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Examining the Effect of Flipped Learning on English Language Learner Mathematics Achievement

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Abstract

English Language Learners (ELLs) are falling behind in mathematics according to the new standardized tests that assess mastery of the Common Core State Standards (Smarter Balanced Test Results, 2017). Simultaneously, flipped learning models have gained momentum in the past decade. Recent studies have found this pedagogical shift to be promising in improving achievement if implemented correctly (Bhagat, Chang, & Chang, 2016; Hung, 2015, Lai & Hwang, 2016; Tawfik & Lilly, 2015; Zengin, 2016). This study used a pre- and post-test quantitative quasi-experimental design to compare the achievement of a mathetmatics standard between the treatment group (n = 30), who received flipped classroom instruction, and the control group (n = 29), who received traditional direct instruction. After data were gathered in a two-week study, independent and paired samples t-tests were performed to determine if statistically significant differences arose between the two groups. The results show the treatment group had more significant growth between the pre-test and post-test than the control group. These findings were consistent with the available research. Recommendations for future work include using a larger sample size with more ELLs to increase statistical power.

Keywords: Mathematics, English Language Learners, Flipped Learning, Common Core State Standards, Student Achievement

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Table of Contents

Examining the Effect of Flipped Learning on English Language Learner Mathematics Achievement

Literature Review

The Common Core State Standards (CCSS; Common Core State Standards: Mathematics, 2013) dictate that teachers deliver mathematical content in real-world contexts and that students develop “habits of mind” to master mathematical understanding. This implementation is designed to increase student comprehension of the mathematical content by exploring the underlying reasoning behind the algorithms taught. According to the CCSS, students will be able to further apply this reasoning to real-world phenomena. This process is meant to stand in lieu of rote memorization methods, which have been employed for decades, particularly through the era of No Child Left Behind (Giroux & Schmidt, 2004), which emphasized memorization over mastery.

Through this process, teachers employ applications to real-world contexts as well as develop foundational expertise, including the eight mathematical practices: making sense of problems and persevering in solving them, reasoning abstractly and quantitatively, constructing viable arguments and critiquing the reasoning of others, modeling with mathematics, using appropriate tools strategically, attending to precision, looking for and making use of structure, and looking for and expressing regularity in repeated reasoning (Mathematics Framework for California Public Schools, 2015). Coupled with a fundamental understanding of mathematical thinking and practice is the need for development of academic language construction as a means of helping students communicate their mathematical thinking beyond numerical representation (ELA/ELD Framework, 2014). Linguistic command over the English language is an implicit prerequisite for four of the practices listed above and a key component of Common Core’s literacy standards. The CCSS in California supports a large population of English Language Learners (ELLs) who have historically performed well below the total national population of students (California Department of Education, 2017).

A nine year longitudinal study by Thompson (2017) indicates that ELLs who enter into the public education system in kindergarten take an average of four to seven years to gain the language mastery necessary to engage fully in grade level instruction provided in English. However, the same study concluded that if a student has not reclassified out of the English Language Development system by grade six, it is unlikely they ever will (Thompson, 2017). Secondary education standards assume the elementary skills, such as reading comprehension, have been mastered. Unfortunately, secondary teachers do not have the time to teach the necessary elementary reading and comprehension skills. Therefore, ELLs who progress to the subsequent grade level without these skills are falling further behind their expected performance each year and many are left without the skills to be college and career ready at the end of high school (Thompson, 2017).

The performance disparity being created poses a challenge to all secondary content area teachers due to the academic language required for content mastery (Janzen, 2008). Students who fall behind in their expected English performance are more likely to fall behind in their mathematics classes given the foundational shift through the CCSS to: be comprehension-based, include critical thinking, and increase methods of communicating answers and rationales. Since these classes are taught using grade-level content and in English only, ELLs often fall well behind their English Only counterparts as they struggle with language. Thus, a fundamental change in instruction must take place in order to support California's existing and increasing population of ELLs to help them to grow to their full potential as mathematical thinkers.

CCSS for Mathematics

The CCSS expectations are that all graduates be lifelong learners and possess the 21st century skills needed to be successful either in the workforce or in higher education (Mathematics Framework for California Public Schools, 2015). The changes in mathematical content are designed to be presented in a real-world context to develop logic skills, instead of forcing students to memorize facts and formulas. Simply knowing that the algorithms work is no longer enough; students must know *why* the algorithms work. Students are expected to develop and build upon skills based on the CCSS throughout the elementary and early secondary grades. The application of these skills are meant to become more complex with each grade to serve as a foundation for learning higher level mathematical thinking and application in the upper-secondary grade levels (Mathematics Framework for California Public Schools, 2015). As the implementation of the CCSS occurred, assessments had to be created to determine student mastery. One such test, the Smarter Balanced Assessment Consortium (SBAC) was developed as a way to measure student progress toward mastery of the aforementioned mathematical standards.

7th grade mathematics SBAC performance comparison. According to the Mathematics Framework for California Public Schools, the mathematics assessment measures student performance based on four claims: Concepts and Procedures, Problem Solving, Communicating Reasoning, and Modeling and Data Analysis (2015). Student performance on all these claims are calculated and accumulated into one achievement level score. Assessment results sort students into four Achievement Level Descriptors (ALDs): Novice (Level 1), Developing (Level 2), Proficient (Level 3), and Advanced (Level 4). The development of skills in the middle grades is integral because they serve as a necessary foundation to success in the upper grades. Therefore, students who achieve at least a Proficient ALD are performing at grade level and are ready to advance to the standards in the next grade. In eleventh grade, the ALD level of Proficient indicates college readiness, according to the Smarter Balanced Assessment System's Interpretation and Use of Scores and Achievement Levels (2014).

