c) educate them on how to use the instructional videos effectively.

Training the intervention group how to use the learning management system. The participants in the intervention group needed to learn how to use the learning management system (LMS), Google Classroom, to access the instructional videos and use the guided questions. A LMS is web-based software that replaces classroom components using various tools such as disseminating assignments (Person, 2012). A set of laptops housed on a dedicated cart was used in the classroom as allowing the teacher to model to the intervention group with how to log onto the LMS, access the online assignments, play the videos, and answer the guided questions that accompanied the video. Each participant used a laptop and verified to the teacher they could access the LMS and could access the assignments. Participants who subsequently had issues accessing the assignments, or could not access the LMS were required to complete the flipped learning assignments before school in the school library or at the beginning of class.

Educating the students and parents with the structure of flipped learning. The parents and students in the intervention group were required to watch two videos on the structure, goals, and use of flipped learning as provided by the LMS. The students were assigned homework via the assignment module of the LMS. The first assignment for the intervention group was to show their parents how to navigate through LMS, watch the video on flipped learning, and summarize what they viewed on the assignment page of the LMS. The researcher was then able to verify if the students completed the assignment by checking if they responded to the guided questions on the LMS's discussion board related to that assignment.

Educating the participants how to use the instructional videos effectively. In order for the instructional videos to be an effective learning tool, two important learning strategies needed to accompany each video: (a) note-taking, and (b) answering guided questions (Lawson, Bodle, & McDonough, 2007; Merkt & Schwan, 2014). Each of the online videos for CPM's Chapters 4 and 5's lessons required the students in the intervention group to take notes as they watched the video and answered the guided questions that accompanied the video. The student's notes on the instructional video and their responses to the guided questions were checked and recorded on a grading sheet on the day of the lesson corresponding to the instructional video.

Note-taking. According to a study by Lawson et. al. (2007), students would perform better on assessments if they took notes when watching the online instructional videos. In the current study, the intervention group was trained to take notes by watching a video of the researcher demonstrating how to take notes. The demonstration video showed the intervention group how to organize their notes using Cornell Notes-taking system (see Appendix D, Figure D5 for note- taking template). The researcher checked for completion of the notes the following day and recorded satisfactory completions using a tally mark system on a printed class roster.

Answering guided questions. Merkt and Schwan (2014) suggested that providing guided questions along with note-taking enhanced student learning. In this study, the guided questions were visible while the student watched the video on the LMS. Consequently, recommended in the assignment's directions that students in the intervention group preview the questions before they watched the video. A discussion board module on the LMS was created for each assignment, allowing the students to interact and share their thoughts about the video and the guided questions with the researcher and each other. A discussion board is web-based message board where people can post and read messages on specific topics. In this study, the researcher monitored and responded to the discussion threads when deemed necessary. The format of the questions on the discussion board was open-ended, and the students could either answer the question or respond to another student's post on a specific thread. At the beginning of the class lesson, the researcher reviewed the guided questions with the intervention group and used their responses to the questions to modify the intervention group's instruction or clarify any misconceptions.

Post-tests

All students in the researcher's classes, including the control and intervention groups were administered the Renaissance Learning STAR math post-tests to eliminate any biases of the study and maintain a consistent routine for all the students. According to Renaissance Learning (2012), the STAR math test can be administered based on the researcher's need. The two

Renaissance Learning STAR post-tests were administered at different times during the study's span of eight weeks. The two post-test assessed the same computational skills assessed on the pre-test (CCSS domains: geometry, ratio and proportional, relationships, the number system, expressions and equations, as well as statistics and probability). The first post-test was completed by the participants after four weeks into the study. The second post-test was completed by the participants at the end of week Eight. All of the participating students took the test on a laptop in the classroom where the study took place. Students who were absent on the day the test was administered or needed extra time to complete the test were required to take or finish the test using a laptop on the following day.

Compilation of Data

An explanation of the scaled scores was necessary for composing an interpretation of whether a groups' academic progress at each testing time-point was similar or different from analysis of the findings. The Renaissance Learning STAR math scaled scores from the intervention and control group were used from each scheduled measure: pre-test, and the two post-tests for analysis. After each test, a summary report was produced using Renaissance Learning's web-based software to compile and organize the students' and groups' data for analysis. Summary reports were created for the control group and the intervention group performance on the pre-test and the two post-tests. The summary reports contained the scaled scores for each student in the sample, and the average scaled score for each group. Each data set was used to interpret the impact of the flipped learning on the intervention group. Specifically, the scaled scores were used for the formal analysis (RMANOVA) and the groups' average scaled scores were used to calculate the difference in average scaled scores for the depiction of performance across each testing time-point.

The summary reports for each testing time-point reported a scaled score between the range of 0 and 1400, inclusive for each student in the sample and an average scaled score between the range of 0 and 1400, inclusive for each group (Renaissance Learning, 2014). As previously mentioned in this chapter, the student's performance on the Renaissance Learning STAR math test translated into a scaled score that reflects the student's ability, and the average scaled score represented the group's performance on the test. Renaissance Learning software provides a table that represents the range of scaled score and how scaled scores can be used for interpreting a student's grade equivalency (see Appendix D, Figure D6 for complete table). The scaled scores and average scaled scores were compiled on a spreadsheet after the students completed each time-point test. The student's scaled score from each testing time-point were used for the analysis.

Debrief

Results from the study and an interpretation of the results were posted to the class website for both students and parents to review. An email was sent to the parents to inform them where they could access the findings and conclusion, as well as provided them an opportunity for asking questions about the results and conclusion. In class, the researcher reviewed the results of the study and explained how the results were interpreted from the collected data.

Analysis

The purpose of this study was to determine the impact of the currently popular form of blended learning called flipped learning on a sample of students. The repeated measures consisted of a pre-test and two post-tests. Over the eight week period of the study each test represented a time-point at which the sample of students completed the requisite Renaissance Learning STAR math test. As stated before, the Renaissance Learning STAR math test assesses the same CCSS domains (geometry, ratio and proportional, relationships, the number system, expressions and equations, and statistics and probability). This allowed the researcher to make comparisons between the groups and across the testing time-points. These testing time-points were referred to as *Pre* for the initial pre-test, *Post1* for the first post-test, and *Post2* for the second and final post-test.

As an initial exploratory analysis to provide an overall depiction of the change in each group's average scaled scores at each time point, difference in average scaled scores were calculated using the average scaled scores from each time-point: 1) *Post1 – Pre,* 2) *Post2 – Post1* and 3) *Post2 – Pre*. In order to determine whether there was a difference in test scores between the control and intervention groups over time, the data sets were analyzed with a 2 (group) x 3 (time) Repeated Measures Analysis of variance (RMAOVA). A main effect of Group or Time would indicate a significant difference in test scores between groups or testing time-point, respectively. Meanwhile, a significant Group x Time interaction would indicate that the difference between groups is larger at one testing time-point compared to another. In the case of a significant main effect of Group or Time or a Group x Time interaction, a post hoc t-test with Bonferroni correction was performed. As an omnibus test, the RMANOVA was chosen to allow the researcher to compare all three test scores over time, while controlling for the Type II error introduced when multiple comparisons (i.e., t-tests) are made (Sato, 1996). All analyses were performed with Statistical Package for the Social Sciences (SPSS) software. The significance level was set at $P<0.05$.

