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The Effectiveness of the Flipped Classroom on Homework and Student Achievement in a Secondary Mathematics Classroom

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Abstract

The purpose of this action research study was to determine the effects, if any, a flipped classroom had on homework and student achievement. The study took place in a high school mathematics classroom over a four-week timeline. Two sections of Algebra 2 were included in this study. Data sources collected from the students included the use of a pre-assessment, quiz, homework rubric, surveys, behavioral logs, and a final assessment that covered the mathematics concepts of rational exponents and radical functions. Additional qualitative data was also collected through teacher observations and teacher-student conversations. While 44% of students' overall grades improved, the final test average was only 67%. Results were inconclusive as to whether using a flipped classroom pedagogy improved student achievement; however, students copying each other's work to receive homework completion points was eliminated during implementation of this pedagogy for the fact that the homework was completed during class time.

Keywords: flipped classroom, student achievement, homework, Algebra 2

In high school settings, homework should be a learning aide to help prepare students for tests and quizzes. Students are receiving 100% on their homework, but then receiving average to failing grades on their tests. Most Algebra 2 classes are tenth and eleventh graders aging between 15-17 years old. There are three teachers that teach Algebra 2 in this secondary school. With allowing students to receive completion points for their homework; homework is not being done well and accurately. There is no thought of learning and applying the material for the test or life skills. Students can get answers with the tap of a button to many mathematics problems via online textbooks and phone apps. Because of this, there is a need to find ways to eliminate cheating and enhance student engagement and learning. When cheating occurs, students are not practicing and learning content, they are simply getting the work done to earn points. Additionally, teachers are not able to hold students accountable for their homework quality, they are essentially giving them the completion points. This also creates a gap with the parents of the students and the teacher because the parent doesn't understand why their student is scoring so well on their homework, but then failing their tests. The teacher is not in a position where they can tell the parent that their student is cheating.

Recognizing this, teachers have several different options: 1) don't assess homework, or 2) change how homework points are achieved/assessed. Since researchers view homework as a tool to help students develop self-regulatory skills and self-efficacy to pursue academic tasks (Bembenutty, 2009), not assessing homework wouldn't be the best option for maximizing student achievement. Previous studies have shown that assigning homework is linked to student achievement for grades 7-12 (Hong, Wan, & Peng, 2011). One finding suggests that students who are regularly assigned mathematics homework in their classes gain more understanding in mathematics (Kitsantas, Cheema, & Ware, 2011).

One way to address this issue is to change the setting of the classroom, implementing the flipped classroom pedagogy. Muir and Geiger (2016) suggest a "flipped" classroom as an

alternative to traditional classroom instruction. Typically, in a flipped class, students prepare for class by watching a video that has been prepared by their teachers to introduce new content and skills (which previously would have been introduced with in-class lectures). This helps with homework because the students are able to interact with the teacher during class time and ask questions in real time about homework content versus listening to the teacher lecture for the hour. This will help in the learning process of the material. Class time allows for targeted and individual instruction, as students rehearse, apply, or transfer the new content/skills they learned about in the previously watched video with supervision and support of their teacher in the classroom (Muir & Geiger, 2016).

With this setting, the teacher is easily able to monitor online video watching, as well as homework completion during class time. Students are not able to participate in class if the video has not been watched before class. This should eliminate cheating as the students are in the classroom while completing their homework, and it should teach them to be prepared and responsible by requiring the video to be watched ahead of time. This pedagogy also maximizes the teacher's time to interact with the students in a one-on-one setting.

Instead of battling with the students to put their phones and headphones away for class, flipped classroom pedagogy is trying to incorporate phones and headphones and channel the students' constant use and attachment to technology for their learning. Prior to the start of class, students will be watching the video on the lesson and taking notes in a packet prepared for them ahead of time by the teacher. Then, during class time, they will be completing the actual homework assignment. For that reason, the purpose of this action research is to see what effects, if any, a flipped classroom has on their quality of homework and student achievement completed in a secondary mathematics classroom.

Theoretical Framework

The Cognitive Theory of Multimedia Learning (CTML) is based on three main assumptions: there are two separate channels (auditory and visual) for processing information; there is limited channel capacity; and learning is an active process of filtering, selecting, organizing, and integrating information (Mayer, 2001). CTML suggests that instructional media should be used in the light of how the human mind works (i.e., video with pictures and sounds). Mayer's CTML presents the idea that the brain does not interpret a multimedia presentation of words, pictures, and auditory information in a mutually exclusive fashion; rather, these elements are selected and organized dynamically to produce logical mental constructs. Furthermore, Mayer (2001) underscores the importance of learning based upon the testing of content and demonstrating the successful transfer of knowledge when new information is integrated with prior knowledge. Design principles including providing coherent verbal, pictorial information, guiding the learners to select relevant words and images, and reducing the load for a single processing channel can be entailed from this theory (David, 2015).

Mayer's CTML encourages the use of a flipped classroom setting in defining the multimedia and individual differences principles (Mayer, 2001). The multimedia principle states that students learn better from words and pictures than words alone (Mayer, 2001). Application of Mayer's principle would suggest that having students watch a video that includes both pictures and text prior to completing homework could improve student achievement. The individual differences principle states that all design principles have a stronger effect on low knowledge learners, also pointing out that teachers need to continue to find ways to reach all students (Mayer, 2001). Taking a completion grade for homework can be interpreted as "bribing" the students to finish their homework and resulting in cheating. Using CTML as a framework in a flipped classroom setting, teachers take advantage of the students' desire to be on technology by having them watch a video at home, but effectively eliminate cheating by having

students complete the assignment in class. Therefore, within the framework of CTML, the flipped classroom environment was expected to provide improved academic achievement when compared to the traditional classroom.