The SBAC scores reported in 2017 showed all seventh grade students who participated in the SBAC test nationwide performed as follows: 18% Advanced, 19% Proficient, 27% Developing, and 36% Novice. Comparatively, an underwhelming 2% of the nation's ELLs scored Advanced, 5% scored Proficient, and 18% scored Developing but, most notably, 76% scored as Novice (Smarter Balanced Test Results, 2017). This data illustrates a performance discrepancy between seventh-grade ELLs and the overall seventh-grade student population. Abedi and Gandara (2006) found that the achievement gap demonstrated in these scores is due to a higher level of language demand in the test items. This difference in testing performance is an indicator of a significant equity issue among ELLs both nationally and in the state of California. To compound this issue, many higher education institutions have begun to take SBAC scores into consideration when evaluating the admission criteria of an applicant. The existing racial and socioeconomic achievement gap is widening as a result. These barriers impact minority students' access to higher education, employment opportunities, and future salaries (Lee, 2002). Many studies have been conducted to examine more self-paced methodologies, such as flipped learning, as a means of closing the gap for ELLs.

Flipped Learning

Flipped learning is a system in which students do the content learning at home instead of the traditional method of doing so in class. For example, in a traditional classroom the teacher would lecture during class time and students would do activities at home; however, in the flipped learning model the student listens to lectures at home and uses class time for activities. This provides more instructional time for teachers to conduct activities in the classroom, which helps students to further their understanding and to expand upon existing knowledge through supplemental materials and activities such as manipulatives and inquiry labs (Bergmann & Sams, 2012). One method of delivering content at home is through the use of digital resources and videos. The self-paced nature (i.e., working at your own speed) of digital media at home allows students to explore content at rates which coincide with their cognitive processing needs (Bergman & Sams, 2012; Moos & Bonde, 2015; Sletten , 2017). Videos allow students to slow down and replay instruction as many times as necessary in order to learn the presented content knowledge without the time constrictions, which tend to accompany the traditional classroom setting.

To demonstrate the efficacy of the flipped learning model, an analysis by Hannafin and Land (1997) indicates that simply substituting technology for traditional lectures is not effective in science classrooms. Instead, a larger change in classroom instruction must be present. Many educators tend to flip their classroom by sending students home with a video lecture and present the practice problems within the classroom (Bergmann & Sams, 2012). Bergmann and Sams (2012), the pioneers of flipped learning, establish that class time that traditionally would be spent on lecture must be comprised of more enriching, experiential activities instead of simple practice problems. The most highly supported use of classroom time is student-centered and self-regulated learning (Bergman & Sams, 2012). Self-regulated learning refers to the use of a variety of strategies to elicit student attainment of the content but also allows for different modes of assessment (Bergman & Sams, 2012; Sletten, 2017). For example, students could draw a visual representation, write a paragraph, construct a problem with manipulatives or solve a series of problems to apply knowledge of adding fractions. To demonstrate mastery, students could: take a summative test, have a verbal discussion with the teacher, deliver a presentation, or write about their understandings. With these strategies, the students are in control of the pace they follow and the resources they use to improve their understanding to demonstrate mastery of the standard by the assessment date (Bergman & Sams, 2012).

Contrarily, Hannafin and Land (1997) argue that student-centered learning can be inappropriate for students of different learning modalities, such as linguistic students who rely on verbal interactions with teachers and classmates. Most research available on flipped learning also utilizes student-centered learning for the in-class time to address the various types of learning. For example, Sletten (2017) conducted research on two groups of students in a college-level Biology course. The control group participated in flipped learning through video lectures, whereas the treatment group participated in a flipped learning setting and student-centered learning activities. The results indicated that flipped learning on its own was superficially beneficial in teaching students but found that the most effective change was a result of the student-centered learning. Therefore, the students tested in the treatment group were more likely to develop a sense of self-efficacy (i.e., confidence in one's ability), a byproduct of receiving student-centered curriculum. Sergis, Sampson, and Pelliccione (2017) found flipped classrooms to have a higher impact on student learning and increased self-efficacy. Self-efficacy refers to a person’s confidence in their ability to perform a task and is crucial in motivating students to continue learning, as their capability to learn or perform a task is perceived as adequate (Bandura, 1982).

Improved self-efficacy for learning helps ELLs improve their language skills to access the material of other subjects. In particular, as an ELL is able to enhance their English language skills they are able to transfer that knowledge into other content areas, which improves their confidence in their abilities (self-efficacy), and subsequently increasing their performance in said content areas. Hung (2015) found flipping the classroom in a language course was more effective than non-flipped lessons in the same course. The flipped lessons resulted in more students who: reached the learning outcome, developed a more positive outlook towards learning, and afforded more effort to the learning process (Hung, 2015).

Despite positive findings surrounding the flipped classroom model, there is scrutiny over flipped learning models that simply provide videos to students (Ash, 2012). Typically, when teachers provide a YouTube video for students to watch, they have little way to ensure the student watched the video or paid close enough attention. This mirrors a common challenge in the traditional classroom setting to a student sitting through a lecture without any meaningful task or way to engage with the content. Moos and Bonde (2015) combined the concepts of flipping the lecture and self-regulation (i.e., allowing students to choose how to apply their content knowledge) by embedding prompts into the videos students watched. This allowed students to watch the video at their own pace and answer the questions when they were comfortable, versus in the traditional classroom where students must learn at the teacher's pace and answer questions before they are ready. They found that students who interacted with the prompts learned more than those who did not. For such reasons, EdPuzzle (EDpuzzle Inc., 2017) was created with the purpose of embedding prompts to monitor student learning while watching videos. Furthermore, EdPuzzle allows teachers to assign videos that are programmed to pause at particular moments (EDPuzzle, 2017). Only after interacting with the prompt or task in some way will a student be allowed to proceed. Teachers are able to view if a student has watched the video, how many times they watched each section, and how they responded to the questions.