Summary of Chapter

This study used a quasi-experimental methodology to determine the effects flipped learning had on the intervention group's academic achievement in a CCSS math class. The two cohorts' (control and intervention group) average scaled scores from their Renaissance Learning STAR math pre-test and two post-tests were analyzed using three analyses: difference in average scaled scores, RMANOVA with repeated measures, and t-tests to determine if there was a difference in performance. The comparison of the all three assessments between the intervention and control groups over the span of this study and the independent comparisons of scaled scores from *Pre*, *Post1*, and *Post2* provided evidence to make an inference to the research question of whether or not flipped learning instruction had an effect on intervention group's achievement. In Chapter Four, the findings of the study were examined to determine the effects that flipped learning has on the seventh grade students' academic achievement in a CCSS math class.

Chapter Four: Results

The focus of this research was to determine the effects of the flipped learning intervention on a group of seventh grade math students' academic achievement. After the data collection was completed, the decrease in the number of participants was discussed, the descriptive statistics were examined, and the Repeated Measures Analysis of Variance (RMANOVA) findings were reviewed. The decrease in sample size and demographics for the participants was examined to determine any changes to the subgroups. Additionally, a descriptive account of the change in each group's average scaled scores from one testing time-point to the next was created using difference in average scaled scores. An analysis was then conducted using a 2 (Group) x 3 (Time) RMANOVA. A post-hoc pairwise comparison (t-tests) would be performed if a main effect existed.

Decrease in Number of Participants

All participant data were collected over a time period of eight weeks. As described in Chapter Three, 122 seventh grade students were originally expected to participate in this study. However, five students (two from the intervention group and three from the control group) were unable to complete the pre-test (*Pre*). During the data collection, five additional students (four from the intervention group and one from the control group) were unable to complete the study due to unforeseen circumstances. One of the participants received a class schedule change before post-test 1 (*Post1*) was administered. The other four participants were absent during one of the testing time-periods. These students could not make up the missed tests because of the unavailability of the laptop cart. Hence, complete data sets were analyzed for 55 participants (26 females, 29 males) in the control group and 57 participants (29 females, 28 males) in the intervention group. Appendix C provides a table with the ethnicity and the school demographics of the students at post-test 2 (*Post2*). Both ethnicity and the socioeconomic demographics are known influences of group and individual performance on tests (Benners, 2010). Initial inspection indicated that the two groups were similar in regard to these demographics.

Descriptive Statistics

Figure 1 provides an illustration of the average scaled scores. During the initial examination of the data, the groups' results (expressed as mean ± SD) of the *Pre* were 759.1 ± 107.4 for the control group and 769.8 ± 90.2 for the intervention group. The *Post1* results were 776.7 ± 100.4 for the control group and 794.1 ± 99.5 for the intervention group. At the final

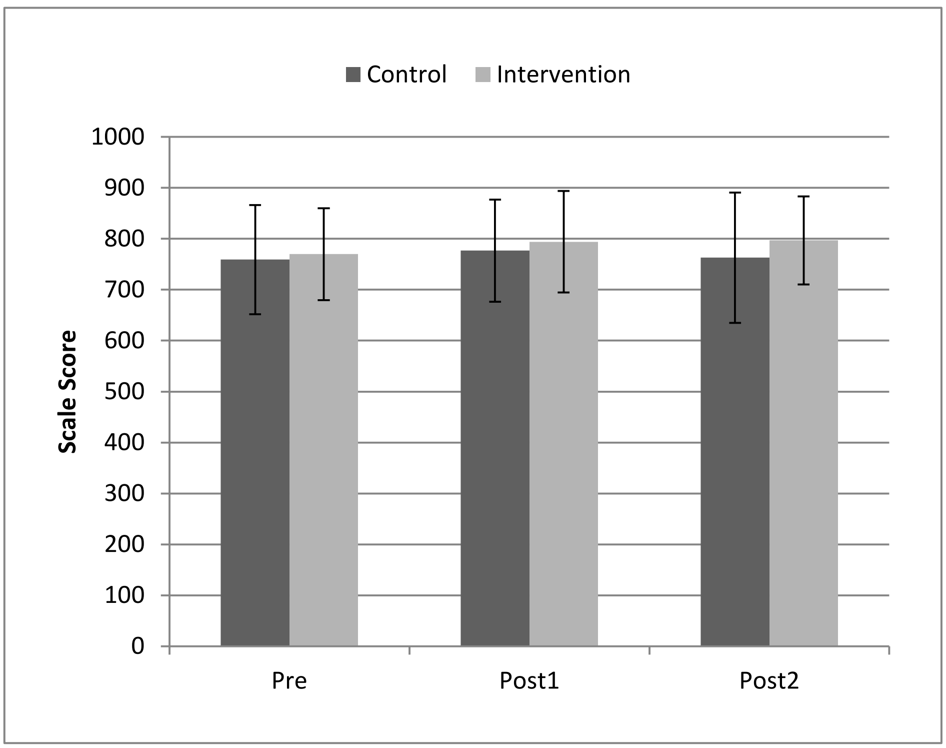

Figure 1. The graph represents performance of the intervention and control groups at each testing time-point. The graph displays the mean ± SD for each group at each of the testing time-points: *Pre*, *Post1*, and *Post2*.

testing time-point, *Post2*, the results were 762.8 ± 128.0 for the control group and 796.8 ± 86.7 for the intervention group. Though figure 1 depicts a difference in average scaled scores between the groups widening from 10.7 at *Pre* to 17.4 at *Post1* and finally 34.0 at *Post2*, it is also important to examine the trend over the time of each testing time-point to substantiate whether it supports the sub question of this research. The difference in average scaled scores was calculated to characterize the change in each group's average scaled scores between each test (see Table 3). Most notable was that there was the average decrease of -13.8 in the control group's test scores from *Post1* to *Post2*. This change in trend was unusual for the whole group and attributes to widening of scores at each testing time-point. Renaissance Learning (2012) takes into account individual fluctuation in performance on its STAR math assessments, but expects an overall trend in growth over multiple testing time-points. Additionally, the large

Table 3

Difference Scores (mean ± SD) and Between-test Effect Sizes (d) for each group and time point

	Post1 - Pre (d)	**Post2 - Post1 (d)**	**Post2 - Pre (d)**
Control	17.6 ± 58.1 (0.17)	-13.8 ± 158.7 (0.12)	3.8 ± 153.3 (0.03)
Intervention	24.2 ± 50.9 (0.26)	2.7 ± 107.0 (0.03)	27.0 ± 103.6 (0.31)

standard deviations across time and in both groups indicated a large spread in changes in performance during each test. For additional descriptive purposes, effect sizes (Cohen's d) were calculated to describe the difference in average scaled scores between each time point in relation to the standard deviation (see Appendix C for complete table). The effects were all considered small.