Review of Literature

This literature review examines the relationship between homework and student achievement, while also emphasizing teacher efficiency throughout the day. The goal of issuing homework is to provide a learning aide to the students that will help them retain the information to utilize on later quizzes, tests, and real life situations.

Homework and Student Achievement

Given that learners conduct homework during non-instructional time with little direction from the instructor and a less constricted timeline to complete it, researchers view homework as a tool to help students develop self-regulatory skills and self-efficacy to pursue academic tasks (Bembenutty, 2009). Homework is assigned for a variety of reasons, such as to supplement learning activities and to practice concepts (Bembenutty, 2009). Past studies examined the relationship between academic achievement and homework using variables such as the amount of homework assigned, time spent on homework, and the amount of homework actually completed (Zimmerman & Kitsantas, 2005). Generally, research using these variables remained inconclusive because most studies found that homework is not related to academic achievement in elementary school (Zimmerman & Kitsantas, 2005). However, for the high school student population, some studies did show positive correlations between homework and achievement (Cooper, 2009). Furthermore, Trautwein, Koller, Schitz, and Baumert (2002) analyzed a series of surveys administered to 1,976 middle school students and found that although the frequency of mathematics homework did positively impact mathematics achievement, the amount of homework and the length of time it took to complete the homework had no effect on achievement.

Other researchers examined the longitudinal effects of completing homework either in school or out of school using the National Education Longitudinal Study (NELS) dataset (Keith, Diamond-Hallam, & Fine, 2004). Results from this study revealed that time spent completing homework in school had a relatively large effect on student achievement whereas time spent completing homework outside of school had an insignificant effect on such achievement (Keith et al., 2004). In the study results, it was also suggested that increased proportions of homework time spent on mathematics actually decreased mathematics achievement. Although this was a surprising finding, lack of understanding of a subject can lead to inefficient and disproportionate effort as well as diminished motivation (Kitsantas, Cheema, & Ware, 2011). Trautwein et al. (2002) found that while the frequency of homework positively affected mathematics achievement, the amount and length of time it took middle school children to complete homework did not have an effect on achievement in mathematics. When coupled with the work of Keith et al. (2004), it has been shown that completing homework at school may have a greater benefit than leaving it for completion outside of school.

Although the research does not specifically suggest a flipped classroom pedagogy, teachers may find success in using this method to emphasize the importance of homework as a learning aid to assist in test taking. According to Bergmann and Sams (2012)

> When we taught in the traditional manner, the students who tended to get most of our attention were the best and the brightest- students who would raise their hands first and ask great questions. But since our introduction of the flipped model, our role has changed; now it is directed to the students who need the most help. (p. 29)

Muir & Geiger (2016), define a flipped classroom as one that provides an alternative to traditional classroom instruction. The flipped classroom model requires students to prepare for class by engaging with resources that have been prepared by their teachers. Class time is then used to do more targeted and individual instruction, while creating a working environment for

students to be completing their homework assignment as well. This has the potential to lessen cheating as the homework would be completed in class. Use of the flipped classroom instructional method is gaining popularity, particular in mathematics classrooms, where it has been reported that it results in greater student motivation and interest, and increased student-teacher interaction (Muir & Geiger, 2016). Other purported benefits include allowing for the review of ideas and concepts, greater transparency for students in relation to learning intent, and greater opportunity for teachers to be aware of students' progress (Muir & Geiger, 2016). Homework is also getting completed in class, which frees up the teacher from the time it takes for grading completion points, and eliminates cheating for homework as the teacher is monitoring the classroom. The students understand digital learning, and by implementing flipped classroom, to them, all we are doing is speaking their language (Bergmann & Sams, 2012).

Flipped Classroom

With the rapid advancement in educational technology, many researchers have recommended the use of technology across the mathematics curriculum as it produces positive results in learning and understanding the concepts (Lazakidou & Retalis, 2010). Researchers and practitioners have been exploring alternative strategies and teaching methods to engage and motivate the students in their learning process (Lazakidou & Retalis, 2010). Other educational models include blended learning, reverse instruction, inverted classroom, and 24/7 classroom (Bergmann & Sams, 2012). The flipped classroom is also one of those alternatives (Bhagat, Chang & Chang, 2016). A flipped-mastery classroom takes the principles of mastery learning and marries them with modern technology to make a sustainable, reproducible, and manageable environment for learning.

In one article, the flipped classroom is described as a model in which learners access the online video lectures uploaded by the instructor prior to the classroom sessions and use class

time to participate in meaningful learning activities, instructor-guided problem solving, and discussions (Chen, Wang, Kinshuk & Chen, 2014). In addition, the flipped classroom allows the learners to learn at their own pace (Davies, Dean, & Ball, 2013). Not only can students learn at their own pace, but the classroom teacher can also use the recorded videos as a resource to send an absent student to. The student will watch the video online and then follow-up with the teacher with any questions they have in regards to the material (Bergmann & Sams, 2012). Most importantly, students appreciate the flipped classroom model for so many reasons: (1) it speaks their own language, (2) it teaches them to take responsibility for their own learning, and (3) it is flexible and allows them to work at the pace that works best for them (Bergmann & Sams, 2012). Instead of being teacher-centered instruction, the environment shifts to a student-centered learning, and therefore frees up the teacher to be more interactive helping individual students throughout class time.