This increases accountability by requiring that students interact and track their progress through the video; thus EdPuzzle is one solution to creating a rigorous flipped learning environment in mathematics.

Flipped learning in mathematics. EdPuzzle (EDpuzzle Inc., 2017) hosts numerous interactive videos for teachers to utilize across all content areas, including mathematics, making it easy for teachers to flip their classrooms. Still, few studies have been conducted to establish the efficiency of flipped learning in mathematics classrooms (Bhagat et al., 2016; Lai & Hwang, 2016; Tawfik & Lilly, 2015; Zengin, 2016). For example, Tawfik and Lilly (2015) conducted research with a college level mathematics course and found that students who participated in flipped learning expressed feeling more confident when speaking about mathematics; however, the students were unable to ask questions throughout the video as they normally would with a traditional lecture. Asking questions is an important step in the process of learning in case the content is unclear.

Conversely, Bhagat and colleagues (2016) conducted a study which indicated that high school mathematics students performed higher on assessments and were more motivated as a result of flipped learning. Bhagat and colleagues (2016) and Tawfik and Lilly (2015) found that students who engaged in the flipped learning method reported higher levels of self-efficacy (i.e., confidence in ability) than those in the control group who did not engage in the flipped learning method. Zengin (2016) took the ideas from these studies a step further and utilized Khan Academy with mathematics students at a university in Turkey and found the flipped learning model increased content retention. Khan Academy is a respected self-teaching website where various topics are explained in simple terms. The creators of the videos use simple language and a multitude of examples to explain concepts. Viewers are then prompted to answer a series of related questions in order to practice and gain mastery of the content, similar to EdPuzzle (EDpuzzle Inc., 2017). To supplement Zengin's (2016) findings, Lai and Hwang (2016) found students benefited more from student-centered learning than with standard flipped learning and found students' self-efficacy to be positively impacted. These findings make important implications for future studies on flipped learning by reinforcing the importance of making that fundamental change in the use of class time, as outlined by Bergman and Sams (2012).

The aforementioned studies focus on flipped learning with post-secondary students but do not include ELLs or students in the lower secondary grades. Lower-secondary grades play a pivotal role in the development of foundational mathematical skills due to the developmental stages of students at this time in their lives. Therefore, the purpose of this study was to examine the relationship between flipped learning and ELLs' mathematics achievement on a CCSS aligned mathematics test in the lower secondary grade setting. This method of teaching has the potential to make mathematics content more accessible for ELLs and subsequently increase performance.

Method

Research Question

The research question for this study was: Does flipped learning increase student performance on Common Core State Standards aligned mathematics tests for seventh-grade English Language Learners?

Hypothesis

Based on prior research (Bhagat et al., 2016; Hung, 2015, Lai & Hwang, 2016; Tawfik & Lilly, 2015; Zengin, 2016), the current study hypothesized that using the flipped classroom model would increase performance on a CCSS aligned mathematics test for seventh grade ELLs.

Research Design

The present study was a quantitative, quai-experimental, nonequivalent-groups, pre-test post-test design. Both control and treatment groups took a pre-test in class before beginning a new unit. The control group was expected to acquire content knowledge through in-class lectures and complete practice problems at home; whereas, the treatment group was expected to acquire content knowledge via videos at home and participate in inquiry based activities in class. Both the treatment and the control groups took a post-test in class immediately following the conclusion of the unit.

Independent variable. The independent variable in this study was the intervention which was the flipped learning model. The flipped learning model is defined as a teaching method where students are delivered standards-based content at home for homework and engage in related activities to apply that knowledge in class (Bergmann & Sams, 2012).

Dependent variable. The dependent variable in this study was student mathematics achievement measured by a CCSS-aligned mathematics test (Illuminate Itembank, 2017). Mathematics achievement is defined by a student's score on an assessment as evidence of mastery of the standard being assessed. This standard (7.EE.4.b) is specifically addressing the student's ability to solve and graph inequalities and apply their understanding in real-world contexts (California Department of Education, 2013).

Setting & Participants

The setting for this study was a middle school in the central coast of California. The school has 1056 total students including 462 female students and 594 male students (Ed-Data, 2018). Furthermore, 98% of the school's students are Hispanic and the school has 462 ELLs (Ed-Data, 2018). The current study includes 59 total participants; 41 participants are male and 18 participants are female. Of these students, 58 students are Hispanic and one student is Caucasian. This sample contains 24 ELLs. The sample is one of convenience because students were accessible to the researcher. They serve as a representative sample of the entire school, district, and county.

Treatment group. The treatment group contains 30 seventh-grade students. There are 18 males and 12 females; 29 of the participants are Hispanic and one student is Caucasian. Of these students, 11 are ELLs. Five students are at or above a seventh grade reading level. All 30 students participated in the flipped learning model. Students received a video form of the in-class lecture with embedded questions which was hosted in EdPuzzle (EDPuzzle, 2017) to be completed as homework. In class, students participated in an inquiry based activity to explore the concept learned in the video.

Control group. The control group contains 29 seventh-grade students. There are 23 males and six females. All 29 participants are Hispanic. Of these students, 13 are ELLs. Three students are at or above a seventh grade reading level. All 29 students participated in the traditional learning model where they gained content knowledge through an in-class lecture. At home, students were assigned a set of practice problems for homework.