Analysis of Variance Results

When assessing the effects of flipped learning over time, RMANOVA revealed no significant effects. There was no main effect of Time ($F_{2,220}$= 2.04; P=0.13), indicating that the students' scores did not change over time, regardless of group. There was not a main effect of Group ($F_{1,110}$= 1.90; P=0.17) either, indicating that there was no statistically significant difference in scores between the control and intervention groups, regardless of time-point. The results revealed no statistically significant difference in test scores between the groups or among testing time-points. In addition, the groups performed similarly at each testing time-point. There was also no significant Group x Time interaction ($F_{2,220}$= 0.62; P=0.54), indicating that the difference between groups was not different at either testing time-point. The Group x Time interaction substantiated that the difference between the groups' performances were not greater at one testing time-point compared to another, even though the intervention group's trend in performance on the measures was increasing greater than the control group. Overall, the main effect in both the circumstance comparing each group across the time of the study and between the intervention and control groups at each testing time-point in this study was nominal. Each group performed similarly from *Pre* to *Post2*, and each of their average scaled scores at each testing time-point was not significantly different from the previous test. In the absence of significant main effects or interactions, post-hoc pairwise comparisons (t-tests) were not performed.

Summary of Findings

The goal of the study was to determine: What effects does *flipped learning* have on seventh grade students' achievement in mathematics delineated in CCSS? A secondary goal was to determine: Do students in a flipped learning environment perform better than students in a non-flipped learning environment with CCSS problem-based curriculum? The findings from the comparison of the differences in average scaled scores across the testing time-points and the RMANOVA revealed that the effect of the flipped learning on the intervention group was statistically insignificant when compared to the control group's performance. The main effect in comparing each group's performance across the time span of the study and between the intervention and control groups at each measure in this study was insignificant. Chapter Five provides an interpretation of the findings, a review of the findings of past studies, a discussion of analysis, and the limitations of the study.

Chapter Five: Discussion and Recommendations

The purpose of the study was to inform K-12 educators about the effects of integrating flipped learning with CCSS math curricula. This chapter examines and interprets Chapter Four's results in the context of this study's research questions, relates the results to previous findings from other studies, discusses the overall impact of flipped learning on the intervention group and relevant subgroups, and explores the variation in trend from the results at each testing time-point. The limitations of this study are also discussed as they pertain to the findings and the design of this study. Finally, the relevance of this study is discussed in reference to past studies, suggestions from the findings are made to K-12 educators interested in integrating flipped learning into their math class, and a solution are offered for the shortcomings of this study as may be applicable for future research.

Interpretation of Findings

This study investigated: What effects does *flipped learning* have on seventh grade student achievement in mathematics as delineated by CCSS? Additionally, the study investigated the sub-question: Do students in a flipped learning environment perform better than students in a non-flipped learning environment with CCSS problem-based curriculum? For both research questions, the comparison of the control and intervention groups' results from the repeated measures were the determinant of the effects of flipped learning. The primary findings from the initial analyses of the effect sizes (Cohen's d) of the difference in average scaled scores for both groups were considered small (see Table 3). In addition, the comparison findings of both groups from the RMANOVA indicated they both performed similarly at each testing time-point.

These results were similar to Findlay-Thompson & Mombourquette's (2014), Schmidt's (2013), and Winter's (2013) statistical analysis of the impact of flipped learning on student's academic achievement. Findlay-Thompson & Mombourquette's (2014) study compared three undergraduate business courses (two of the classes used traditional instruction, and the third integrated flipped learning) and found that there was no difference in grade results among the three courses. The course grades were based on students' performance on multiple assessments and other assignments. Schmidt's (2013) study compared various forms of blended learning (including flipped learning) with traditional instruction in K-12 math and science class. However, Schmidt only used one assessment (Nebraska State Accountability assessment) to compare students' academic achievement in math and science. The results from the State assessment did not yield any difference in the groups' achievement levels. Similarly, Winter's (2013) study found that there was no difference in academic achievement between two groups enrolled in an introductory physics course. Winter's pre-test and post-test results indicated the group receiving the flipped learning performed much like that of the control group. Winter suggested both the instructor and students needed more time to adjust to the flipped learning model before significant results could be achieved.

Though these three studies found similar results to this study's findings, their comparisons of learning environments are different from this study. The three studies associated flipped learning as yielding similar academic results to traditional instruction. However, traditional instruction has already been established as an ineffective learning environment in math unless combined with other instructional strategies (Randel, 2012). Additionally, traditional instruction is teacher-centered and contradicts the recommendations for instructional strategies stated in the California CCSS Mathematics Framework. This study compared flipped learning to a non-flipped learning environment that combines traditional instruction, student-centered instruction, and problem-based learning (PBL). Both learning environments compared in this study were acceptable forms of instruction recommended in the California CCSS Mathematics Framework. This study's findings provide a relevant perspective of flipped learning in terms of the CCSS compared to the other three studies, which makes this study different from the other three previous studies.

However, Wiginton's (2013) results contrast the results of this study and the aforementioned three studies. In Wiginton's study, the students in the flipped learning environment outperformed the students in the traditional instructional learning environment. Though Wiginton's study compared flipped learning to a traditional instructional learning environment, the design of the study is of importance for this study's interpretation of the results. The size of the sample and the academic homogeneity of the groups may have influenced the results. As a consequence this study factored in the influence of academic homogeneity on its interpretations of the findings. To gain a better perspective of the results of this study, the researcher adjusted for the inherent benefits of being the intervention group's math teacher by gathering other forms of data that allowed for a more accurate interpretation of the study's data. Examination of the intervention group's overall results, an indicator as to the homogeneity within the subgroups, and the variation in student performance from *Post1* to *Post2* were needed to validly interpret the impact of flipped learning and identify limitations of this study.

Overall Impact of Flipped Learning

The results of this study indicate that the overall impact of the flipped learning intervention was nominal. In comparison between the control and intervention groups' performance, flipped learning was equally as an effective learning environment as the control group's non-flipped learning environment (teacher centered instruction was part of the class lesson) when paired with the Common Core State Standards (CCSS) curriculum. This finding was based on the statistical insignificance in difference in the average scores at all of the testing time-points between the two groups. It is likely that the flipped learning intervention garnered an insignificant effect because a few extreme outliers might have skewed the RMANOVA results, and the time allotment for adjustment to the flipped learning assignments was inadequate. Both points are discussed below.

The size of the standard deviation at each testing time-point for the intervention group (*Pre* = 90.2, *Post1* = 99.5, and *Post2* = 86.7) and control group (*Pre* = 107.4, *Post1* = 100.4, and *Post2* = 128.0) indicated a large spread of performance. Figure 2 provides a visual of the spread of the individual performance for the intervention group. The range of the scale score for the Renaissance Learning STAR math test (scale score range is 0 to 1400) and the spread of the performance for the intervention group indicated that there were scaled scores that impacted the average scale score at each testing time-point. Therefore, the outlying scores affected the tests of statistical significance (meaning the two tests of main effects and the test of interaction effect) when comparing the intervention and control groups' overall performance on the repeated measures.