Student Achievement and Teacher Efficiency

Implementing the flipped classroom pedagogy allows the teacher to use the class time in an effective manner. Teachers can cover more topics and also give remedial assistance to low achievers (Bhagat et al. 2016). The findings from a previous study revealed that low achievers in the experimental group performed better than the control group. Low achievers got more attention from the teachers, and they discussed the problems to understand the mathematical concept. Therefore, the flipped classroom model may help low achievers to improve their performance in mathematics (Bhagat et al. 2016). On the other hand, teachers can engage with average and high achievers to solve more problems and participate in more class discussions (Davies et al., 2013).

Research studies have found that students demonstrated greater satisfaction and a more positive attitude towards the flipped classroom when compared to traditional classroom pedagogy (Davies et al., 2013). This, in turn, increased their learning motivation (Davies et al.,

2013). Abeysekera and Dawson (2015) also postulated that flipped classroom environments are likely to satisfy students' need for competence, autonomy, and relatedness, which may result in greater levels of both intrinsic and extrinsic motivation of the students. These studies provide evidence that the flipped classroom has a great potential to enhance learning performance and academic gains among learners.

Bhagat et al. (2016) compared the flipped classroom with the conventional method of teaching a mathematical concept, trigonometry, in order to examine its learning effectiveness. Both interventions delivered the same learning content by the same instructor. During the flipped classroom implementation, students accessed videos at their convenience and were also permitted to re-watch the lessons, which was not possible during implementation of the conventional method of teaching. The statistical results of this study indicated that students in the experimental group outperformed students in the control group on the post-test (Bhagat et al., 2016). This suggests that the flipped classroom environment improved the learning achievement of the students in the experimental group, and it is also consistent with their previous studies (Davies et al., 2013). In addition, students were highly satisfied with and positive about the flipped classroom, which resulted in greater learning motivation and achievement (Davies et al., 2013).

Homework

When teachers design homework assignments, teachers' understanding of students' homework problems helps them develop assignments that meet each individual students' readiness and needs (Hong et al., 2011). To generate homework more relevant, teachers need to know the reasons students do not complete their assignments (Hong et al., 2011). Students' views of homework, including the value from effort put into their homework assignments, are positively related to their achievement. Teacher knowledge and understanding of students' decreased interest in completing homework is a critical step to improving homework

performance (Hong et al., 2011). Teachers with a good understanding of students' homework experiences can improve the quality and relevance of homework and lessen the homework problems that students experience (Hong et al., 2011). Homework is a joint effort involving student, educator, and parent. In another study, the instance of homework and Chinese Students– not only do Chinese teachers assign a large amount of homework, but Chinese parents want their children to be given large amounts (Ebbeck, 1996). It is likely that Chinese teachers and parents perceive additional practices and reviews provided by homework as a useful contribution to students' achievement at school. Research on homework with Chinese students is pertinent due to the high level or interest in homework by teachers and parents (Dandy & Nettelbeck, 2002), and to the high level of academic achievement of Chinese students when compared to students of Western countries (Hong, Wan, & Peng, 2011).

Self-Assessment

Potential benefits to students' self-grading is its ability to increase their engagement and commitment to the learning goals of a course (Edwards, 2007). Self-grading also provides immediate feedback – a benefit that can positively influence learning and increase retention (Edwards, 2007). Self-evaluation further provides an opportunity for students to deepen their understanding about a subject – for example, to better understand why a given answer is wrong, or why an alternate answer is better (Simkin, 2015). Self-grading improves class attendance, makes the classroom experience a friendlier, more productive, and cooperative environment, reduces student-teacher conflict, decreases student anxiety, and provides a shared sense of ownership for the learning process (Edwards, 2007). Furthermore, self-grading can enhance student self-esteem and confidence, motivate them to learn, and increase positive attitudes about a course and the instructor who teaches it (Simkin, 2015). On the contrary, students who generously grade their work tend to fall among the lower-performing individuals in a class (Simkin, 2015).

Potential benefits of student self-grading to instructors is the ability to assign homework that the professors might otherwise not require – a characteristic of special advantage to teachers of large classes and a policy that authorities list among the seven best practices of teaching (Chickering & Gamson, 1987). A second advantage is the time that instructors save because their work is limited to recording tasks instead of grading tasks (Sadler & Good, 2006). A third advantage is the potential to increase student engagement and transform students from passive listeners to active evaluators and motivated learners (Stefani, 1994).

Disagreement or Difference of Assigning Homework

Cooper, Robinson & Patall state that homework involves tasks assigned to students by school teachers; these tasks are meant to be carried out during non-instructional time (as cited in Bembenutty, 2011, p. 7). Cooper et al. (2006) reported in a synthesis of homework research that the relationship between homework and school achievement is stronger in grades 7-12 than in K-6. They also suggest that students' motivation to complete homework differs in varying degrees across various subjects. For instance, students spend more time and effort on math homework than English homework (Trautwein, Ludtke, Schnyder, & Niggli, 2006). The relationship between school achievement and time spent on homework is significantly higher for mathematics than for reading (Cooper et al., 2006).

Homework nature, content structure, and teachers' homework assignment practice may be part of the reasons for these discrepancies between mathematics and English subjects. The mathematics subject may be considered highly important in Chinese society, whereas English as a second language may not reach that level of importance, so the different homework behaviors depend on subject domains (Trautwein et al., 2006).

Homework assignments that require an extended amount of time to complete due to their size of assignment have no impact on mathematics achievement. Hong et al. (2011) speculated that when students are given large amounts of homework, their motivation toward the topic

declines. Students also reported with their mathematics homework that when they received too many and too difficult assignments, they concluded that they checked out and thought of themselves as lazy or tardy more so than their teacher thought (Hong et al., 2011).