Measures

The current study utilized a digital pre-test and post-test to measure the effectiveness of the flipped classroom model in enhancing student progress toward the standard. These tests aligned to the CCSS and included multiple choice, selected response, and explicit constructed response questions (See Appendix A and Appendix B). The tests were created by a team of mathematics teachers using the Illuminate Itembank which includes questions from authorities such as Inspect® by Key Data Systems (Illuminate Itembank, 2017). Both tests contained ten items which participants had 40 minutes to complete.

Validity. The pre-test and post-test were developed using the Illuminate Inspect® Itembank and demonstrated formative validity (See Appendix A and Appendix B). The user selects the standards to be assessed and then a multitude of approved questions are supplied to show mastery of that standard (Illuminate Itembank, 2017). The Inspect® Itembank includes only items aligned to the CCSS (Key Data Systems, 2018). The test questions were selected by a group of four seventh grade mathematics teachers in order to ensure the test was not too simple for the grade level. More than one question was selected for each assessed standard to reduce the probability of students guessing correctly and, therefore, incorrectly demonstrating mastery.

Reliability. Two factors make this measure reliable. Both tests have an answer key to eliminate bias from the grader. Additionally, students were tested in the same conditions in which they interact with the material in in-class settings, as well as how they take the SBAC test (California Department of Education, 2017). The pre-test and post-test were constructed to have different questions that measure the same standard and procedure. For example, question one of Appendix A correlates to question three of Appendix B. This eliminates the possibility of students learning the answers to the pre-test and duplicating them in the post-test. Students were not able to view their scores on the pre-test before taking the post-test. Both tests were scored by the testing software and were checked for accuracy by the teacher. The school district subscribes to the Inspect® Itembank provided by Key Data Systems (Key Data Systems, 2018) which ensures the items are aligned to the CCSS and the expected level of rigor. Key Data Systems reports internal reliability within the Inspect® Itembank where the seventh grade mathematics items have a .85 coefficient on the Kuder-Richardson 20 (KR20); the coefficient is a measure of internal reliability that provides the same result as Cronbach's alpha (Forrester, 2016).

Intervention

The treatment group participated in the flipped classroom model to receive instruction. In other words, instead of doing homework problems at home, students watched a lecture video made by the researcher and hosted in EdPuzzle (EdPuzzle, 2017) to receive content knowledge. All students have a Chromebook they can take home and have access to internet at home. Hotspots are available from the school library in the event that a student cannot access internet at home. As Bergmann and Sams (2012) and Hannafin and Land (1997) point out, a fundamental change needs to happen during class time in order for the flipped classroom to be effective. To create this change, the treatment group participated in inquiry based in-class activities to utilize the knowledge gained from the videos. Inquiry based learning focuses on delivering instruction through class discussions, projects, and other class activities (Zhang, 2015). See Appendix C for examples of inquiry based activities related to inequalities. The intervention lasted two weeks between the pre-test and post-test.

Procedures

All participants took a 10 question pre-test on Illuminate to assess baseline understanding and mastery of the standard (i.e, solve and graph inequalities and apply their understanding in real-world contexts) being taught before the intervention period. The control group continued through the unit in a traditional lecture format and did practice problems for homework. The treatment group participated in the flipped learning model by watching videos for homework and doing inquiry based problems in class (See Appendix B). After the unit finished, all participants took a 10 question post-test to assess knowledge gained and mastery of the standard that was taught. The scores for the pre-test and post-test were analyzed to determine whether flipping the classroom affected student achievement on the test.

Fidelity. Fidelity was ensured for the treatment group by a daily push-in teacher who confirmed the intervention was being executed consistently. The push-in teacher checked to make sure there was no direct instruction, and that students were engaged in an activity to extend their knowledge gained from the corresponding video. The control group had another teacher drop in twice during the ten days in order to ensure the control setting was consistent. This teacher was looking for direct instruction and made sure the students were not engaging in full activities, but rather single problems or questions (i.e., business as usual). This teacher also reviewed the corresponding 20% of the flipped lecture videos to ensure that the traditional lectures were similar. Only the treatment group had access to the videos and inquiry activities. All materials for the inquiry activity were collected each day to ensure the control group had no interaction with the inquiry based activities. Both teachers observing the treatment and control groups used the fidelity checklist (See Appendix D).

Ethical Considerations

The control group had access to all the material used by the treatment group after the procedures were completed to address the fairness of the treatment group potentially having a more effective learning experience. The teacher utilized intervention time to work with students who did not perform adequately according to the results of checks for understanding performed throughout the lessons. However, both models (traditional and flipped) are now considered to be normal education practices and do not pose a risk to student access to the content since all students will still receive instruction. Additionally, all students have Chromebooks provided by the school district that they can take home. Each student confirmed they have internet access at home. Students could check out a hotspot from the school library in the event that a student did not have internet access at home. In order to protect confidentiality, each student was given a number in the data analysis to eliminate the use of names.

Validity threats. In order to decrease the threat of getting better scores due to retesting, the pre- and post-tests were different, but strongly correlated. The post-test was similar to the pre-test, but the order of the items changed and the items differed in the quantities represented in each question (e.g., "solve $2x > 4$" would change to "solve $6 > 3x$"; see Appendices A and B). The tests were given approximately two weeks apart based on the pace of the unit. Throughout the two weeks, two teachers observed the treatment group and the control group to ensure fidelity. These teachers also helped eliminate researcher bias, as the control group would not be given the intervention if the teacher observed that it was successful with the treatment group.