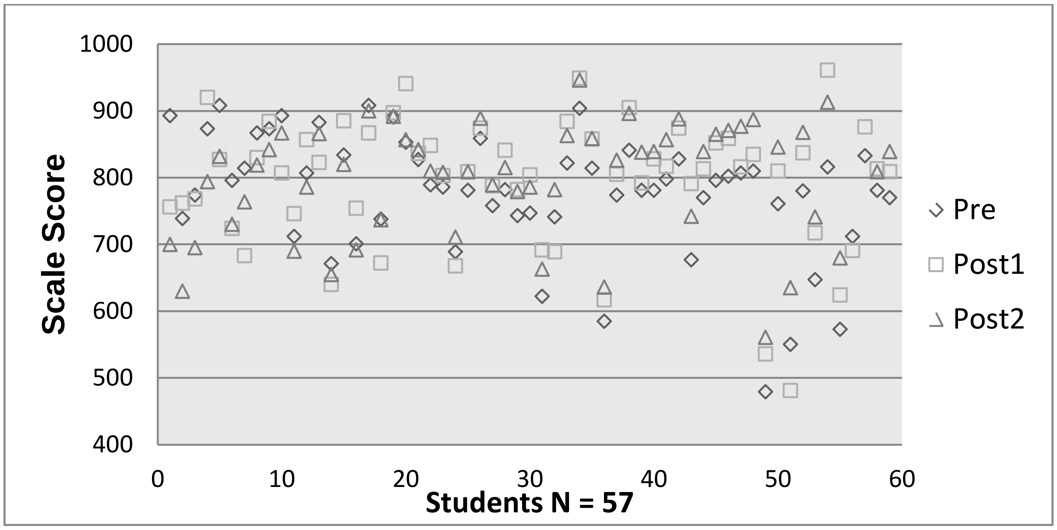

Figure 2. The Scatter plot displays the spread of the intervention group's performance on each of the repeated measures.

Additionally, the intervention group was slow to adjust to the flipped learning intervention. As stated in Chapter Three, the researcher checked each student's notes on the day following the required viewing of each instructional video. This provided the researcher with benchmark feedback on whether the students were completing the flipped learning assignments. As demonstrated in Figure 3, participants gradually increased the rate of completing the flipped learning assignments (online instructional videos, taking notes on the videos and responding to the guided questions on the LMS) over the course of the study. However, the students in general were not prepared for the lesson that followed the flipped learning assignments. It follows that not adequately completing the flipped learning assignments is likely to have impacted their learning the curriculum over the course of the study and subsequently impacted the overall growing trend of performance of the intervention group from *Pre* to *Post2* on the repeated measures.

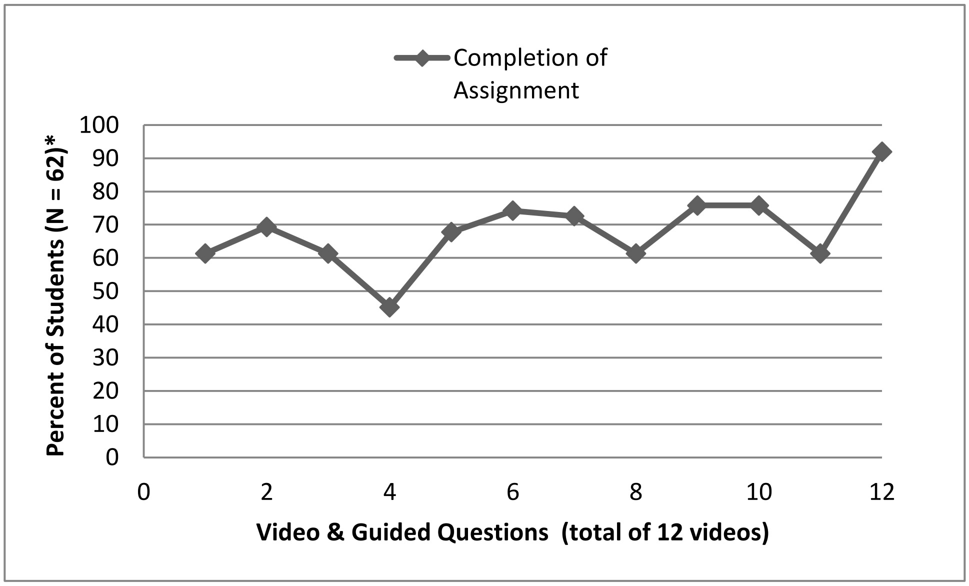

Figure 3. The line graph displays the percent of students in the intervention group completed the flipped learning assignment. The flipped learning assignment entailed watching the instructional video, taking notes on the video, and responding to guided questions. *Note: the sample size (n=62) represents all of the participants in the intervention group (n=57), plus the 5 students who did not complete the repeated measures.

Impact on Subgroups

It is also important to examine the subgroup's performance on the repeated measures to better understand the effects of the flipped learning intervention (Davis, 2015, April 13). Generalizing from comparisons of averages does not reveal the individual impact within the demographic subgroups of the sample. Individually, the intervention group participants' performance varied with both male and female students, indicating an increase (n=37) or decrease (n=18) in their scaled scores from the *Pre* to *Post2* (see Table 4).

Another concern for this study was the impact of flipped learning had on the students who were struggling with math. These students were identified based on criteria set by the school district. Students who performed two grade levels or more below their current grade on the Renaissance Learning STAR math test were considered a student struggling with math. In Appendix D, Figure D6 provides the grade equivalency of the scaled scores students receive on

Table 4

Intervention Group's Demographics and Difference in Subgroup's Scaled Scores

		Increase in scaled score from *Pre* to *Post2*		Decrease in scaled score from *Pre* to *Post2*	
Gender	N=55	#	%	#	%
Male	28	17	60.7	11	39.3
Female	27	20	74.1	7	25.9
Mean ± SD		810.94 ± 87.26		767.72 ± 79.98	
Demographic Criteria					
SED	31	20	64.5	11	35.5
ELL	13	8	61.5	5	38.5
SPED	5	4	80	1	20
Struggling with Math*	11	8	73%	3	27%

Note: Socio-economically disadvantaged (SED), English Language Learner (ELL), Special Education (SPED).
*Participants qualified as students struggling with math based on their performance on the *Pre* with a scaled score < 721.

the Renaissance Learning STAR math test. Based on Figure D6, seventh grade participants who received a scaled score below 721 were performing at a fifth grade level or lower. These participants were performing two grade levels or more below their current grade level. However, the mean and standard deviation for students that increased in scaled score from *Pre* to *Post2* (810.94 ± 87.26) and the students that decreased in scaled score (767.72 ± 79.98) showed they were heterogeneous in performance. Additionally, Table 4 shows 11 of the 55 participants in the intervention group qualified as students struggling with math (based on their performance on *Pre*). Most of the students struggling with math (72%) increased their performance from *Pre* to *Post2*. This indicates that overall students struggling with math benefited from the flipped learning intervention. Also, the heterogeneity of performance amongst the participants in the subgroup that decreased in scaled score from *Pre* to *Post2* indicates other factors may have influenced their performance on the repeated measures. This will be discussed later in the limitations of the study.

Table 4 also provides a synopsis of each demographic subgroup's difference in average scaled scores. Most students in the subgroups (socio-economically disadvantaged, English language learners, and Special Education) demonstrated gains from *Pre* to *Post2*. This can also be reinforced with the conversion table in Appendix D as it shows the relation between the scaled score and Grade Equivalency (GE). In general, the flipped learning intervention did not negatively impact students struggling with the math concepts or their academic performance. The learning intervention did not negatively impact participants in these subgroups, as most participants in these subgroups demonstrated a positive trend in gains with the repeated measures in the flipped learning environment.