Summary

Mattis (2015) summarized that efficient instruction, such as flipped classroom instruction, leads to better learning outcomes with less mental effort. He also indicated that students are far more apt to partaking in collaborative team-based learning in class when lectures are moved outside of class time. Mathematics educators are being pushed to improve the performance of the students in mathematics, and with the rapid advancement in educational technology, many researchers have recommended using technology across the mathematics curriculum as it produces positive results in learning and understand the concepts (Lazakidou & Retalis, 2010). In recent years, the flipped classroom approach has gained prominence in the education system. Numerous studies have shown positive effects of the flipped classroom model in teaching and learning activities. Students have been found more satisfied with the learning environment of the flipped model, and that they also performed better in the flipped classroom compared to students in the traditional classroom (Davies et al., 2013).

The flipped classroom is meant to effectively combine traditional and online education by utilizing both in-class and out-of-class time (Mattis, 2015). Flipped classroom setting eliminates cheating within the classroom, as the student is responsible for watching the video the night before and then will be working on their homework during class time with the teacher present. Further, if the teacher has an exit slip within the video that they submit online, there should be no traces of cheating. The teacher will be able to create such a learning environment to capture low, average, and high achievers, and therefore producing a win-win for student and teacher.

Methodology

Action research guided this study with the intent of improving classroom practice. Action research is "a systematic approach to investigation that enables people to find effective solutions to the problems that confront their everyday lives" (Stringer, 2014, p. 1). Both qualitative research (i.e., teacher journals and student discussions), and quantitative research (i.e., students' test and quiz scores, behavioral logs, student check-in, pre- and post-surveys) were gathered resulting in use of a mixed-methods methodology.

This study occurred in a high school mathematics classroom in a mid-sized, Midwestern town. Thirty percent of the school's student population was free and reduced lunch. The mathematics class consisted of tenth and eleventh graders, 15-17 years old. The sample featured 25 male students and 32 female students (n=57). Out of the 57 students, six of them were on independent education plans (IEPs) and four were on 504 plans.

The research was conducted over a four-week time period with the implementation of the flipped classroom during a unit covering rational exponents and radical functions, which is required material for the class. Prior to the research, a parent letter was sent home with the students to explain the study, giving them the option to opt out of the research study. No students opted out. Day one of the study started with a student check-in (Appendix A) asking questions geared toward describing their previous behaviors with homework: how often they completed their homework, whether or not they had to take their homework home to complete it, and if they felt they learned from doing their homework and were able to apply the skills learned to their tests and quizzes. The check-in also determined whether students had ever been in a flipped classroom setting before, and if they were able to access the on-line tutorials from home. If students did not have access to the internet at home, zip drives with the videos prerecorded were provided to them throughout the unit.

Flipped classroom strategies were implemented for four weeks and data collection included behavioral logs (Appendix B), which the students filled out themselves every Tuesday and Thursday marking whether they were on task, using their phone appropriately, and engaged in doing their homework during class time. Homework rubrics (Appendix C) were also used on every homework assignment, which were almost daily, to score completed homework and the quality of their work. In addition, a teacher reflection journal (Appendix D) was recorded in after each hour to describe the atmosphere and classroom environment. A fourteen-question short answer pre-assessment was given to get a handle on the students' knowledge of rational exponents and radical functions. A mid-point quiz with fifteen problem-solving questions, no multiple choice, was given mid-unit. The unit finished with a fourteen-question post-test mirroring the pre-test to help check for growth in the students' mathematics knowledge.

The pre-assessment averages and final test averages were compared to see what improvement, if any, had been made after implementation of the flipped classroom pedagogy. The research ended with a series of post-check in questions, different from the pre-check in questions (Appendix A), in addition to a post-research survey (Appendix E). The post-research survey was a five-question survey where students circled on a scale of 1-10 their stance on that question. The questions were designed to help the teacher better understand how the students perceived homework, and if the flipped classroom had any effects on helping them prepare better for their quiz or test.

On day one of the unit, the flipped classroom instructional model was explained to the students, and any unanswered questions were addressed. Course videos were created and posted on Schoology, an online platform that the school district used for teachers and students to connect outside of the classroom. For each day of instruction, students were required to watch the video through Schoology at home. Then during the following class period, they worked on the assignment in class. This method prepared the students for their assignment, but time was

still allotted for students to ask questions and have full interaction with the teacher throughout the in-class work time.

Prior to the start of class, the teacher researcher checked the analytics on Schoology to see who had watched the video, and therefore would be able to participate in the day's work. While students watched the video at home, they filled out notes on a prepared sheet/packet which they brought to class the following day to help them complete the assignment in class.

Throughout the unit on rational exponents and radical functions, a teacher journal was kept to track student behaviors, record time and effort the intervention took, and make note of particular challenges students had transferring their understanding from the on-line video instruction to the in-class assignments. The teacher journal summed up each day by describing classroom behavior, classroom atmosphere, peer interaction, and work ethic. The teacher was also able to write down notes related to specific students. During class, the teacher interacted with the students, answered questions, and observed problem-solving skills the students used to complete their homework assignments. The teacher also spent time with lower academic achievers to help them understand the mathematics concepts more thoroughly. On the other hand, the teacher pushed the average to high academic achievers to finish their homework and move on to the next video. The teacher included whether the students were interacting and/or helping each other, and whether the assignment was being completed. Lastly, the teacher could write down specific pointers on that day's lesson on whether it was better received, why or why not, if the students finished quicker, if the notes were more difficult, etc., to really breakdown and access the students' maximum learning apex. The students filled out behavioral logs as well to self-reflect on their participation and behavior every Tuesday and Thursday throughout the intervention. The behavior logs specifically asked the students if their phones were stowed or used appropriately in re-watching the video, if they were on task, and if they asked questions or

helped other classmates as they proceeded through the assignment. There was also room for the student to write in any other thoughts on the day in the "notes" area. This provided one measure of student engagement in this instructional model. Additionally, throughout the intervention, the teacher analyzed the completion and quality of homework using a homework rubric. On the homework rubric, students self-assessed their completion with how many problems they were able to get through during the class period from their assignment, and how well they understood it. The teacher then was able to quickly analyze how they self-graded.