Data Analyses

All data were entered into the Statistical Package for the Social Sciences® (SPSS®) for Windows, version 24.0.0 (SPSS, 2016). No names or identifying information were included in the data analysis. Before analyses were conducted all data were cleaned to ensure no outliers were present (Dimitrov, 2012). After cleaning the data, independent and paired samples t-tests were conducted to determine the significant difference in between pre-test and post-test performance on the Illuminate test in the control group or the treatment group. Further, before interpreting the analytical output, Levene's Homogeneity of Variance was examined to see if the assumption of equivalence has been violated (Levene, 1960). If Levene's Homogeneity of Variance was not violated (i.e., the variances were equal across groups), data would be interpreted for the assumption of equivalence; however, if the variances were not equal across groups the corrected output would be used for interpretation.

Results

Two independent samples t-tests were conducted on the whole sample ($n = 59$) for both the pre and post assessment scores. Results for the pre-test were: Levene's Homogeneity of Variance was not violated ($p > .05$), meaning the variance between groups was not statistically different and no correction was needed, and the t-test showed non-significant differences between the mean scores on the pre-tests between the two groups $t(57) = .84$, $p > .05$. This means there was no significant difference between the means on the pre-test for both the treatment and control group and they could be compared (see Table 1). Results for the post-test were: Levene's Homogeneity of Variance was not violated ($p > .05$), meaning the variance between groups was not statistically different and no correction was needed, and the t-test showed non-significant differences between the mean scores on the post-tests between the two groups $t(57) = .36$, $p > .05$. This means there was no significant difference between the means on the post-test for both the treatment and control group. Thus, even though the mean scores improved from the pre-test, the intervention was not impactful enough to provide statistically significant improvement in student scores (see Table 1).

Table 1

Results of Independent Samples T-Tests

	Mean	SD
Pre-test		
Treatment	2.07	1.46
Control	2.41	1.72
Post-test		
Treatment	3.60	1.87
Control	3.17	1.69

Note. SD = Standard Deviation.

After determining the differences between pre and post assessment scores between groups, two paired t-tests were run for both groups (i.e., treatment and control) to determine if participants mean scores from pre to post were significantly different within each group (See Table 2). Results for each group were as follows: treatment group, $t(29) = -3.52$, $p < .001$; control group, $t(28) = -2.72$, $p < .01$. This indicates that the control and treatment groups showed a statistically significant difference in mean scores from the pre-test to the post-test. Additionally, the negative t-value for both groups indicates an increase in scores from the pre-test to the post-test. Thus, both the control and treatment groups learned and gained knowledge, but the treatment group showed greater and more significant growth from the pre-test to the post-test; suggesting partial confirmation that the intervention was successful. This is to be expected since both the traditional and flipped learning models are acceptable teaching methods. Table 2 shows that the control group's mean score increased by 0.76, while the treatment group's mean score increased by 1.53; demonstrating that the treatment group increased their average score more than the control group. This provides partial support that the intervention helped the treatment group make greater gains; however, these gains were not statistically significant as shown by the results of the independent t-test.

Table 2

Results of Paired T-Tests

	Mean	SD
Treatment Group**		
Pre	2.07	1.46
Post	3.60	1.87
Control Group*		
Pre	2.41	1.72
Post	3.17	1.69

Note. SD = Standard Deviation. * = $p < .01$. ** = $p < .001$.

Discussion

According to the new standardized tests that assess mastery of the CCSS, ELLs are falling behind in mathematics (Smarter Balanced Test Results, 2017). ELLs who progress through the grade levels without the appropriate language skills are not performing at grade level and are falling further behind their expected performance in the content areas each year (Abedi & Gandara, 2006; Janzen, 2008). Many of these students are left without the skills to be college and career ready at the end of high school (Lee, 2002; Thompson, 2017). Moreover, the lower-secondary grades play a pivotal role in the development of foundational mathematical skills due to the developmental stages of students at this time in their lives. Middle school educators must refine their pedagogy to match the needs of this population of students. Flipped learning allows students to gain content knowledge at home and apply that knowledge in class (Bergman & Sams, 2012). Recent studies have found this pedagogical shift to be promising if implemented correctly (Bhagat et al., 2016; Hung, 2015, Lai & Hwang, 2016; Tawfik & Lilly, 2015; Zengin, 2016). Therefore, additional research must be conducted to examine the flipped learning model as a viable option to help ELLs acquire the content skills necessary to be successful in mathematics.

The purpose of this study was to examine the relationship between flipped learning and ELLs' mathematics achievement on a CCSS aligned mathematics test in a lower secondary grade setting. This study included 29 seventh-grade students who received traditional classroom instruction (i.e., control group) and 30 seventh-grade students who received flipped classroom instruction (i.e., treatment group). The control group gained content knowledge in the classroom and performed practice problems for homework. The treatment group gained content knowledge through videos with embedded prompts at home and participated in inquiry based activities in the classroom. The current study hypothesized that using the flipped classroom model would increase performance on a CCSS aligned mathematics test for seventh-grade ELLs.

The results in Table 2 indicate that the students in both the treatment and control groups learned the content knowledge, but the treatment group displayed a greater amount of growth. In a study with two groups of students who participated in the flipped learning model, Moos and Bonde (2015) found that the students who interacted with embedded prompts learned more than those without embedded prompts. The results of the current study and previous studies suggest that students need to be able to access content knowledge and answer practice questions at their own pace; only available through flipped learning.

Both the traditional learning model and the flipped learning model are considered to be acceptable teaching practices, which is why there was not a statistically significant difference between the control and treatment group on the post-test as indicated in Table 1. This finding is consistent with other studies of the flipped learning model (Bergman & Sams, 2012; Moos & Bonde, 2015; Sergis et al., 2017; Sletten, 2017). Sletten (2017) specifically pointed out that flipped learning was only superficially beneficial in teaching students, but the most effective change was a result of the student-centered learning. The results of the current study indicate an insignificant difference between the treatment and control group post-test scores, but a larger amount of growth for the treatment group between the pre-test and post-test. These studies suggest that the reason for this result is the use of inquiry based activities in class rather than the flipped learning model itself.