Variation in Student Performance on the Repeated Measures

The differences in average scaled scores in Table 3 also indicate that the smallest change for the intervention group was from *Post1* to *Post2* (2.7) in comparison to *Pre* to *Post1* (24.2). It is important to note that the Renaissance Learning STAR math test focused on assessing students' computational skills using pertinent algorithms (Renaissance Learning, 2014). As stated in Chapter 3, each participant's test was an individualized test that assessed skills based on the following CCSS domains: geometry, ratio and proportional relationships, the number system, expressions and equations, as well as statistics and probability. These skills were re-assessed with a different level of difficulty each time the student completed the Renaissance Learning STAR math test. A probable reason for the intervention group's lower-than-expected performance on *Post2* was due to the change in lesson topics. The lessons in the first four weeks of the study focused on computational skills (simplifying expressions and equations, part-to-whole relationships and probability) that were assessed on the *Pre* and *Post1*. However, the lessons after *Post1* focused on developing a problem-solving skill called the 5D process. The 5D process is an organizational skill used to dissect and solve a word problem through a methodical trial and error process (Deitiker et al., 2013). Lessons 5.3.1 through 5.3.5 assisted the students with developing the problem-solving skill (see Appendix B, Table B1). The 5D process was not assessed because the purpose of Renaissance Learning STAR math test measure was to evaluate computational skills. The intervention group's results from *Post2* may have been affected by the change in the type of skills taught after *Post1* was administered; therefore, the intervention group's scaled scores reflected on *Post2* did not reflect their learning of the 5D process. The expected gain in scaled score from *Post1* to *Post2* for the intervention group may have been affected by the change in math skill focus.

In general, the findings from this study's analysis indicate that the flipped learning intervention was equally as an effective learning environment as the control group's learning environment with the CCSS curriculum. This interpretation is similar to Winter's (2013) findings with comparing flipped learning to traditional instruction in a college level physics course. In terms of the performance of the subgroups (see Table10), the outcomes show that each subgroup showed positive gains with the flipped learning intervention. Though the intervention group's heterogeneity in performance and the size of the standard deviation for each average scaled score on the repeated measures make it difficult to generalize the overall effect of flipped learning, other factors point to a limitation of this study. The insignificance from the RMANOVA, the gradual rate of students completing the flipped learning assignments throughout the course of the study, and the small difference in average scaled score from *Post1* to *Post2* indicate the length of the study was also a factor impacting the findings of this study. Additionally, the results from *Post2* hinder the researcher's ability to do an overall comparison of trends in performance between the control and intervention groups. More testing time-points are needed to make a comparison or inferences about the impact of the flipped learning and non-flipped learning environments.

Limitations

While there are many advantages with using a repeated measures design, there are also disadvantages. The *carryover effect* and *practice effect* can influence the results of a study using a repeated measures design (Lamb, 2003, February; Minke, 1997, April; Nimon & Williams, 2009). The carryover effect (the treatment carries over to impact the next treatment) was not an issue for this study since the intervention group received only one treatment (flipped learning assignments). However, the practice effect was a disadvantage for this study. The practice effect is a condition in which the participants' performances on the measures change because of repeated testing. In all repeated measures designs, the practice effect needs to be taken into consideration. Participants either become better with practice with each measure or become fatigued or bored (Lamb, 2003; Minke, 1997, April; Nimon & Williams, 2009). In the case of this study, the participants became fatigued or bored when they completed *Post2*. As stated in Chapter 2, the Renaissance Learning STAR math test was administered four times a year for all middle school students in the district. As this study also used the STAR math test as the repeated measure, participants in the study had exposure to the test up to an additional four times during the school year. Also, the results from the initial analysis of the intervention group's difference in average scaled scores, the change in performance between *Post1* and *Post2*, and the performance heterogeneity of the subgroup that decreased in scaled score from *Pre* to *Post2* suggest the practice effect may have negatively affected the intervention group's performance on *Post2*. Additionally, there was no incentive for the participants to increase their performance on the repeated measures, because their performance on each of the measures did not impact their grade in the class.

The presence of testing fatigue or boredom suggests an additional limitation of the study, which was the length of the treatment. The intervention group's gradual adjustment to the flipped learning assignments suggests the length of the study impacted the results of this study. If the duration of study had lasted a longer time, the results might have been different.

Other limitations applicable to this study were related to the form of the data collected. In many cases, it is suggested that quasi-experimental studies use qualitative data to support and better explain the quantitative results (Scott & Usher, 1996). While evidence suggests that inferences made from this study's results denote plausible explanations, the evidence is limited and cannot take into account other factors (such as: do the students prefer the flipped learning environment over the traditional learning environment?). Additionally, the lack of randomization of homogenous grouping based on academic performance makes it difficult to determine if the results can be generalized for the rest of the student population (Mertler, & Charles, 2011). Strategies to counter these limitations are discussed in this study's recommendations.

Recommendations

Three important inferences were attained during the course of the study. First, this study's review of literature has found a new direction for researchers interested in investigating flipped learning in the realm of K-12 education. Second, the findings from this research suggest that flipped learning is a viable learning environment that K-12 teachers can integrate with their math instruction. Third, upon recognition of the limitations of the data collected for this study, counter measures to neutralize such limitations are suggested.

New Direction for K-12 Research

The findings from this research correspond with past research in establishing whether flipped learning has a positive or negative impact on student academic achievement. However, this study's review of literature shows there are limitations to what previous studies have contributed for K-12 public school teachers in terms of CCSS. Past studies have compared flipped learning to traditional instruction that is primarily teach-centered (Butt, 2014; Findlay-Thompson, & Mombourquette, 2014; Fulton, 2012; Lage, Platt, & Treglia, 2000; Strayer, 2012). However, these studies have little relevance for K-12 public education because their results were drawn from a teacher-centered instructional learning environment that is considered obsolete within the context of the California CCSS Mathematics Framework. K-12 public education needs studies that investigate flipped learning with CCSS curriculum that encompasses problem-based learning (PBL), student-centered instruction, technology-supported learning, and traditional instruction strategies. Though this study provides a relevant analysis for its audience, more research is needed to determine whether flipped learning is a viable learning environment that can be integrated with CCSS curriculum and other learning environments.

Flipped Learning is a Viable Learning Environment

Though there are few studies investigating flipped learning in K-12 education, the findings from this study suggest that flipped learning is a viable learning environment that can be integrated with a CCSS math curriculum for K-12 teachers. Flipped learning is a viable learning environment because it was shown from the findings of this study to be equally as an effective learning environment as the control group's non-flipped learning environment that combines traditional instruction, student-centered instruction, and PBL in the classroom. Also, the findings from this study suggest flipped learning's ability to support all learners in a heterogeneous math class.

The results of analysis of the difference in the average scaled scores at each of the testing time-points for each group, and the results from RMANOVA support the findings of equivalency between the flipped learning and non-flipped learning environments. The findings from the comparison of the difference in average scaled scores across the testing time-points and the RMANOVA revealed that the intervention group performed statistically similar to the control group on the repeated measures. While a trend in performance for each group can be seen from Figure 1, other perspective can be seen when comparing each group's performance at each testing time-point. Further inspection of Figure 1 shows when comparing both groups' average scaled scores at each testing time-point, they are close in performance. Furthermore, Table 3 shows that the trend in change from *Pre* to *Post2* for each group was small. Table 3 provides additional support for the evidence that both groups performed similarly at each testing time-point. These statistical results show both forms of instruction were equally effective in terms of the seventh grade students' academic achievement in math.