Tests and quizzes from previous units as well as the current unit being studied, were used to see if there were demonstrable improvements in student achievement. Previous grades included homework averages for chapter four: polynomial functions, and chapter five: rational exponents and radical functions from last year, as well as the chapter four test, and the chapter five quiz and test for the researcher to be able to compare those scores with this year's scores from the current class sample. Grades used from this year included chapter four and chapter five homework averages, as well as chapter four's test and chapter five's quiz and test averages. These were all compiled so the researcher could compare students' academic achievement in chapters using traditional teaching to the specific chapter where a flipped classroom pedagogy was implemented.

Upon completion of the chapter test, a post check-in was given to the students to determine how the students felt about the flipped classroom setting. It also examined whether they found it beneficial for completing homework, if it affected how well they felt they learned the content, and whether their overall grade went up, stayed the same, or went down. The chapter test and post check-in were delivered and wrapped up on a Friday. On Monday, the five question post-research survey was given for the students to rate the different aspects of the flipped classroom and to leave any additional notes for the teacher.

Analysis of Data

The purpose of this study was to determine the effects, if any, a flipped classroom would have on homework quality and student achievement in a secondary mathematics classroom. The thought process of eliminating cheating on their homework was twofold: 1) by having students complete their assignments in class while the teacher was present, and 2) by filling out the homework rubric to show completion. The homework rubric also served the teacher by lessening the time it took of grading per problem an entire homework assignment. The rubric was meant to be an efficient way of noting the completion and quality of work the student was handing in. Students circled the number they felt they achieved through the amount of work completed.

The fourteen-question pre-test was given in a different form from the final chapter test, but included the same material. The pre-test was given prior to any chapter material had been gone through to display the students' basis of knowledge of the upcoming chapter. After two weeks of flipped classroom, the students were given a fifteen-question quiz to see what they had learned so far, and if there had been improvement and learning since the pre-test. At the end of the four weeks, the final test was administered. In Figure 1, the average and median percentages of each Chapter 5 assessment are exhibited.

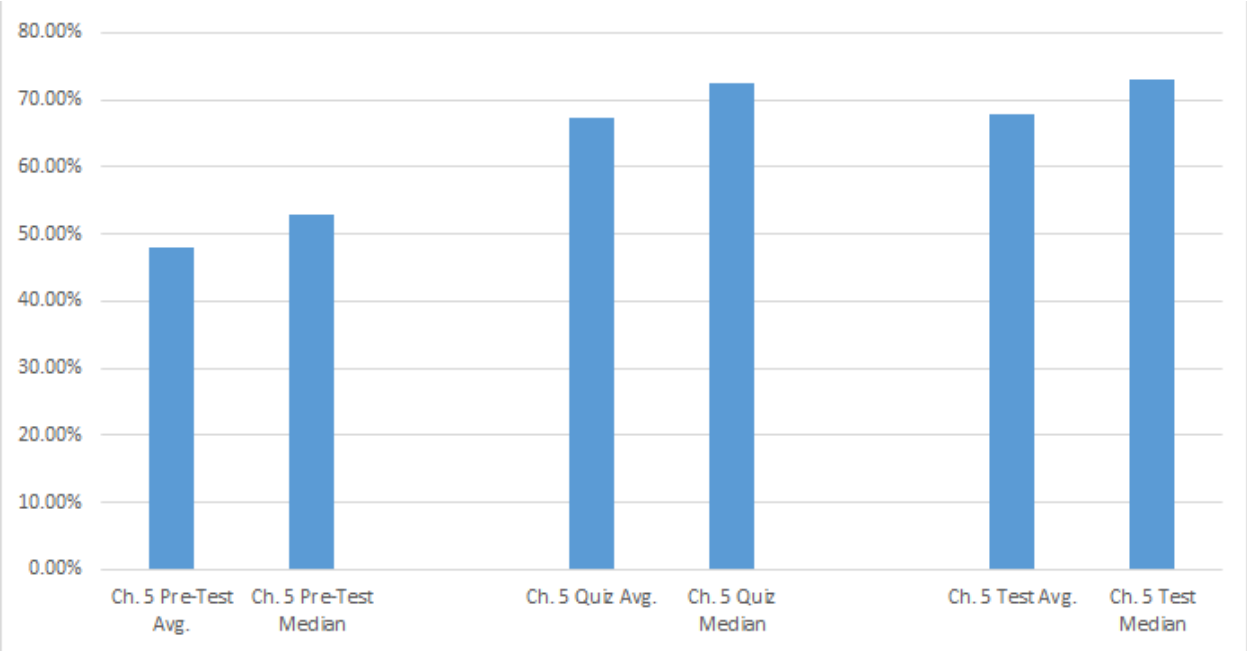

Figure 1. Pre-test, Quiz, Final Chapter test (Flipped Classroom). Averages and Medians in percentages.

The four weeks can also be summarized through the behavioral logs and teacher journaling. Both were used to remind the teacher of that day/week's classroom environment. It also reminded the teacher on how the lesson was received, and how the homework was coming along per student/class.

Because of varying class sizes or students' previous knowledge in mathematics, comparisons were also made between the previous chapter (Chapter 4: Polynomial Functions), and the current chapter (Chapter 5: Rational Exponents and Radical Functions), as well as the previous year (2018) and current year (2019) to better understand the effects of the flipped classroom. Additionally, Chapter 4 homework, quizzes, and test averages and medians were included to display previous and current student achievement.