These results provide further evidence that the flipped learning model is a viable teaching method for mathematics classrooms. The flipped learning model excels in providing educators with more in-class time to engage students with inquiry based activities and other enriching tasks. This method also ensures that all students can do the homework; provided they have a device to watch the video on. This is not a guarantee for the traditional model where students must have successfully acquired the content knowledge in-class in order to do the homework at home. Further research with a larger sample size could indicate higher homework completion rates, increased acquired content knowledge, and increased engagement. Although the current study contributes to the research base, there are certain limitations that should be addressed in future studies.

Limitations and Future Studies

Based on the findings, the greatest limitation in this study was the sample size. The descriptive statistics analyses were conducted on all of the participants regardless of English language acquisition or reclassification status. The small amount of ELL participants resulted in no statistical power with which to find a difference for this population. Similarly, this study used a sample of convenience because the researcher had access to these students and control over how they were taught; requiring no additional training for other participating teachers. Future iterations of this study should gather a larger sample size in order to increase the statistical power of the results.

Another limitation is individual variety and complexity; individuals grow and learn in various ways. Students from the control group may have responded differently to the intervention than students from the treatment group, yielding a different result. Future studies should consider performing both teaching models with the same group of students.

Furthermore, none of the flipped classroom videos had 100% viewership before students engaged with the inquiry activity, leaving gaps in their understanding of the content. This is especially problematic since the videos and mathematical concepts build upon themselves.

Students who did not watch one video could experience difficulty understanding the subsequent video. Similarly, some students in the control group did not complete their homework everyday throughout the duration of the intervention. The homework assignments in a traditional classroom are meant to provide the students with practice to apply gained content knowledge and solidify their procedural understanding. This limitation could be addressed by following up with the students who did not complete their homework and their parents. Additionally, informing the parents of the importance of homework completion prior to the data collection period could increase buy-in and support for the research.

Finally, future iterations of this study should consider the impact of inquiry based activities by utilizing a second treatment group. The first treatment group should participate in the flipped learning model without inquiry based activities while the second treatment group should participate in both the flipped learning model and the inquiry based activity. Similarly, it would be worth exploring a treatment group – control group hybrid where the students gain content knowledge through inquiry based activities in class and apply that knowledge at home with the practice problems. This change would help isolate the reason for any statistically significant finding while doubling the sample size.

In conclusion, the flipped learning model provides educators an opportunity to change how and where the learning occurs in a mathematics classroom. Teachers can now spend more class time engaging students in enriching explorations that provide students with the deeper level of understanding the CCSS call for. Allowing students to engage with the content knowledge at their own pace at home allows ELLs the opportunity to slow or repeat the instruction as needed. These vulnerable students now have an unprecedented opportunity to excel academically and our educators have a new methodology that has the potential to help close the achievement gap.

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Appendix A

(Illuminate Itembank, 2017)

7th grade Math Inequalities Pre-Test

1. Solve for *c* in the inequality below.

   Note: Your answer should be a simple INEQUALITY.

   $$13>-16-c$$

2. Bill wants to get a grade of at least 70 on the next test. Each wrong answer causes Bill to lose 4 points. What inequality could be used to find the number of wrong answers, x, Bill can get and still receive a score of at least 70?

   a. $100-4x\geq70$

   b. $100-4x\leq70$

   c. $(100-4)x\leq70$

   d. $(100-4)x\geq70$

3. Solve for *k* in the inequality below.

   Note: Your answer should be a simple INEQUALITY.

   $$-15<9+4k$$

4. What is the solution to the inequality $-2x-35>-1$?

a. $x < 17$

b. $x < -17$

c. $x > -17$

d. $x > 17$

5. Solve for k in the inequality below.

$$2k+1>17$$

a. $k>15$

b. $k<8$

c. $k>8$

d. $k<15$

6. Four more than a number, n, is less than fifteen. Which inequality represents this relationship?

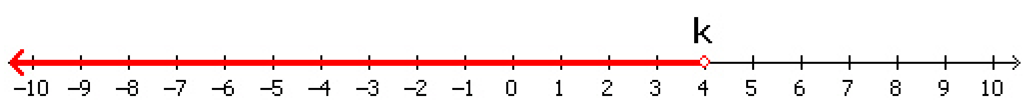
a. $15 \leq n+4$

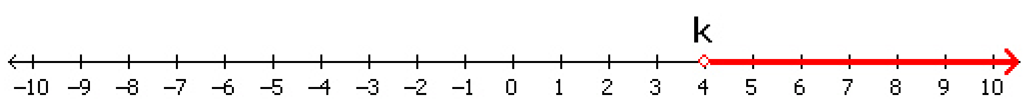
b. $n+4<15$

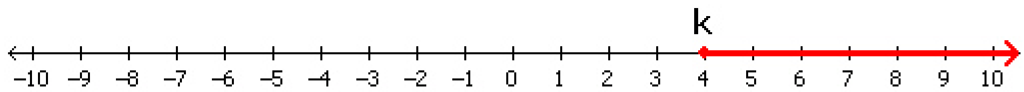
c. $n-4<15$

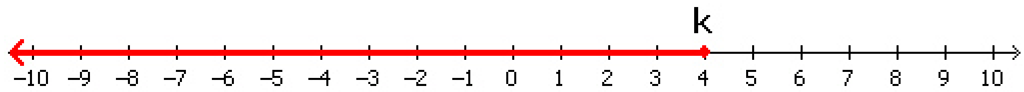
d. $4+n \leq 15$

7. Which choice is the solution set for $3k+8 \geq 20$?

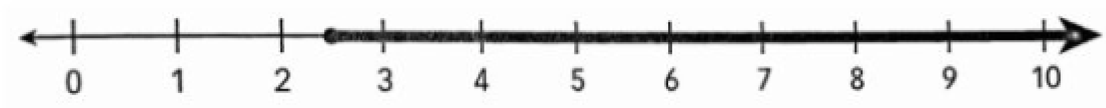
a. 

b. 

c. 

d. 