Additionally, there was a positive trend with academic achievement on the repeated measures for the intervention group when compared to control group. Figure 1 and Table 3 depict the widening in performance between the control group and intervention group at each testing time-point. Also, the subgroups' (SPED, ELL, SED, and students struggling with math) growth from *Pre* to *Post2* support the trend in academic achievement for the intervention group (see Table 4). The findings suggest flipped learning did not negatively impact participants struggling with the math skills nor did the findings suggest that the subgroups were negatively impacted by the learning environment. The widening in performance between the control group and intervention group at each testing time-point, and the inspection of the performance of the subgroups on the repeated measures suggest that K-12 educators have a viable option when integrating flipped learning into their math classes.

However, the findings from this study also suggest that educators must reserve judgement on the effectiveness of flipped learning. As students need time to adapt to the new learning environment, teachers must make allowances for that adaptation before they see the impact of flipped learning on student learning. Figure 3 shows the need for providing time for adaptation, because during the course of the study, participants gradually increased the rate of completing the flipped learning assignments. K-12 teachers must provide a supportive environment that allows time for the students to adjust to the flipped learning environment.

Future Research

It is recommended that researchers extend the length of studies like this. As discussed above, the length of this study was a key limitation to this study. The findings were incomplete and/or inconclusive with regard to the effects of the flipped learning on seventh grade student's learning. A trend was also difficult to be determined based on three testing time-points. Future studies can increase the number of repeated measures and increase the length of time between (two) measures. Increasing the number of repeated measures would ensure a definitive trend in performance when comparing each group. Also, increasing the length of time between measures can counter the practice effect and reduce the fatigue or boredom of test-taking (Nimon & Williams, 2009). Additionally, incentives that prompt students to perform well on each measure may alleviate the large standard deviations present in this study. Future research can begin at the beginning of the school year and include time for the intervention group to adjust to the flipped learning environment. In addition, future research can include qualitative data (for example, in the form of interviews with the participants in the intervention group) to support new findings or provide additional perspective on the results from the repeated measures.

Conclusion

Flipped learning is a practical learning environment for K-12 teachers to integrate with CCSS math instruction. As previous literature has presented, flipped learning develops a learning environment that integrates student-centered learning, uses technology as a student-learning tool, and blends well with other learning environments (including PBL). Though this study's findings show the effects of flipped learning were statistically insignificant in comparison to the control group's results, results also indicate that it is not an inferior learning environment. For K-12 teachers, the findings along with past studies still signify that flipped learning is a positive learning environment for student-centered instruction and can produce notable results when blended with other learning environments.

The shortcomings induced by the practice effect and the inconclusive evidence as to whether flipped learning is a better learning environment suggests that the length of the data collection needs to be extended. Initiating the study at the beginning of the school year, expanding the length of the flipped intervention, and increasing the number of repeated measures and the time between the measures may provide results that are more suited for determining the control and intervention groups' performance trend. Additionally, including a qualitative data component to cross reference with the results of the repeated measures can provide a stronger interpretation of the results.

In conclusion, the research on flipped learning is still in its infancy in relation to K-12 public education. This study provides a foundation for future studies on flipped learning in K-12 public education, with the goal of investigating the effectiveness of flipped learning on student learning. As K-12 teachers adjust their instruction to conform to the expectations expressed in the California CCSS Mathematics Framework, teachers will be searching for learning environments that foster student-centered learning, employ current technology as a learning-tool, and blend well with other learning environments such as PBL. It is important that K-12 educators see flipped learning as a malleable learning environment that can be adapted to meet the learning needs of all students and incorporate future CCSS curricula and teaching strategies.

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Appendix A

Economic, School, Gender and Ethnicity Demographics for the Control and Intervention Group After Pre

	Control Group N=59		Intervention Group N=58	
Economic and School Demographics Criteria	**Students**	**%**	**Students**	**%**
Special Education	6	10.16	6	10.34
Non Special Education	52	88.14	51	87.9
English Language Learners	23	39	15	25.6
Socio-economically Disadvantage	31	53	38	65.5
Non- Socio-economically Disadvantaged	27	45.7	19	32.75
Gender Demographics	**Students**	**%**	**Students**	**%**
Female	29	49.1	28	48.2
Male	30	50.9	30	51.8
Ethnicity	**Students**	**%**	**Students**	**%**
Hispanic	32	54.3	30	53.1
White	18	30.5	21	36.1
Two or More Ethnicities	5	8.4	4	6.3
Filipino	1	1.7	2	3.3
African American/Black	1	1.7	1	1.3
Asian	2	3.4	0	0

Note: The demographics is based on a sample size (N = 117) after the control group and the intervention group completed the pretest. Three students from each group were not able to complete the pre-test and accounted for in this study. Students also can qualify as multiple demographic criteria.

Appendix B

Table B1

Mathematical Topics of Lessons for CPM's Chapters 4 and 5

Lesson [a]	Lesson Objectives
Chapter 4, Section 3: Simplifying Expressions and Equations	
4.3.3	The concept of zero and the identity property of zero.
Chapter 5, Section 1: Part to Whole Relationship	
5.1.1	Part-Whole Relationships
5.1.2	Finding and Using Percentages
Chapter 5, Section 2: Probability	
5.2.1	Probability Games
5.2.2	Computer Simulations of Probability
5.2.3	Compound Independent Events
5.2.4	Probability Tables
5.2.5	Probability Trees
5.2.6	Compound Events
Chapter 5, Section 3: Problem Solving Skills	
5.3.1	Describing Relationships Between Quantities (Introduce 5D process)
5.3.2	Explaining the 5-D process.
5.3.3	Strategies for Using the 5-D Process
5.3.4	Using Variables to Represent Quantities in the 5D process
5.3.5	More Word Problem Solving using the 5D process

Note: Adapted from Deitiker, L., Hamada, L., Hoey, B., Kysh, J., & Sallee, T. (2013). *Core Connections, Course 2: Teacher*. (Vol. 1), (2nd ed.). Sacramento, CA: CPM Educational Program.

[a] CPM lessons are organized in a numerical format based on: Chapter. Section. Lesson. 5.1.5 is interpreted as chapter 5, section 1, lesson 5

Table B2

Mathematical Topics of Instructional Videos for CPM's Chapters 4 and 5

Lesson [a]	Video Topics
4.3.3a	The concept of zero and the identity property of zero.
4.3.3b	Review problem 4-104 with applying the identity property of zero to variables: x and (– x)
5.1.1	Review how to convert a fraction to a percent, and using a linear model to find an unknown amount.
5.1.2	Reviews over problem 5-14: using a linear model to find an unknown amount.
5.2.1	Explain how to write a probability of an event: P (event), using problem 5-23.
5.2.2	Reviewed how to use the CPM web-tool: Random Number Generator.
5.2.3	Reviewing theoretical and experimental probability with flipping a coin.
5.2.4	How to play Ten 0's Game
5.2.5	Review how to create a probability table
5.2.6	Review how to create a probability table and probability tree
5.3.1	Explaining the 5-D process.
5.3.3	How to identify variables in a word problem and consecutive integers with a variable using the 5D process.