All data were collected during a four-week unit (Chapter 5) during which a flipped classroom pedagogy was used. These score averages and medians will be displayed in a bar graph (Figure 2) for the current year (2019) and the previous year (2018). The bar graph presents both the quiz and test score average and median, so that when a student turns in a blank test, the

average can be skewed by the scores of zero, therefore the median gives a more accurate percentage for us to analyze. The bar graph shows homework averages being higher overall in the current year versus the previous year. With the flipped classroom, the bar graphs exhibits the quiz score being a much lower average and median than the previous year. The Chapter 5 test average is also lower, but looking closer at the median, the percentage is minimally improved from the previous year.

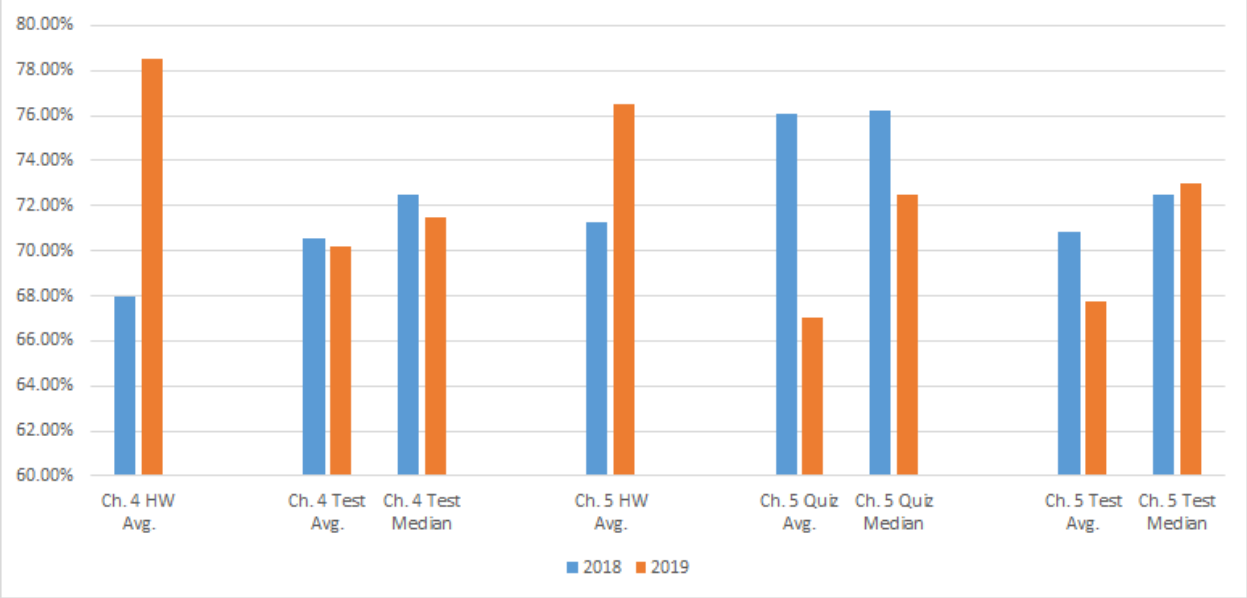

Figure 2. Chapter 4 Comparison to Chapter 5, 2018 to 2019.

The pre-check in results will be displayed in table form with the percentages under each question that was asked on the pre-check in according to student response. Question 1 of 6 in the pre-check in lets the teacher know if any students will have difficulties viewing the videos online. A flash drive of the videos is available to those who may not have internet available to them. The second question lets the teacher and student know what their first quarter grade was as a baseline for them to track what sort of achievement level they are at. Questions 3-5 allow the teacher to get a feel on the students' perception of homework. And lastly, basic information to the teacher on who has already participated in a flipped classroom setting. The post check-in was a simple three question survey for the student to sum up their flipped classroom experience. Additional percentages according to student response on the behavioral logs were calculated as

well. Finally, notes from the teacher journal will also be included in the findings and summarize the intervention.

Findings

To answer the research question, students were given a pre-test on rational exponents and radical functions to measure a baseline of their knowledge on this subject. Students were also required to complete a pre-check in consisting of questions related to how they complete and learn from their homework. Results from the pre-check in are listed in Table 1.

Table 1

Pre-Check-in Results

Do you have access to Wi-Fi/Internet at home?				
Yes			No	
(94%)			**(6%)**	
What is your first quarter grade?				
A	B	C	D	F
(17%)	**(21%)**	**(30%)**	**(17%)**	**(15%)**
Do you think you learn from your homework assignments?				
I do not learn				I learn a lot
1	2	3	4	5
(4%)	**(17%)**	**(38%)**	**(36%)**	**(6%)**
How often do you do math homework at home?				
Every night				Never
1	2	3	4	5
(32%)	**(26%)**	**(23%)**	**(11%)**	**(8%)**
How often do you complete your homework?				
Never				Always
1	2	3	4	5
(4%)	**(11%)**	**(11%)**	**(30%)**	**(43%)**
Have you ever participated in a flipped classroom setting?				
Yes			No	
(66%)			**(34%)**	

Note. There were 32 Female and 25 Male for a total of 57 students

Eighty percent of students answered a 3 or higher that they learn from their homework assignments, but first quarter grades are a range from A's to F's. Of the 57 students, sixty-six percent of students had participated in a flipped classroom prior to this study, so the setting wasn't new to more than half of the students, which helped them have a familiarity with how the class would operate. Ninety percent of students received participation points for watching videos before class.