8. The number line shows the solution set to which inequality?



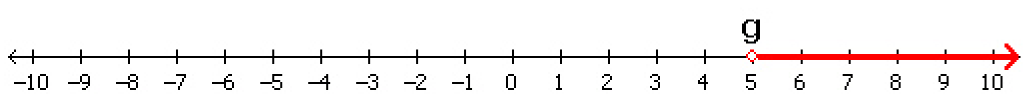
a. 3x+2≥17

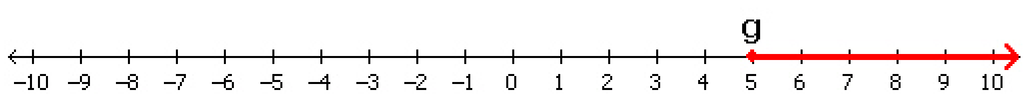
b. 12+4x>22

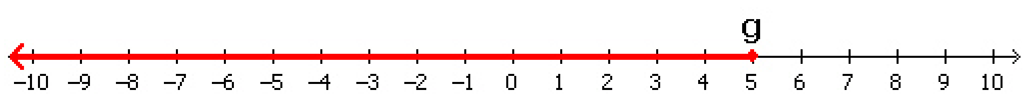
c. 4x+4x>22

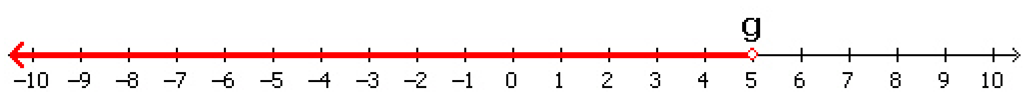
d. 12+4x>22

9. Which choice is the solution set for −9g−5≥−50?

a. 

b. 

c. 

d. 

10. Bob originally had 14 cards. Then, Jimmy gave him k cards. Bob now has less than 49 cards. Which best describes Bob's current amount of cards?

a. $k+14<49$

b. $k-14>49$

c. $k-14<49$

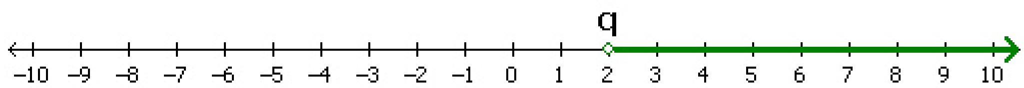
d. $k+14>49$

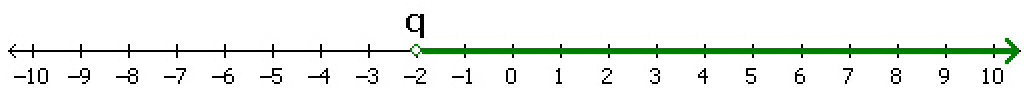
Appendix B

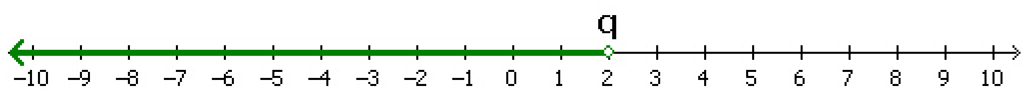
(Illuminate Itembank, 2017)

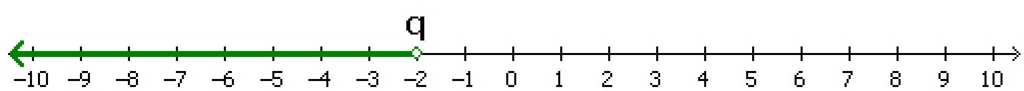
7th grade Math Inequalities Post-Test

1. Which choice is the solution set for $4q-4<-12$?

   a. 

   b. 

   c. 

   d. 

2. Nine more than a number, n, is greater than ten. Which inequality represents this relationship?

   a. $9+n\leq10$

   b. $n+9>10$

   c. $10\leq n+9$

   d. $n-9>10$

3. Solve for f in the inequality below.

   NOTE: Your answer should be a simple INEQUALITY.

$$13+3f>-2$$

4. What is the solution to the inequality $-x - 33 > 20$?

   a. $x > 53$

   b. $x < -53$

   c. $x < 53$

   d. $x > -53$

5. Bill wants to get a grade of at least 85 on the next test. Each wrong answer causes Bill to lose 3 points. What inequality could be used to find the number of wrong answers, x, Bill can get and still receive a score of at least 85?

   a. $(100-3)x \geq 85$

   b. $(100-3)x \leq 85$

   c. $100-3x \geq 85$

   d. $100-3x \leq 85$

6. Solve for k in the inequality below.

   NOTE: Your answer should be a simple INEQUALITY.

   $$9 < 19 - 2k$$

7. Solve for b in the inequality below.

   $$4b+3 > 19$$

   a. $b<4$

   b. $b>5$

   c. $b<5$

d. $b>4$

8. George originally had 10 cards. Then, Ronald gave him k cards. George now has less than 49 cards. Which best describes George's current amount of cards?