Note: Adapted from Deitiker, L., Hamada, L., Hoey, B., Kysh, J., & Sallee, T. (2013). *Core Connections*, *Course 2: Teacher*. (Vol. 1), (2nd ed.). Sacramento, CA: CPM Educational Program.

[a] CPM lessons are organized in a numerical format based on: Chapter. Section. Lesson. 5.1.5 is interpreted as

Appendix C

Socioeconomic and Ethnicity Demographics after *Post 2**

	Control (n=57)		**Intervention** (n=55)	
Category	**#**	**%**	**#**	**%**
Economic and School Demographics Criteria				
Special Education	6	10.0	5	9.1
Non-Special Education	52	90.0	51	92.7
English Language Learners	22	38.5	14	25.5
Non-English Language Learners	35	61.4	41	74.5
Socio-economically disadvantaged	30	53.0	31	56.3
Non-socioeconomically disadvantaged	26	47.0	24	43.7
Ethnicity				
Hispanic	32	54.3	28	53.1
White	17	30.5	20	36.1
Two or More Ethnicities	5	8.4	4	6.3
Filipino	1	1.7	2	3.3
African American/Black	0	1.7	1	1.3
Asian	2	3.4	0	0.0

Note: The demographics represent the control group and the intervention group after they completed the *Post2*. Three students from the intervention group and two students from the control group were not able to complete the *Post1* or *Post2* and accounted for in this study. Students also can qualify as multiple demographic criteria. *Data from Appendix A

Appendix D

IRB #: 719605-1

To: Jared Montgomery

Title of Project: The Effects of Flipped Learning on Middle School Students' Achievement in Common Core Mathematics

This letter certifies that the above referenced project was reviewed and approved by the University's Institutional Review Board in accordance with the requirements of the Code of Federal Regulations on Protection of Human Subjects(45 CFR 46), including its relevant subparts.

Continuing Review

This approval is valid through the expiration date shown below. If this research project will extend beyond that date, a continuing review application must be submitted at least 30 days before this expiration using the Continuing Review form available on the IRB website. (www.csusm.edu/irb)

Modifications to Research Protocol

Changes to this protocol (procedures, populations, locations, personnel, etc.) must be submitted and approved by the IRB prior to implementation using the Minor Modification Form available on the IRB website.

Unanticipated Outcomes/Events

The California State University San Marcos IRB must be notified immediately of any injuries or adverse conditions.

[ ] Approved Information Sheet or Consent Form(s) are included. Only approved consent forms may be used to obtain participant consent.

Approval Date: 2/24/2015

Expiration Date: **2/23/2016**

IRB Chair: Konane Martinez

Figure D1. This figure represents Human Subjects Research Approval Letter. This study received exemption status for review.

STAR™ Math

Summary Report

1 of 1

School:

Reporting Period: 8/18/20 - 6/4/20
(2014-2015 School Year)

Report Options
Reporting Parameter Group: All Demographics [Default]
Test Type: Enterprise
Group By: Class

Class:

Enterprise Tests

	GP	SS	GE	PR	NCE
Average	7.53	753	6.7	43	46.2

Summary

Student Totals		
Test Type	**Students**	**Avg. SS**
Tested	31	753
Not Tested	0	-

PR Distribution		
Percentile	**Students**	**Percent**
Below 25th	6	19.4
25th to 49th	13	41.9
50th to 74th	8	25.8
75th & Above	4	12.9

GE Distribution		
GE	**Students**	**Percent**
0.0 - 0.9	0	0.0
1.0 - 1.9	0	0.0
2.0 - 2.9	0	0.0
3.0 - 3.9	2	6.5
4.0 - 4.9	4	12.9
5.0 - 5.9	1	3.2
6.0 - 6.9	10	32.3
7.0 - 7.9	5	16.1
8.0 - 8.9	2	6.5
9.0 - 9.9	0	0.0
10.0 - 10.9	7	22.6
11.0 - 11.9	0	0.0
12.0 - 12.9+	0	0.0

Figure D2. This figure represents an example of a Summary Report of Scaled Score and Norm Referenced Scores. *The figure was adapted from Renaissance Learning. (2012). *Getting the Most out of STAR Assessment: Using Data to Inform Instruction and Intervention*. Retrieved from https://resources.renlearnrp.com/US/STAR/STAREntGettingMost.pdf

Dear 7th Grade Parents,

We are almost done with the school year, and some changes are going to be made with how your child prepares for the class lessons. For the rest of the year, your child will be participating in a popular learning environment called *flipping the classroom*. Flipping the classroom exchanges certain forms of instruction, such as lectures, and puts them on video for your child to view before the next lesson. Your child can view the instructional videos at home on a computer, a mobile device, or on a school computer. This will provide more time for your child to receive one-on-one support in the classroom. Also, flipping the classroom will provide more class-time for your child to collaborate with his/her classmates with class projects, and be able to work on more challenging math problems.

Flipping the classroom will not affect how the current math curriculum is taught, however your child will be required to watch the video before the next lesson. Your child will need to have access to a computer or a mobile device for at least 10 to 15 minutes to watch an instructional video, take notes, and respond to their classmates online while answering the guided questions. Many issues may arise with this expectation; nevertheless your child has many options at school to view the videos. This includes: using the library computers before or after school, viewing the videos on their personal mobile device with the school Wi-Fi, or viewing the videos on a classroom computer.

Currently, all the 8th grade teachers are using a form of flipping the classroom. Your child's experience with this learning environment will also help prepare them for next year. If you have any question please feel free to email me: [redacted], or you can call me at [redacted]. Additionally, I have a website explaining what flipping the classroom is: [redacted], which I will share with your child.

Sincerely,

Jared Montgomery

Figure D3. This figure was the introductory letter that was sent home to the parents in the intervention group to inform them about the study.

Queridos Padres séptimo grado,

Casi hemos terminado con el año escolar, y algunos cambios que vamos a realizar con cómo su hijo se prepara para las lecciones de clase. Para el resto del año, su hijo estará participar en un ambiente de aprendizaje populares llama dar la vuelta al aula. Hojeando el aula intercambia ciertas formas de enseñanza, tales como conferencias, y los pone en el vídeo para a su hijo a ver antes de la próxima lección. Su hijo puede ver los videos de instrucción en el hogar en un ordenador, un dispositivo móvil, o en un equipo de la escuela. Esto proporcionará más tiempo para su niño reciba apoyo oneonone en el aula. También, dar la vuelta al aula proporcionará más tiempo de clase para que su hijo colabore con su / sus compañeros de clase con proyectos de clase, y ser capaz de trabajar en los problemas matemáticos más difíciles.

Hojeando el aula no afectará la forma en que se enseña el currículo de matemáticas actual, sin embargo, su hijo tendrá que ver el video antes de la próxima lección. Su hijo necesitan tener acceso a un ordenador o un dispositivo móvil durante al menos 10 a 15 minutos para ver una video instructivo, tomar notas y responder a sus compañeros de clase en línea mientras contesta la preguntas guiadas. Muchos problemas pueden surgir con esta expectativa, sin embargo su hijo tiene muchas opciones en la escuela para ver los videos. Esto incluye: el uso de las computadoras de la biblioteca antes o después de la escuela, ver los vídeos en su dispositivo móvil personal con el WiFi de la escuela, o ver los vídeos en un ordenador en el aula.

Actualmente, todos los profesores de octavo grado están utilizando una forma de dar la vuelta al aula. Su la experiencia del niño con este ambiente de aprendizaje también ayudará a prepararse para el próximo año. Si tiene alguna pregunta no dude en enviarme un correo electrónico: [redacted], o puede llamarme al [redacted]. Además, tengo una página web que explica lo que dar la vuelta al aula es: [redacted], que Voy a compartir con su hijo.

Atentamente,
Jared Montgomery

Figure D4. This letter is a Spanish version of the introductory letter to the parents in the intervention group.

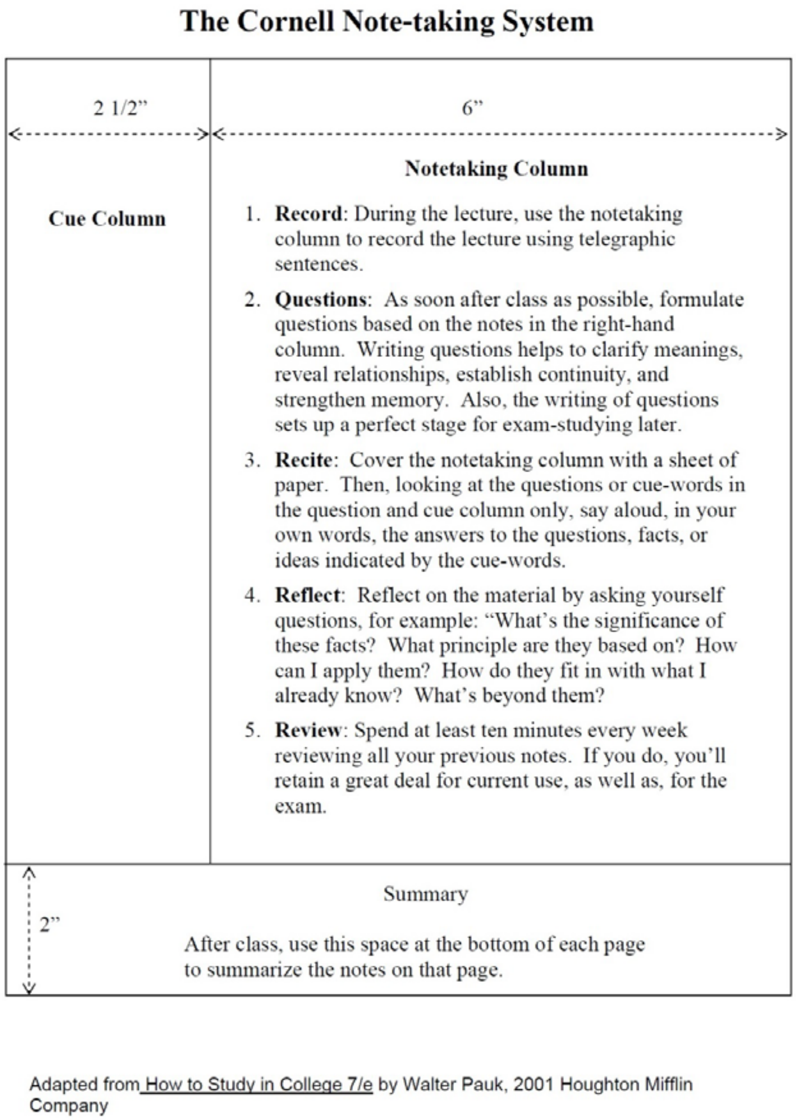

Figure D5. The figure represents a template the intervention grouped used for the Cornell Note-taking System. Cornell University Learning Strategy Center (2012). Figure was obtained from: The Cornell Note taking System [pdf]. Retrieved March 15, 2015, from http://lsc.cornell.edu/LSC_Resources/cornellsystem.pdf

Conversion Tables

Table 53: Scaled Score to Grade Equivalent Conversions

Scaled Score	Grade Equivalent[a]	Scaled Score	Grade Equivalent	Scaled Score	Grade Equivalent	Scaled Score	Grade Equivalent	Scaled Score	Grade Equivalent[b]
0–163	0.0	482–491	2.7	691–695	5.4	794–795	8.1	825–826	10.8
164–176	0.1	492–501	2.8	696–701	5.5	796–797	8.2	827	10.9
177–189	0.2	502–510	2.9	702–706	5.6	798–799	8.3	828	11.0
190–202	0.3	511–520	3.0	707–711	5.7	800–801	8.4	829–830	11.1
203–215	0.4	521–529	3.1	712–716	5.8	802–803	8.5	831	11.2
216–228	0.5	530–538	3.2	717–721	5.9	804–805	8.6	832	11.3
229–241	0.6	539–547	3.3	722–726	6.0	806	8.7	833	11.4
242–254	0.7	548–556	3.4	727–730	6.1	807–808	8.8	834–835	11.5
255–267	0.8	557–564	3.5	731–735	6.2	809	8.9	836	11.6
268–280	0.9	565–573	3.6	736–739	6.3	810–811	9.0	837–838	11.7
281–294	1.0	574–581	3.7	740–743	6.4	812	9.1	839	11.8
295–307	1.1	582–589	3.8	744–747	6.5	813	9.2	840–841	11.9
308–320	1.2	590–597	3.9	748–751	6.6	814	9.3	842	12.0
321–333	1.3	598–604	4.0	752–755	6.7	815	9.4	843–844	12.1
334–345	1.4	605–612	4.1	756–758	6.8	816	9.5	845	12.2
346–358	1.5	613–619	4.2	759–762	6.9	817	9.6	846–847	12.3
359–370	1.6	620–627	4.3	763–765	7.0	818	9.7	848	12.4
371–382	1.7	628–634	4.4	766–768	7.1	819	9.8	849–850	12.5
383–394	1.8	635–641	4.5	769–772	7.2		9.9	851	12.6
395–405	1.9	642–647	4.6	773–775	7.3	820	10.0	852–853	12.7
406–417	2.0	648–654	4.7	776–778	7.4	821	10.1	854	12.8
418–428	2.1	655–660	4.8	779–780	7.5		10.2	855–857	12.9
429–439	2.2	661–666	4.9	781–783	7.6	822	10.3	858–1400	12.9+
440–450	2.3	667–673	5.0	784–786	7.7		10.4		
451–460	2.4	674–679	5.1	787–788	7.8		10.5		
461–471	2.5	680–684	5.2	789–791	7.9	823	10.6		
472–481	2.6	685–690	5.3	792–793	8.0	824	10.7		

a. Extrapolated estimates were made for grade equivalents 0.0 to 0.9 based on the minimum expected Scaled Score for the Grade 1.0 grade equivalent.

b. Grade Equivalent scale scores for 11.0 to 12.9+ are based on the 2002 norms.

Figure D6. The figure is a picture of Renaissance Learning STAR math Conversion Table shows scaled scores and grade equivalency. Conversion Table was adapted from Renaissance Learning. (2014). *STAR Math: Technical Manual*. Retrieved from https://resources.renlearnrp.com/US/Manuals/SM/SMRPTechnicalManual.pdf