Thirty percent of the students had an average grade going into this chapter; less than half of the students said they are doing homework each night, and about the same said they complete their homework at home each night, however more than half said that they do not learn from their homework. This presents a problem of homework not being a learning aide for the students to apply to tests and quizzes, but furthermore in the real world. This will also bring test and quiz scores down when the students are not properly completing their homework, and are not able to apply what they learned to their end result – the chapter test, or their finals.

Forty-four percent of students' grades went up after implementing the flipped classroom while thirty-nine of the students' grades stayed the same (Table 2). Eighty-one percent of the students felt they learned the mathematics concept better from working on their homework assignments in class, and thirty-two percent of students always finished their mathematics homework during class.

Table 2

Post Check-In

Did your overall grade go up or down since starting the flipped classroom?

Yes	Same	No
(44%)	**(39%)**	**(17%)**

Do you think you learned the concept better from working on your homework assignments in class?

I did not learn				I learned a lot
1	2	3	4	5
(7%)	**(12%)**	**(29%)**	**(37%)**	**(15%)**

How often did you finish your math homework during class?

Every day				Never
1	2	3	4	5
(32%)	**(29%)**	**(20%)**	**(17%)**	**(2%)**

Note. There were 32 Female and 25 Male for a total of 57 students

Figure 1 in the Data Analysis section summarizes the overall assessment accomplishments, so the teacher researcher can verify if there was any improvement within rational exponents and radical functions while using the flipped classroom pedagogy. These percentages are displayed in Table 3, so the reader can numerically see the improvement as well. The final test average was 67.77%, with a 19.77% improvement from the pre-test, but no significant change from the quiz midway through.

Table 3

Comparison of Pre-test, Quiz and Test Averages

Test	Average
Ch. 5 Pre-Test Avg.	48.00%
Ch. 5 Quiz Avg.	67%
Ch. 5 Test Avg.	67.77%

Note. Averages were based on 57 total students

Table 3 also shows that the flipped classroom setting had consistent improvement from the pre-test starting point to the Chapter 5 final test. Figure 2 in the Data Analysis section

summarized this year to last year's averages, which included the homework average improved five percent from last year for Chapter 5. Table 4 below, shows the teacher researcher and the reader, there is a decrease overall in the quizzes and tests from 2018 to 2019. Homework was the only thing to improve from 2018 to 2019. Note that from 2018 to 2019, the sampling of students is not the same. So despite this year's Chapter 5 homework being a substantial improvement, it should be noted that Chapter 4's homework average from this year was much improved from last year's as well.

Table 4

Comparing Ch. 4 (traditional style Classroom) to Ch. 5 (flipped classroom)

Test/Quiz/HW Title	2018	2019
Ch. 4 HW Avg.	67.98%	78.50%
Ch. 4 Test Avg.	70.57%	70.18%
Ch. 5 HW Avg.	71.30%	76.5%*
Ch. 5 Quiz Avg.	76.10%	67%*
Ch. 5 Test Avg.	70.83%	67.77%*

Note. *Averages were from a flipped classroom

Chapter 4 was a 78.5% homework average, which is the highest recorded for Chapter 4 or Chapter 5, and for last year or this year, but the test average is still right around average (70%). Chapter 5's test average is significantly lower than Chapter 4 despite also having a strong percentage for Chapter 5 homework average. This could mean one of two things: 1) Chapter 4 material is not as difficult as Chapter 5 material, or 2) the flipped classroom was not as successful as teaching as a traditional classroom setup was. Comparing only Chapter 5 also fluctuates with its results. The homework average increased by 5.2% with the flipped classroom. However, the quiz and the test averages were both lower in the flipped classroom setting. Again, one of two things could be factored in: 1) the students have a different level of knowledge or 2)

the flipped classroom was not as successful at getting students to apply what they learned while completing homework to their quizzes and tests. Chapter 5 homework improvement may be due to the flipped classroom setting, however in Chapter 4 the homework had improvement in this year as well. This leads us to another possibility that the students might be stronger in homework, and not so much in tests, or they are not applying the knowledge learned from the homework to their tests and quizzes.

To further analyze the classroom environment, behavioral logs were handed out and filled out by the students every Tuesday and Thursday. Student responses stayed consistent week to week on their behavior logs, as well as showed that the flipped classroom did not affect classroom behavior. From the behavioral logs, eighty-six percent of students declared they were not disruptive during the switch. Teacher journaling supported this result, summarizing that students were interacting appropriately with each other and asking each other questions and working together to solve the homework problems. The student interaction and discussion were all welcomed behavior within this setting. Fifty percent of students claimed they were prepared for class, used their cell phone appropriately, and were on task. The main disclaimer bringing this percentage to half was that the students did not come prepared for class. Students noted on their behavioral logs that they did not like that they had to prepare for class by watching a video ahead of time and take notes as well. In this regard, they stated, they much prefer the traditional teacher-centered lecturing classroom setting.

Student response from the post-check in showed improvements in homework grades from 44% of their overall grades improving with the flipped classroom. However, the verbal feedback from the students' post-study was that the students didn't prefer the setting, but largely because they were responsible for watching the video ahead of time. "Mr. Welch, I enjoyed your videos and the different approach to the classroom learning, but I didn't like that I needed to watch the video ahead of class in order to get my daily participation points." Another student quoted,

"Why do I have to watch the video ahead of time, isn't that what class time is for?" A different note said, "I never had any homework! I was able to always get it done during class time." The students specifically compared the flipped classroom setting to their self-paced Civics class. Their task in Civics is to follow their online syllabus, and work at their own pace. Having to watch the videos and take notes ahead of class time was atypical of how class had traditionally been instructed. Noted in the teacher reflection was that students were interacting with each other with the open classroom setting, but they were not asking the teacher as many questions to ensure their homework was getting done and accurately. The teacher researcher did note that work was being done in class.