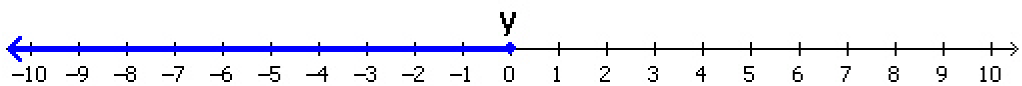
a. $k-10>49$

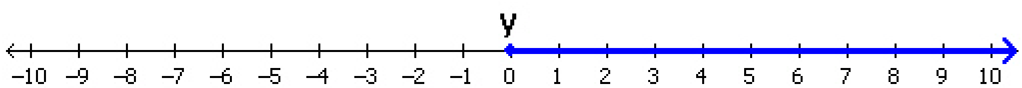
b. $k-10<49$

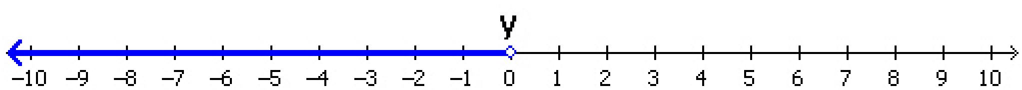
c. $k+10<49$

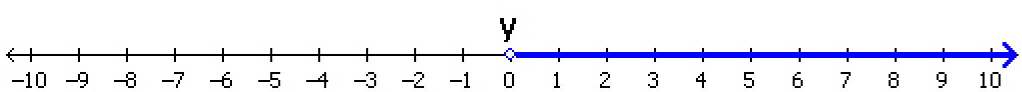
d. $k+10>49$

9. Which choice is the solution set for $-9\geq-9+5y$?

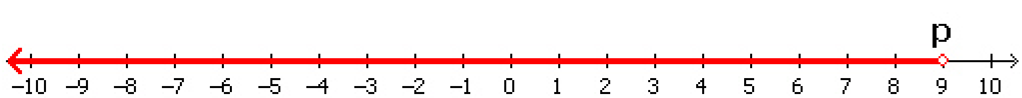
a. 

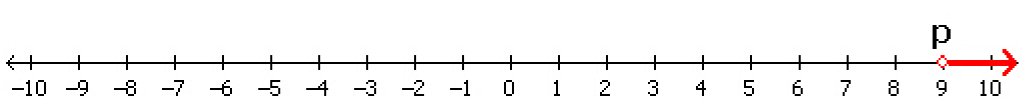
b. 

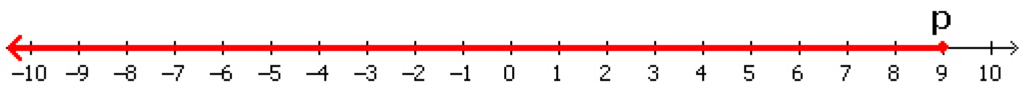
c. 

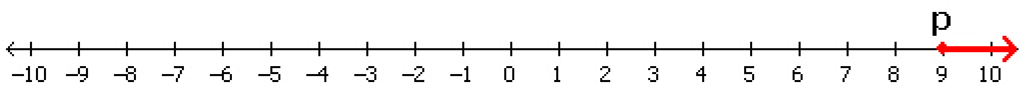
d. 

10. Which choice is the solution set for $-8p+2\leq-70$?

a. 

b. 

c. 

d. 

Appendix C

Sample Inequalities Inquiry Based Activity (Dietiker, Baldinger, & Kassarjian, 2013)

6-37. WHEN IS THE BOUNDARY POINT INCLUDED?

Represent the solution for each of the variables described below as an inequality on a number line and with symbols.

a. The speed limit on certain freeways is 65 miles per hour. Let x represent any speed that could get a speeding ticket.

b. You brought $10 to the mall. Let y represent any amount of money you can spend.

c. To ride your favorite roller coaster, you must be at least five feet tall but less than seven feet tall. Let h represent any height that can ride the roller coaster.

6-38. Ellie was still working on her dollhouse. She has boards that are two different lengths. One long board is 54 inches.

a. The length of the short board is unknown. Ellie put three short boards end-to-end and then added her 12-inch ruler end-to-end. The total length was still less than the 54-inch board. Draw a picture showing how the short and long boards are related.

b. Write an inequality that represents the relationship between the short boards and 54 inches shown in your diagram in part (a). Be sure to state what your variable represents.

c. What are possible lengths of the short board? Show your answer as an inequality and on a number line.

6-39. Jordyn, Teri, and Morgan are going to have a kite-flying contest. Jordyn and Teri each have one roll of kite string. They also each have 45 yards of extra string. Morgan has three rolls of kite string plus 10 yards of extra string. All of the rolls of string are the same length. The girls want to see who can fly their kite the highest.

a. Since Jordyn and Teri have fewer rolls of kite string, they decide to tie their string together so their kite can fly higher. Write at least two expressions to show how much kite string Jordyn and Teri have. Let x represent the number of yards of string on one roll.

b. Write an expression to show how much kite string Morgan has. Again, let x be the number of yards of string on one roll.

c. How long does a roll of string have to be for Jordyn and Teri to be able to fly their kite higher than Morgan's kite? Show your answer as an inequality and on a number line.

d. How long does a roll of string have to be for Morgan to be able to fly her kite higher than Jordyn and Teri's kite? Show your answer as an inequality and on a number line.

e. What length would the roll of string have to be for the girls' kites to fly at the same height?

Appendix D

Fidelity Checklist

Control Group		
Week of Observation	**Date Observed**	**Initial**
Tuesday, February 20, 2018 to Friday, February 23, 2018		
Monday, February 26, 2018 to Friday, March 2, 2018		

Treatment Group		
Week of Observation	**Date Observed**	**Initial**
Tuesday, February 20, 2018 to Friday, February 23, 2018		
Monday, February 26, 2018 to Friday, March 2, 2018		