Action Plan

There is a need to find ways to eliminate cheating and enhance student engagement and learning. The intent of assigned homework is to provide a learning tool; however, when cheating occurs, students are not practicing and learning content, they are simply getting the work done to earn points. After analyzing the data produced by this study, it is clear that student achievement is challenging to target and assess. Students learn at all different levels and may be very successful in one unit, but struggle with the next. If teachers use only one way of teaching (e.g., traditional lecture teaching, flipped classroom pedagogy, self-paced), there is a risk that not all students will be reached.

Using a flipped classroom pedagogy takes preparation, responsibility, and accountability on behalf of the student, as well as preparation on behalf of the teacher planning the lessons through video and getting them all recorded. This study lends a hand to flipped classroom being a successful pedagogy for some students, as not all students appreciate the preparation flipped classroom takes with having to watch the video and take notes prior to class time. A considerable number of high school students struggle in school. Thus, it is necessary to develop methods to help students who struggle academically to better understand mathematical concepts.

Flipped classroom instructional environments have not yet been well researched. As teachers, to be able to give variety to teaching methods, this research concluded that using a flipped classroom pedagogy would be best to use when teaching easier topics, such as linear functions or sequences and series – topics that lend themselves to higher student achievement. With more difficult material, such as factoring and rational exponents and radical functions (the unit that flipped classroom was integrated for with this study), discussion amongst students and teacher occurs at a higher frequency and therefore these topics would not be best covered using a flipped classroom pedagogy.

Results are hard to track and receive solid proof that flipped classroom is effective or not effective as students individually excel in different units or do better at certain tests. Having concrete proof that flipped classroom was in fact the reason the student was more successful was hard to come by. Students are stronger in some units and struggle with others, and rational exponents and radical functions is usually a topic students tend to struggle more with. Hence the 44% of students' grades improved, but the average test score for chapter 5 was still only a 67%.

A different research angle could be to set up the two sections of Algebra 2, one maintaining the traditional lecture teaching, while the second section of class implementing flipped classroom pedagogy. This would be another way to compare and see if there is more student achievement improvement due to the flipped classroom. A recommendation would be to set up the research as done with this study, with a pre-test for each section, to have that basis of comparison to start with. As always though, the students vary, and one class may have naturally higher achieving students.

To conclude, with the forward motion of technology, and the adoption of the flipped classroom, both teaching and learning mathematics can be made more gratifying and effective with the common goal being to better our students and improving their homework results, which

in turn can be used as a learning tool to improve their test results. This pathway being implemented for each student is a great way to build a foundation that the student can rely on as they move into the real world.

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Appendix A

Pre-Check in and Post-Check in

Pre-Check in

Do you have access to Wi-Fi/Internet at home?

Yes No

What is your first quarter grade?

A B C D F

Do you think you learn from your homework assignments?

I do not learn I learn a lot

1 2 3 4 5

How often do you do math homework at home?

Every night Never

1 2 3 4 5

How often do you complete your homework?

Never Always

1 2 3 4 5

Have you ever participated in a flipped classroom setting?

Yes No

Note. There were 32 Female and 25 Male for a total of 57 students

Post-Check in

Did your overall grade go up or down since starting the flipped classroom?

Yes Same No

Do you think you learned the concept better from working on your homework assignments in class?

I did not learn I learned a lot

1 2 3 4 5

How often did you finish your math homework during class?

Every day Never

1 2 3 4 5

Note. There were 32 Female and 25 Male for a total of 57 students

Appendix B

Behavioral Log

Student: Date: Hour:

Rate how you did in class this week to maximize your learning. Use this scale:

A= Great **B**= Pretty Good **C**= Average **D**= Needs Improvement **F**= Terrible

Hedricks, C. (2017). *Improving Schools Through Action Research: A Reflective Practice Approach* (4th Ed.). Pearson Education Inc.

Behavior	**Student Assessment**	**Comments**
Prepared for class:	**A B C D F**	
Appropriate use of cell phone:	**A B C D F**	
On task during work time:	**A B C D F**	
Disruptive behavior:	**A B C D F**	
Asks questions/helps others:	**A B C D F**	

Notes:

Appendix C

Homework Scoring Rubric

Score	**Criteria**
5	Problems are done and the work is shown
4	2 - 3 problems are skipped and/or some of the work is missing
3	4 - 6 problems are skipped and/or most of the work is missing
2	7 or more problems are skipped
1	No work is shown
0	Did not get turned in

Appendix D

Teacher Reflection Journal

Date: **Section:**

1. What percent of students watched the video prior to class?

2. Which student stood out today and Why?

3. What were some things that went really well today?

4. What were some things that were a challenge today?

5. What did I learn about student learning today?

Appendix E

Post-research Survey

1. Do you think you learned more from doing your assignments in class with the teacher?

No									Learned a lot more
1	2	3	4	5	6	7	8	9	10

2. Did you find it more helpful to watch the lesson at home and take notes at home?

I did not like watching the lesson at home									Extremely helpful
1	2	3	4	5	6	7	8	9	10

3. Did you like doing homework in class?

I prefer doing it at home									Extremely helpful doing it in class
1	2	3	4	5	6	7	8	9	10

4. How often did you watch the video?

Did not watch									Every night
1	2	3	4	5	6	7	8	9	10

5. Did you feel the flipped classroom setting prepared you more for tests/quizzes?

Not at all prepared									Very prepared
1	2	3	4	5	6	7	8	9	10

Notes: