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The Influence of a Flipped Classroom on Student Achievement, Homework Completion, and Student Perceptions in a High School Algebra 2 Class

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Abstract

The current study investigated the use of technology, specifically flipped classroom practices, in a high school math classroom. This study took place in a rural Maine high school to discover what effects the flipped classroom would have on student achievement, student self-efficacy, and homework completion in an Algebra 2 course. The participants were 43 students, from 8th to 12th grader, in 5 Algebra 2 courses. The researcher compared performance on classroom assessments in both conditions and found no statistical significance on performance. The majority of participants reported no change in self efficacy following the flipped classroom, and the researcher observed a slight increase in homework completion during the flipped classroom.

Literature Review

Introduction

The state of Maine requires that students successfully complete three years of mathematics in high school in order to earn a diploma. Each year juniors across the state have been required to take the Scholastic Aptitude Test (SAT) and elementary students the Maine Educational Assessment (MEA). Each of these exams contains a section about mathematics. The results of these tests have been used, along with other factors, to create a ranking of schools in the state.

In 2008 Maine released a three-year summary of Maine Educational Assessment (MEA) results grades 3-8 which reported that 56% of students met or exceeded the standard for mathematics. The 2011-2012 SAT results for Maine showed that only 46% of students were proficient or proficient with distinction in the area of mathematics. At Mt. Blue high school alone, 38% of students tested on the 2011-2012 SAT's were proficient or proficient with distinction. In fact, 34% of Mt. Blue's juniors tested substantially below proficient in math. In 2012-2013 Mt. Blue dropped from 38% to 33.5% proficient or proficient with distinction, but increased slightly in 2013-2014 to 34.9% proficient or higher (DOE, 2014).

These low and dropping test scores give good reason for educators to search for new initiatives and teaching techniques that may better fit the learning needs of todays students. In an effort to keep up with an ever-changing world, there has been a recent push to incorporate technology use into the classroom to enhance learning and student motivation in hopes of improving student achievement, as well as preparing students for a

technology heavy workforce (Gasser, 2011). One form of technology use in the classroom has been the laptop initiatives implemented in many schools across the nation and the world. It has been shown that in order for these initiatives to be successful there must be teacher buy in (Dunleavy, Dexter, & Heinecke, 2007; Newhouse, 2001; Penuel, 2006) and innovative teaching strategies (Weston & Bain, 2010).

With increased access to technology through 1-to-1 laptop initiatives, the switch to the Common Core standards, and an increased effort to implement Mass Customized Learning, a new teaching style, known as the flipped classroom, has become prominent in many high school and college math courses. With a new emphasis on this new teaching technique, it is important to have research to support its use.

This literature review will discuss the impact of 1-to-1 technology use in schools on student perceptions and achievement. It will define the flipped classroom and discuss the research that has been done with regards to this teaching technique in a mathematics classroom. It will also look at the impact of how students perceive their mathematical abilities, and the effects of those perceptions on their achievement in mathematics. Students views on homework completion in a mathematics classroom will also be addressed.

Maine Laptop Technology Initiative

Maine implemented a 1:1 laptop program in an effort to increase student access to technology and thus their readiness to enter the modern work force. The Maine Learning Technology Initiative (MLTI) was started by Governor Angus King when an unexpected

surplus of money was discovered in the state budget in 2000 (Task Force on the Maine Learning Technology Endowment, 2001). The first distribution of laptops to all seventh graders took place in 2002. The following year all eighth graders were included in laptop distribution, and in 2009 some high schools chose to participate in the rollout as well. Currently, slightly more than half of Maine's high schools have one to one laptops for their students.

This initiative seems to have been successful. According to Walters (2009) MLTI is the longest-running statewide ubiquitous computing effort in the country and in fact Maine has been seen as world leaders for laptop initiatives.

> Experts say the program has achieved technological equity, but the broader goal of linking laptops to improved student achievement has been more elusive. An August 2011 report, commissioned by the state legislature, concluded that the laptop program "has had a significant impact on curriculum, instruction, and learning in Maine's middle schools," but also that it had been carried out unevenly across school districts and subject areas." (Morrell, 2012, p.1).

Mt. Blue, located in RSU 9 in Western Maine, was one of the high schools to start a one-to-one laptop rollout in 2009. Starting that year, and every year since, technology has been a focus for teacher professional development. Every teacher is required to set one goal each year regarding the use of technology in the classroom and then reflect upon these goals at the end of each year. According to research (Penuel, 2006), given this teacher preparation and collaboration time Mt. Blue should have a good foundation to build its laptop initiative from. With laptops in the hands of every student it has been easier for Mt. Blue to integrate technology into their courses.

The Effects of Technology in the Math Classroom

Some studies have been done to learn about the effects of technology in the classroom with respect to student achievement and perceptions (Beal, Qu, & Lee, 2008; Gleason, 2012; Pugalee, 2001). One study found positive results, concluding that students were more likely to seek help from a computer than they were from a peer or teacher in a high school algebra course. (Beal, Qu, & Lee, 2008). Another study found negative results, stating that no significant relationship between test scores and technology use, with the exception of geometry which showed a small negative relationship (O'Dwyer, Russell, & Bebel,l 2008). Some studies suggest modest increases more frequently in the ELA domain than the mathematics (Bebell & O'Dwyer, 2010), while other studies concluded that laptop use had an effect on some math scores but generally not on reading scores (Morell, 2012).

In many studies the use of technology was found to increase student motivation (Beal, Qu, & Lee, 2008; Trimmel & Bachmann, 2004; Pugalee, 2001). With initial studies involving technology in the classroom pointing towards potentially positive effects on student engagement and achievement, schools are looking for ways in which to utilize these new tools. One way in which schools have attempted to improve their mathematics instruction through the use of 1-to-1 laptops, has been to implement the flipped classroom.

What is the Flipped Classroom?

The flipped classroom, also known as the inverted or backwards classroom, is still in a stage of innovation, according to Love, Hodge, Grandgenett, and Swift (2014). Not everyone implements this teaching technique in the same way, but it was created with the intent of moving the lecture out of the classroom (Strayer, 2012). The flipped classroom allows students to receive instruction outside of class time so that they can spend class applying and practicing their new knowledge. Some instructors use online tutoring programs to allow students to receive instruction outside of class (Strayer, 2012), while others film their own lectures and post them online for students to view outside of class (Love, Hodge, Grandgenett, &Swift, 2014). For the purposes of this study, the flipped classroom involved students watching pre-selected youtube videos for homework with a study guide which was filled out while watching the video. Students then came to class to practice and apply the new material with the teacher present to answer questions and help as needed. This is in contrast to the traditional classroom where students receive instruction during class time, usually by lecture, and then are sent home to do practice problems when the teacher is not available to help.

The Effects of the Flipped Classroom

Love, Hodge, Grandgenett, and Swift (2014) stated that, "very little research has been undertaken to rigorously assess the potential effects on student learning that can result from the flipped classroom environment" (p. 317). The majority of studies that have been done, involving the flipped classroom, have been at the college level. One

study sought to discover if the flipped classroom would have an effect on student achievement based on classroom size. The only significant effect found was that student engagement decreased in the larger classes (Gleason, 2012). Other studies indicated that there is little long term achievement differences in students course grades in a flipped classroom versus a traditional classrooms (Love, Hodge, Grandgenett, & Swift, 2014). Similar homework completion rates were found when the flipped classroom was compared to a traditional classroom (Strayer, 2012). One positive effect of the flipped classroom noted that higher levels of innovation and the ability to connect content to future careers were found in the flipped classroom setting(Love, Hodge, Grandgenett, & Swift, 2014; Strayer, 2012). Another positive result showed that though long term grades were similar in the flipped classroom setting when compared to the traditional classroom setting, it was found that students in the flipped classroom setting had a tendency to perform higher on quizzes throughout the semester then did students in the traditional classroom (Love, Hodge, Grandgenett, & Swift, 2014).

While students in the flipped classroom were more able to connect content to real life, traditional classroom students exhibited higher levels of task orientation than did those in the flipped classroom. It was also noted that students in a traditional classroom were more comfortable with classroom routines. (Strayer, 2012).

Self-Efficacy in the Math Classroom

The initial findings that technology use in the classroom can lead to increased motivation (Beal, Qu, & Lee, 2008; Trimmel & Bachmann, 2004) and the use of the

flipped classroom can lead to stronger connections of content to the real world (Love, Hodge, Grandgenett, & Swift, 2014; Strayer, 2012), is especially promising when combined with the research about student's self-efficacy in the math classroom. Research shows that on average, student mathematics self-efficacy was significantly related to mathematics achievement and a statistically significant relationship existed between classroom climate and mathematics self-efficacy and achievement (Peters, 2013). It has also been shown that overall school engagement significantly predicted math achievement scores (Sciarra &Seirup, 2008).

Homework Completion in the Math Classroom

Completing homework has also had an effect on student achievement in mathematics. One study showed that American high school students completing one to two hours of homework daily earn the best test scores (Maltese, Tai, & Xitao, 2012). Some studies have shown that boys reported statistically significant lower homework completion than girls, and teacher feedback has a positive effect on homework completion (Xu, 2011). Though students completing one to two hours of homework daily earn higher test scores, it was also found that homework completion did not impact the final grade for the class (Maltese, Tai, & Xitao, 2012).

Summary

The literature suggests that there are positives effects from using laptops in the classroom including increased motivation, class participation, teacher and student technology use, and student interest level (Bebell & O'Dwyer, 2010). Some studies

suggest modest increases more frequently in the ELA domain than the mathematics (Bebell & O'Dwyer, 2010), while other studies concluded that laptop use had an effect on some math scores but generally not on reading scores (Morell, 2012). The evidence gathered on the effects of laptops on student achievement has been minimal and contains some contradictions. This leaves room for more research to follow. There is a need to discover if one-to-one laptops have any effect on student achievement in the core academic areas including mathematics.

One use for one-to-one laptops is to implement the flipped classroom. Research suggests that the flipped classroom may have positive effects on student motivation and short term student achievement (Love, Hodge, Grandgenett, & Swift, 2014; Strayer, 2012). Much of the research found about the flipped classroom was done at the college level (Gleason, 2012; Love, Hodge, Grandgenett, & Swift, 2014; Strayer, 2012). This leaves room for research about the flipped classroom to be done at the high school level.

The Maine Learning Technology Initiative (MLTI) has been very successful in terms of implementation (Morell, 2012), but it would be valuable to have research to show effects on student achievement in the core academic areas. One way in which MLTI can be helpful is to implement the flipped classroom. Little research has been done to support the use of the flipped classroom at the high school level. More research is needed to discover the value of the flipped classroom and its effects on student achievement and perceptions.This study sought to answer the following questions:

1. How will implementing a flipped classroom approach, through the use of one-to-one laptops, effect students achievement on teacher designed assessments in an Algebra 2 course?

2. How do students perceive their mathematical abilities in a flipped classroom versus a traditional classroom?

3. Is there a difference in the rate of homework completion for a flipped classroom versus a traditional classroom?

Significance of the Study

Maine, and more specifically, Mt. Blue High School has exhibited low test scores in the area of mathematics. This resulted in a need to find ways to improve mathematics instruction. There has been little research on the effects of laptop initiatives on student achievement in the core academic areas, including mathematics. The daily use of one-to-one laptops with the flipped classroom allowed data to be collected regarding student achievement, self-efficacy, and homework completion in mathematics. This study provided the researcher with insights into how her students learned best.

Methods

Five groups of high school Algebra 2 students were studied. For half of the research period, two of the five classes worked in the traditional classroom style while the other three courses worked in the flipped classroom style. The second half of the research period changed the roles of the classes so the two classes in the traditional

setting started working in the flipped classroom setting and the three flipped classrooms switched to the traditional style. Assessment data was collected and compared for both parts of the study.

Student surveys were given in order to search for a change in student perceptions. Homework data was also collected throughout the study to determine a change in completion rates between the two teaching styles.

Site of the Study

This study took place at Mt. Blue High School, located in Farmington, Maine. Farmington has a population of 4,288 according to the 2010 Census report. According to the 2008-2012 data, Farmington had a total of 2,051 people age 25 years and over, and of these 241 had less than a high school diploma, 528 had a high school diploma, 419 had some college or an Associate Degree, 335 had a Bachelor Degree, and 528 had a Master, Doctorate, or Professional Degree. (World Media Group, 2014). A comparison of Farmington's education levels to that of the state and country may be seen in Figure 1 below. The average income in Farmington is $18,536 and 34.79% of the population in Farmington is below the poverty line according to the ASC data from 2008-2012. A comparison of Farmington's average income to that of the state and country may be seen in Figure 2 below.

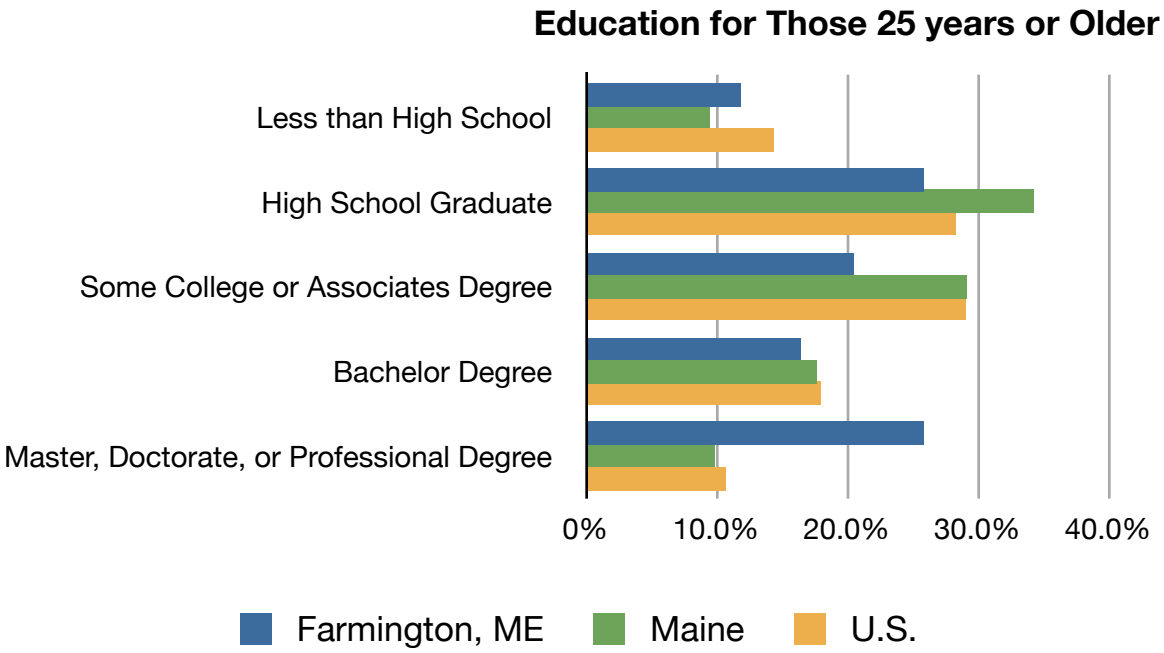

Figure 1. A comparison of education levels for those 25 years and older in Farmington, Maine, and the U.S.

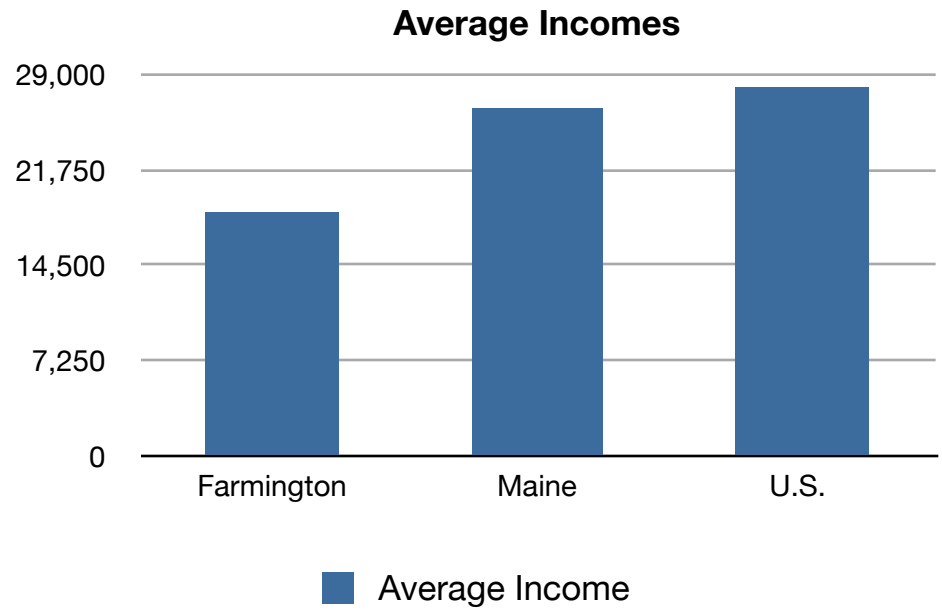

Figure 2. A comparison of the average income of those in Farmington, Maine, and the U.S.

Mt. Blue is part of RSU 9; the district services students from the towns of Farmington, Wilton, Weld, Starks, New Sharon, Chesterville, Industry, New Vineyard, Temple and Vienna. In October of 2013, the district had a total of 2538 students and 1478 of these were eligible for Free or reduced lunch. Mt. Blue High School had 715 students in October of 2013 and 342 of them qualified for free or reduced lunch. (DOE, 2014). As of May 14th 2014, there were 698 students enrolled at Mt. Blue High School. Of these 698 students, 167 are freshman, 184 are sophomores, 179 are juniors, and 168 are seniors. Eight students at the high school identify as Asian/Pacific Islander, 8 as Black, Not Hispanic, 656 as White/Caucasian, 12 as Hispanic, 1 as American Indian/ Alaskan, 1 as Native Hawaiian/Other Pacific Islander, 11 as two or more races, and one was unclassified. The high school consists of 364 males and 334 females and has an average annual dropout rate of 4.1% based on the past 7 years of data.

Student Achievement

All of the schools in RSU 9 ranked as a C on the Maine Report Card system with the exception of Cape Code Hill School which ranked as a B. This ranking is based on numerous factors, including standardized test results. The math results on the NECAP's for 2009-2014 may be seen in Table 1 below.

Table 1

NECAP Results for Mathematics

Year	Number of Students Below Proficient	Total Number of Students Tested	Percent of Students Below Proficient
		6th Grade	
2009-2010	76	188	40%
2010-2011	67	159	42%
2011-2012	66	149	44%
2012-2013	56	159	35%
2013-2014	88	177	50%
		7th Grade	
2009-2010	68	184	37%
2010-2011	67	182	37%
2011-2012	70	172	41%
2012-2013	70	152	46%
2013-2014	69	168	41%
		8th Grade	
2009-2010	60	186	32%
2010-2011	72	182	40%
2011-2012	61	185	33%
2012-2013	78	177	44%
2013-2014	72	146	49%

Mt. Blue High School had 168 juniors take the SAT in 2012-2013. In mathematics, 25.6% of the juniors did not meet the standard, 38.1% partially met the standard, 33.3% met the standard, and a suppressed value occurred for exceeding the standard.

Participants in the Study

A convenience sample of 85 students were offered the chance to participate in this study. Sixty-two of these students were in Algebra 2 College Prep (CP) courses, and 23 were in an Honors Algebra 2 course. Forty-five students agreed to participate in the

study, but two of these students switched classes part way through the study and so only 43 were included in data analysis. Students participating in this study ranged from 8th to 12th grade. Thirty-eight females and 47 males were asked to participate. Twenty four females and 19 males agreed to be participants. In order for students under the age of 18 to participate their parents had to first sign a consent form. Once this form was signed by the parents, then students were asked to sign an assent form stating they were willing to participate in the study. Some students were 18 years old and therefore able to sign an adult participation form, but an informational letter was still sent home to their parents so they would be aware of what their child had been asked to participate in.

Some studies have been done at the college level to determine what effects the flipped classroom approach to teaching may have an student achievement (Gleason, 2012; Love, Hodge, Grandgenett, & Swift, 2014; Strayer, 2012). However, there is little research on how this approach effects students at a high school level. This research study helps to fill this gap.

Instruments

A survey, regarding students self-efficacy, perceptions, and homework completion, was administered twice during this study. Data was collected from a series of tests and quizzes, as well as student homework assignments, during the period of study.

Student survey.

The student survey, found in Appendix A, was given once at the beginning of the study and then again at the end of the flipped classroom portion of the study. This survey was designed by the researcher to determine students perceived self-efficacy in mathematics. Research states that students with higher levels of self-efficacy and motivation have higher achievement in mathematics (Peters, 2013; Sciarra &Seirup, 2008). This survey was comparable to that of Love, Hodge, and Grandgennett's (2014) perception survey. This survey was reviewed by another math teacher to ensure validity. The results of the first survey were compared to the results of the second survey to see if there was a change in ratings after the exposure to flipped classroom.

Quizzes and tests.

Throughout the study students took a series of tests and quizzes that were designed by the researcher (Appendix B). These assessments were reviewed by other mathematics teachers to ensure validity.

For each quiz and test some classes worked in a flipped classroom style while others worked in a traditional style. Each CP class took the same assessment and results were compared to see if there is a difference between teaching styles. These results were comparable to Gleason (2012), Love, Hodge, Grandgenett, and Swift (2014), and Strayer (2012), in that the students did not have a choice which teaching method they received, all classes were taught by the researcher, the classroom expectations were the same for every class, and common assessments were used.

Homework.

Throughout the study students in both the flipped classroom and the traditional classroom were given homework assignments. These assignments were not be graded on correctness, but on completeness. At the end of the study homework completion rates during the flipped classroom setting were compared to homework completion of the same students during the traditional classroom setting to see if any change occurred.

Data Analysis

At the end of the study means and standard deviations were calculated for each assessment in each class. A table was created to display which teaching style produced the highest average for individual classes and to compare standard deviations to see if they were similar for each style. Then two-tailed t-tests were calculated to see if there was a statistically significant difference in the means of the flipped classroom assessments and those from the traditional classroom for each individual class. Students were also grouped by survey responses such that participants responding with sometimes, often, or always to each question would be one group and those responding with seldom or never were in another group. For these groups of participants, two-tailed t-tests were run in order to discover if there were a difference between teaching styles . Two-tailed t-tests were also run on all the participants as one group comparing tests from the flipped classroom to tests from the traditional classroom and also comparing quizzes from the flipped classroom to quizzes from the traditional classroom. Percentages of homework completion were calculated throughout the study for individual classes, and for the

participants as one whole group. This data was compared to look for a change between the flipped classroom and the traditional classroom.

Data from the student surveys at the beginning of the study was compared to that of the final student surveys to understand if individual students had a change in perception about their mathematical abilities. The researcher tallied the number of participants who increased their response on the Likhert scale, decreased their response, reported the same response, or chose not to respond to each of the survey questions after both surveys had been administered. The researcher also compared the results of individual surveys to assessment results to discover a possible trend in the data which might suggest that certain self perceptions in math may lead to certain achievement levels.

The data was analyzed and used to find changes in student achievement, student perceptions, and homework completion.

Results

This study sought to answer three questions:

1. How will implementing a flipped classroom approach, through the use of one-to-one laptops, effect students achievement on teacher designed assessments in an Algebra 2 course?

2. How do students perceive their mathematical abilities in a flipped classroom versus a traditional classroom?

3. Is there a difference in the rate of homework completion for a flipped classroom versus a traditional classroom?

Once the data was collected and analyzed the following results were found.

Student Achievement

When comparing averages on tests in the flipped classroom to tests in the traditional classroom, three classes had a slightly higher average in the flipped classroom while two had a slightly higher average in the traditional classroom. In comparing averages on quizzes in the flipped classroom to quizzes in the traditional classroom, three classes had a slightly higher average in the traditional classroom while two had a slightly higher average in the flipped classroom. Test and quiz data can be seen in table 2 below. With similar assessment scores (table 2) and standard deviations (table 3) no significant change was found on student achievement in the flipped classroom when compared to the traditional classroom. The t-values for the tests run on each class comparing the flipped tests to the traditional tests, as well as the flipped quiz to the traditional quiz may be seen in table 4 below. All calculated two-tailed t-tests came back with findings that were not statistically significant.

Table 2

Test and Quiz Averages by Class

	Traditional Test	Flipped Test	Traditional Quiz	Flipped Quiz
Class 1 CP	82.7	78.7	83.5	88.3
Class 2 CP	86.1	84.7	90.6	87.7
Class 3 CP	70.17	70.7	83.0	90.7
Class 4 Honors	84.6	85.5	86.1	70.0
Class 5 CP	69.4	81.6	78.4	75.2

Table 3

Standard Deviations on Assessment Scores by Class

	Traditional Test	Flipped Test	Traditional Quiz	Flipped Quiz
Class 1 CP	10.46	15.10	16.74	12.58
Class 2 CP	10.19	9.46	9.34	12.02
Class 3 CP	15.37	14.80	11.09	7.23
Class 4 Honors	11.50	10.76	13.61	18.18
Class 5 CP	17.04	15.63	15.52	19.89

Table 4

Two-tailed t-values for Tests and Quizzes by Class

	Class 1 CP	Class 2 CP	Class 3 CP	Class 4 Honors	Class 5 CP	All Participants
Tests	0.605	0.790	0.537	0.813	0.272	0.981
Quizzes	0.584	0.629	0.102	0.008	0.784	0.169

All t-values and their corresponding degrees of freedom were put into an online p-value calculator and all results were found to be not statistically significant.

Student Perceptions

Students were given a pre and post survey to measure self perceptions about their mathematical abilities. The majority of students had no change on their second survey as compared to their first on every question except how frequently they use online instructional videos, which 53.5% of the participants reported using more frequently. Any change in response from never to always was counted as an increase, while any change from always to never was counted as a decrease. When asked if they believed they could earn an A in their current math class, 30.2% of participants reported an increase in the belief that they could earn an A, after the flipped classroom model, when compared to their initial responses, while only 20.9% decreased.

An equal number of participants reported an increase in nervousness before a test as did those who reported a decrease, ending at 16.3% each. There were also an equal number of participants who reported an increase in the belief that they were good at math as those who reported a decrease.

More students reported a decrease in nervousness before a quiz than an increase, with 23.3% reporting a decrease in nervousness before a quiz and 18.6% reporting an increase. Figure 3 below shows how many participants increased, decreased, stayed the same, or did not respond to each survey question.

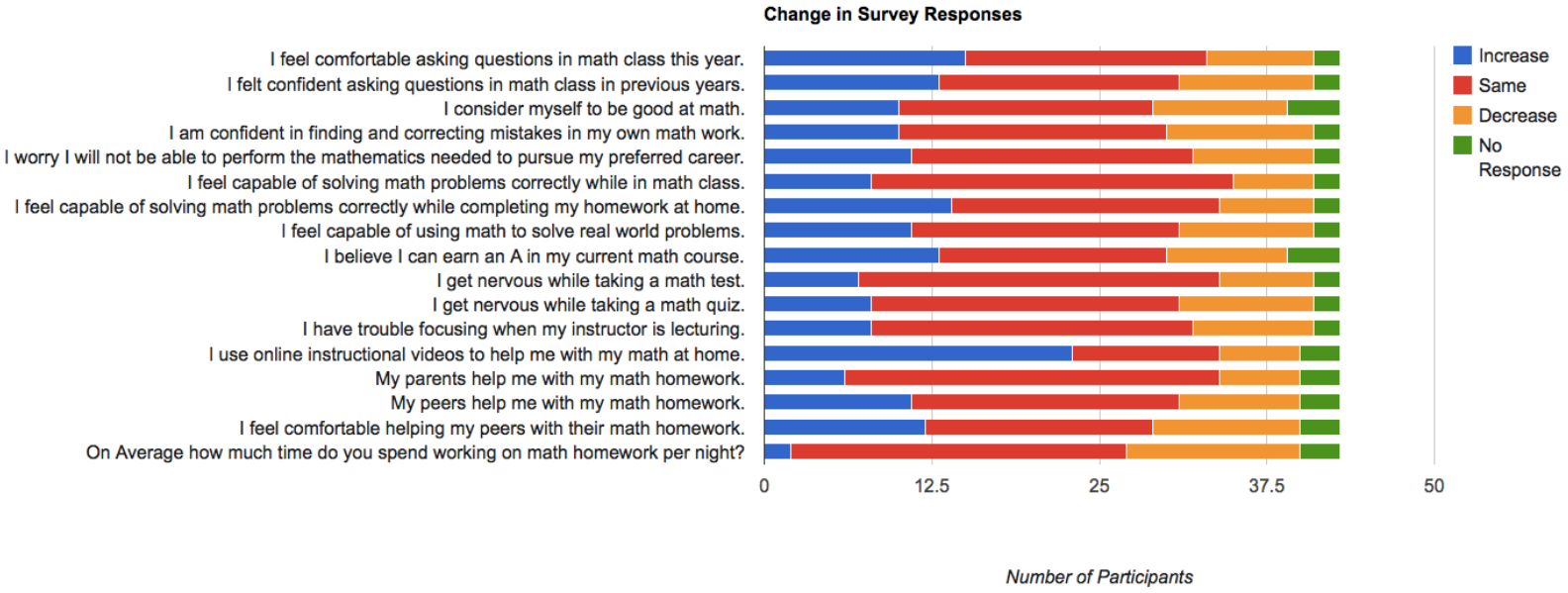

Figure 3. A comparison of responses to the self perception survey given at the beginning of the study and the survey given after the flipped classroom unit.

When comparing students self perceptions from one survey to the next, most students had no change from their initial responses. A range of seven to fifteen participants' survey results showed an increase in certain areas of self-efficacy depending on the question, while a range of six to eleven participants' survey results revealed a decrease in certain areas of self-efficacy depending on the question. Overall there was a a slightly larger increase in the self-efficacy of participants than there was a decrease, though the majority of participants had no change.

Homework Completion

Homework grades were calculated as the percentage of problems attempted for any given assignment. Therefore, if ten problems were assigned and a student completed two of them, that student would receive an 80 on the assignment. Four out of five classes had a higher mean for homework completion in the flipped classroom and smaller standard deviations in the flipped classroom. The one class who had a higher mean in the traditional class also had a smaller standard deviation in the traditional classroom. Table 5 below shows the homework means and standard deviations by class for the traditional classroom, and Table 6 shows the means and standard deviations by class for homework completion in the flipped classroom. When the participants where looked at as one large group, instead of by individual classes, the mean homework completion for the traditional classroom was 77.4 with a standard deviation of 39.4 and the mean homework completion for the flipped classroom was 83.5 with a standard deviation of 35.

Table 5

Means and Standard Deviations for Homework in the Traditional Classroom

Traditional	Class 1 CP	Class 2 CP	Class 3 CP	Class 4 Honors	Class 5 CP
Mean	70.3	69.8	59.0	97.3	66.0
Standard Deviation	41.9	45.4	46.0	12.5	46.6

Table 6

Means and Standard Deviations for Homework in the Flipped Classroom

Flipped	Class 1 CP	Class 2 CP	Class 3 CP	Class 4 Honors	Class 5 CP
Mean	92.0	75.9	83.6	85.1	79.2
Standard Deviation	25.5	42.2	36.5	31.7	40.6

Overall the flipped classroom had slightly higher homework completion rates than the traditional classroom did.

Limitations

This study was limited by the fact that it took place in one high school in rural Maine and all students were being taught by the same teacher, who was also the researcher. The length of the study was short, allowing for only one unit of the flipped classroom and one unit of the traditional classroom to take place. Results may not be comparable to schools in urban areas or students of different grade levels. The population of students participating were primarily white and therefore results may not apply to students of different ethnic backgrounds. This study was also only one form of the flipped classroom. The flipped classroom can be implemented in many different ways and the timeframe of this study allowed for only one method to be studied. This research should not be compared to other forms of the flipped classroom.

The researcher was biased in her belief that technology use in the math classroom does not improve student achievement. This bias may have had an effect on how

students perceived the use of technology in the math classroom and therefore could have effected their opinions of the flipped classroom.

This study consisted of five Algebra 2 courses that were chosen as a convenience sample. These classes were also chosen in order to allow for greater numbers of participants, however the number of participants still remained small. An Algebra 1 course was also taught by the researcher, but was not included in the study because the content was not comparable to that of an Algebra 2 course. The content taught during the study was different during the flipped classroom and the traditional classroom and therefore could be a factor in why students received the scores they did. The researcher required that students identify themselves on their surveys in order to look for connections between individuals' perceptions and achievement. It is assumed that students were honest in their responses.

This study is also limited by the differences in homework assignments between the flipped classroom and the traditional classroom. While the time it takes students to complete the assigned work was made to be similar, the level of thought process necessary to do so was extremely different. In the traditional classroom students were asked to attempt anywhere from ten to twenty problems on their own based off what they learned in class. These problems ranged from easy to difficult on every assignment. The flipped classroom homework required students to fill in notes from the video they watched and attempt three to five easy problems on their own.

Discussion

Student Achievement

It is important to note that even though none of the t-tests came back as being statistically significant, that does not mean that the flipped classroom had no effect on student achievement. Though the t-tests were not statistically significant, many of the means and standard deviations point to similar findings as those of Love, Hodge, Grandgenett, & Swift (2014) who found that students performed higher on quizzes in the flipped classroom than in the traditional, but little differences were found on long term achievement. More of the classes in this study had higher quiz averages in the flipped classroom, though overall the achievement did not change much.

The most likely reason no significance was found for any t-test is the size of the study. As seen in Table 2 above, class 5 had an average of 69.4 on the traditional test and an 81.6 average of the flipped test: a difference of 12.2 points. However, only five students from class 5 participated in the study, making it more difficult to find statistical significance.

As seen in Table 3 above, the highest standard deviations on any assessments occurred on the flipped classroom quiz for class 4 and class 5. This seems to have occurred because multiple students who scored extremely high on the traditional quiz ended up scoring extremely low on the flipped classroom quiz. Their low scores on the the flipped quiz were further away from the mean than their high scores on the traditional quiz causing larger standard deviations because of the small number of participants.

The largest difference in assessment data occurred in the Honor Algebra 2 class when comparing their flipped classroom quiz to their traditional classroom quiz. The t-test found no statistical significance, but the average still dropped from an 86.1 in the traditional classroom to a 70.0 in the flipped classroom, a difference of 16.1 points. This drop was deemed to be uncharacteristic of the class and caused the researcher to spend an additional class reviewing material in a traditional format after the quiz. If the cause of the drop was the flipped classroom teaching, than taking the time to teach the material again in a traditional format may have prevented the same drop from occurring on the flipped classroom test.

Self-Efficacy

The student surveys were analyzed for every individual question to see how many students increased, decreased, or remained the same on the Likhert scale. For any given question a range of 7-15 participants' survey results showed an increase in certain areas of self-efficacy, while a range of 6-11 participants' survey results showed a decrease in certain areas of self efficacy. This suggests that the flipped classroom may work well and strengthen perceptions of some students while causing others to struggle and feel worse about their mathematical abilities. Peters (2013) found that students' mathematics self-efficacy was significantly related to achievement, so if the flipped classroom can raise the self-efficacy of some, but decrease the self-efficacy of others, than it is worthwhile to discover what types of students succeed in this setting in order to better place students in their classes.

Gleason (2012) looked at the flipped classroom based on class size, and the only significant effect found was that student engagement decreased in the larger classes. Similarly, the majority of students in this study reporting a decrease in self-efficacy came from the largest class in the study. However, because the class is only larger than the others by a few students, it is also a possibility that the level of the class has something to do with the results. The Honors Algebra 2 class was the largest class, had the greatest negative change in quiz data during the flipped classroom, and was the only class to decrease in average homework completion during the flipped classroom.

The student survey showed that while some students increased in self-efficacy, a similar number of students decreased. The researcher noticed that many students who did not feel comfortable talking and asking questions in front of the whole class during a traditional setting, seemed to be more connected and willing to ask for help in the flipped classroom when the researcher was able to spend more one on one time with them. Likewise, many students who consistently participated during the traditional classroom seemed to respond less on homework questions and express higher levels of frustration during the flipped classroom.

The one result from the student survey with the largest increase was that after the flipped classroom far more students were more likely to use online instructional videos for help. This is a positive result for students because regardless of what style classroom they are working in, it provides them with additional resources to help them gain understanding of a concept. Even when the flipped classroom ended, the researcher found that many students would go back to the website and watch the instructional videos again to help them prepare for quizzes and tests. It also proved to be very valuable for

students who missed class because they were able to watch the videos and feel like they were not so far behind. The majority of participants also indicated on the survey that they did not receive help from their parents at home, so the videos are useful when no adults in the household are capable of helping with math homework.

Peters (2013) found that on average, student mathematics self-efficacy was significantly related to mathematics achievement and a statistically significant relationship existed between classroom climate and mathematics self-efficacy and achievement Likewise, Sciarra and Seirup (2008) stated, overall school engagement significantly predicted math achievement scores. If in fact, the flipped classroom can lead to increased self-efficacy and student engagement for some students, as this study suggests, then it is likely that in time those students might show increased achievement on assessments. For this reason it is important to know whom the flipped classroom will work well for.

Homework Completion

This study has shown a slight increase overall in homework completion during the flipped classroom. Maltese, Tai, and Xitao (2012) found that students completing 1-2 hours of homework daily earned higher test scores, which may suggest that the flipped classroom in beneficial to students as they are more likely to complete their homework. However, the student surveys also showed that students were spending less time working on their homework during the flipped classroom, which may not be beneficial since Maltese, Tai, and Xitao (2012) found the best amount of time to be 1-2 hours and my

survey results showed that most students were working for less than an hour a night on math homework.

Strayer (2012) found similar homework completions in the flipped classroom compared to the traditional classroom. Though there is a slight increase overall in homework completion during the flipped classroom for this study, the rates are still similar and thus are comparable to that of Strayer (2012). However, this study has shown that while most classes had higher homework completion rates in the flipped classroom, the Honors Algebra 2 class had a lower rate in the flipped classroom. One reason that the homework rates increased for the flipped classroom in most classes may have been due to the nature of the assignments. While traditional classroom homework required students to use knowledge gained in class to complete the assignment with notes taken in class to help with understanding, the flipped classroom homework required students to take notes while watching a video and try only three to five problems on their own. One possible reason that the Honors class homework completion decreased when all of the other classes increased may be due to the fact that the Honors class has a tendency to ask more questions during a lecture than any of the other classes. By having their questions answered in class they could phrase their notes in terms that made sense to them, but when watching a video they could not have their questions answered and therefore did not attempt the problems on their own for fear of teaching themselves incorrectly.

It is also important to note that the small number of students participating in each class can cause the means to shift significantly by just one or two students completing or not completing an assignment. This is also the reason why Table 5 and Table 6 above

have such large standard deviations. Most homework grades are either a 100 or a zero, though it is possible to earn grades in between by partially completing an assignment. This causes the standard deviations to be large because students who do not do their homework at all score significantly far from the mean.

Recommendations

Future studies should conduct multiple units in the flipped classroom and multiple units in the traditional classroom to provide a more focused data set. It would also be beneficial to study a larger population taught by multiple teachers. It would be worthwhile to discover if the level of a class is a factor in how the flipped classroom effects student achievement, self-efficacy, and homework completion, as well as, if the length of time spent on homework has the same effects on test scores in the flipped classroom as it does in the traditional classroom.

The researcher has found ample evidence to suggest that some of her students had positive results in the flipped classroom while others found better results in the traditional classroom. This leads the researcher to believe that a blended model may work well for her future students. The researcher will continue to add to the website of instructional videos that were used for this study and make them available to all of her Algebra 2 courses in future years. For students with excessive absences the researcher plans to allow them to catch up by following a flipped classroom model as it will allow the student to move through the material at their own pace without the teacher present.

The math department at Mt. Blue High School should look at these results and use them to discuss the value of blended teaching practices. The ability to have students working more independently could be very useful in moving towards a standards based grading system, and other math teachers who have been working in the flipped classroom model should also share data from their classes so as to provide a more detailed data set representative of more of the school population. Those currently teaching in a traditional style should also share data from their classes to compare with those teaching in the flipped classroom style and determine if the results of this study are similar to what they see in their own classes.

Conclusion

Overall this study has shown little difference between the flipped classroom and the traditional classroom, but it seems to work well for a certain group of students and causes obstacles for other students. It would be extremely valuable to follow this study with more research to discover which type of students perform best in the flipped classroom, and which students perform better in the traditional classroom. With this data schools may be able to offer both settings in order to help reach the most students.

References

Beal, C. R., Qu, L., & Lee, H. (2008). Mathematics motivation and achievement as predictors of high school students' guessing and help-seeking with instructional software. *Journal of Computer Assisted Learning*, *24*(6), 507–514.

Bebell, D., & O'Dwyer, L. M. (2010). Educational outcomes and research from 1:1 computing settings. *Journal of Technology, Learning, and Assessment*, *9*(1).

DOE (2014). Data warehouse. Retrieved from http://dw.education.maine.gov/DirectoryManager/Web/Maine_report/MaineLanding.aspx

Dunleavy, M., Dexter, S., & Heinecke, W. F. (2007). What added value does a 1:1 student to laptop ratio bring to technology-supported teaching and learning? *Journal of Computer Assisted Learning*, *23*(5), 440–452.

Gasser, K. W. (2011). Five ideas for 21st century math classrooms. *American Secondary Education*, *39*(3), 108–116.

Gleason, J. (2012). Using technology-assisted instruction and assessment to reduce the effect of class size on student outcomes in undergraduate mathematics courses. *College Teaching*, *60*(3), 87-94.

Love,B., Hodge,A., Grandgenett, N. & Swift, A (2014). Student learning and perceptions in a flipped linear algebra course, *International Journal of Mathematical Education in Science and Technology, 45:3*, 317-324, DOI: 10.1080/0020739X.2013.822582

Maine Department of Education, (2012). Maine Education - Maine High School Assessment - School Summary Reports 2011-2012. (n.d.). Retrieved October 14, 2012, from http://www.maine.gov/education/mhsa/school_reports.htm

Maine Department of Education, (2012). Maine Education - Standards & Assessment - MEA - State and School Results. (n.d.). Retrieved October 14, 2012, from http://www.maine.gov/education/mea/edmea.htm

Maltese, A., Tai, R., & Xitao Fan3, x. (2012). When is homework worth the time? Evaluating the association between homework and achievement in high school science and math. *High School Journal*, *96*(1), 52-72.

Morell, R. (2012). Maine's decade old school laptop program wins qualified praise. *The Hechinger Report.* Retrieved November 4, 2012 from http://hechingerreport.org/content/maines-decade-old-school-laptop-program-wins-qualified-praise_10049/?utm_source=Newsletter&utm_campaign=ca7eddf6db-Weekly_newsletter_11_2_201211_2_2012&utm_medium=email

Newhouse, P. (2001) A follow-up study of students using portable computers at a secondary school. *British Journal of Educational Technology, 32*(2), 209-219.

O'Dwyer, L.M., Russell, M., Bebell, D., & Seeley, K. (2008). Examining the relationship between students' mathematics test scores and computer use at home and at school. *Journal of Technology, Learning, and Assessment*, 6(5). Retrieved November 26, 2012 from http://www.jtla.org.

Penuel, W. R. (2006). Implementation and effects of one-to-one computing initiatives: A research synthesis. *Journal of Research on Technology in Education*, *38*(3), 329-348.

Peters, M. (2013). Examining the relationships among classroom climate, self-efficacy, and achievement in undergraduate mathematics: A multi-level analysis. *International Journal Of Science & Mathematics Education*, *11*(2), 459-480.

Pugalee, D. K. (2001). Algebra for all: The role of technology and constructivism in an algebra course for at-risk students. *Preventing School Failure*, *45*(4), 171–76.

Sciarra, D. T., & Seirup, H.J.(2008). The multidimensionality of school engagement and math achievement among racial groups. *Professional School Counseling, 11*(4), 218-228.

Strayer, J. F (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15,* 171-193.

Trimmel, M., & Bachmann, J. (2004). Cognitive, social, motivational and health aspects of students in laptop classrooms. *Journal of Computer Assisted Learning*, *20*(2), 151–158.

Vandenbussche, J., Griffiths, W., & Scherrer, C. (2014). Students' perceptions of homework policies in lower and intermediate-level mathematics courses. *Mathematics & Computer Education*, *48*(2), 149-163.

Waters, J. K. (2009). Maine Ingredients. *T.H.E. Journal*, *36*(8), 34–39.

Weston, M. E., & Bain, A. (2010). The End of Techno-Critique: The Naked Truth about 1:1 Laptop Initiatives and Educational Change. *Journal of Technology, Learning, and Assessment*, *9*(6).

World Media Group (2014). Retrieved from http://www.usa.com/farmington-me.htm

Xu, J. (2011). Homework completion at the secondary school level: A multilevel analysis. *Journal Of Educational Research*, *104*(3), 171-182.

Appendix A

Section 1

	Never	Seldom	Sometimes	Often	Always
I feel comfortable asking questions in math class this year.					
I felt confident asking questions in math class in previous years.					
I consider myself to be good at math.					
I am confident in finding and correcting mistakes in my own math work.					
I worry that I will not be able to perform the mathematics necessary to pursue my preferred career path.					
I feel capable of solving math problems correctly while in math class.					
I feel capable of solving math problems correctly while completing my homework at home.					
I feel capable of using math to solve real world problems.					
I believe I can earn an A in my current math course.					
I get nervous while taking a math test.					

	Never	Seldom	Sometimes	Often	Always
I get nervous while taking a math quiz.					
I have trouble focusing when my instructor is lecturing.					
I use online instructional videos to help me with my math at home.					
My parents help me with my math homework.					
My peers help me with my math homework.					
I feel comfortable helping my peers with their math homework.					

Section 2

On Average how much time do you spend working on math homework per night?

None Less than 1 hour 1-2hours 2-3 hours More than 3 hours

Last year, was your math homework graded:

For Completion For Correctness Not Graded

Appendix B

Chapter 4 TestV2

Name_____ **Date**_____

Simplify Completely.

1.) $\sqrt{-32}$

2.) $\frac{2-3i}{5-2i}$

3.) $\frac{5}{6i}$

Solve by finding square roots.

4.) $6(x+3)^2 = 48$

5.) $s^2 - 33 = -101$

Solve by completing the square.

6.) $x^2 + 6x = 10$

7.) $6t^2 + 24t + 48 = 0$

Solve using the quadratic formula.

8.) $t^2 - 6t + 16 = 0$

9.) $x^2 - 2x - 13 = 0$

10.) $5x - 5x^2 - 7 = 8x + 2$

Graph the following inequality and system of inequalities in two variables.

11.) $y > -2x^2 + 8x - 1$

12.) $y \geq 3x^2$
$y < -x^2 + 2$

13.) Write a quadratic equation in vertex form with the given information.
Vertex: (1,5) **Point on graph: (-1,2)**

14.) Write a quadratic equation in intercept form with the given information.
x-intercepts: -1,5
Point on Graph: (2,4)

15.) Write a quadratic equation in standard form for a parabola that passes through the given points. (-1,9), (1,1), (3,17)

Bonus: Solve for x.
$$2x^2+6x-4 = 0$$

Quiz Sections 5-1 and 5-2

Name_____ Date_____

Simplify completely.

1.) $(a^2b)(a^3b^2)$

2.) $(x^{-2}y^3z^2)^{-4}$

3.) $(4x^{12}y^3z^{-1})^2$

4.) $\dfrac{16q^0r^{-6}}{4q^{-3}r^{-7}}$

5.) $\left(\dfrac{3}{2}\right)^{-1}$

6.) $\left(\dfrac{4p^{-4}s^6}{6ps^7}\right)^2$

7.) $\left(\dfrac{x^2y^{-3}}{3y^2}\right)\left(\dfrac{y^2}{x^{-4}}\right)$

8.) $\left(\left(\left(\dfrac{5x^{15}y^{21}z^{33}}{25x^{-67}y^7z^{-18}}\right)^5\right)^{-2}\right)^0$

Use synthetic substitution to evaluate the polynomial function for the given value of x.

9.) $f(x) = -3x^3 + x^2 + 5x - 9$; $x = 2$

10.) $f(x) = -2x^6 - x^3 + 3x^2 - 4$; $x = -1$

Quiz Sections 5.2-5.3

Name_____ Date_____

Describe the end behavior of the graph of the polynomial function by completing the statements.

1.) f(x) = $-3x^5 + 2x^3 + x - 3$

$f(x) \to ?$ $f(x) \to ?$

$x \to \infty$ $x \to -\infty$

2.) f(x) = $2x^3 + x^2 - 7$

$f(x) \to ?$ $f(x) \to ?$

$x \to \infty$ $x \to -\infty$

3.) f(x) = $5x^2 + 3x - 8$

$f(x) \to ?$ $f(x) \to ?$

$x \to \infty$ $x \to -\infty$

4.) f(x) = $-4x^5 + 5x^4 - x^6 - 2$

$f(x) \to ?$ $f(x) \to ?$

$x \to \infty$ $x \to -\infty$

5.) Graph f(x) = $x^3 - 5$

Simplify Completely

6.) $(2y^2 - 5y + 1) + (y^2 - y - 4)$

7.) $(5s^4 - 2s^3 + 9) - (-2s^4 + 8s^2 - s + 2)$

8.) $2x^3(5x - 1)$

9.) $(y - 1)(y^2 + 6y - 2)$

10.) $(2z+1)^3$

Quiz Sections 5.4 and 5.5

Name_____ **Date**_____

Factor the polynomials completely and solve for the given variable.

1.) $y^3 - 5y^2 = 0$

2.) $4w^4 + 40w^2 - 44 = 0$

3.) $x^6 - 4x^4 - 9x^2 + 36 = 0$

4.) $x^4 - 25 = 0$

Divide using polynomial long division.

5.) $(x^2 + x - 17) \div (x - 4)$

6.) $(4x^2 + 5x - 4) \div (x^2 - 3x - 2)$

Divide using synthetic division.

7.) $(2x^2 - 7x + 10) \div (x - 5)$

8.) $(x^3 - 4x + 6) \div (x + 3)$

Choose a method to divide.

9.) $(3x^4 - 5x^3 + 4x - 6) \div (x^2 - 3x + 5)$

10.) $(2x^3 + x^2 - 8x + 5) \div (x + 3)$

Chapter 5 Test

Name_____ Date_____

Simplify completely.

1.) $\left(\frac{x^2y^{-4}}{5y^2}\right)\left(\frac{y^3}{x^{-6}}\right)$

2.) $\left(\frac{3p^{-4}s^3}{6ps^4}\right)^2$

3.) $(ab)^0$

4.) $(3x^4 - 2x^2 + 4x + 1) + (-2x^4 + x^3 + 4x^2 - 3)$

5.) $(2s^4 - 3s^3 + s - 9) - (-2s^4 + 8s^2 - 3s + 2)$

6.) $(y - 2)(y^2 + 5y - 7)$

7.) $(3z+2)^3$

8.) $(2x - 3)(x + 1)$

Describe the end behavior of the graph of the polynomial function by completing the statements.

9.) $f(x) = -3x^6 + 2x^3 + x - 3$

$f(x) \to ?$ $\quad x \to \infty$

$f(x) \to ?$ $\quad x \to -\infty$

10.) $f(x) = 3x^3 - x^2 - 7$

$f(x) \to ?$ $\quad x \to \infty$

$f(x) \to ?$ $\quad x \to -\infty$

Graph

11.) $f(x) = x^3 - 6$

Use synthetic substitution to evaluate the polynomial function for the given value of x.

12.) $f(x) = -2x^3 + x^2 + 4x - 8$; $x = 3$

13.) $f(x) = -2x^4 - 2x^3 - x + 4$; $x = -1$

Use direct substitution to evaluate the polynomial function for the given value of x.

14.) $f(x) = -3x^4 - 2x^3 - x^2 + 4$; $x = -4$

15.) $f(x) = 2x^2 + 3x - 1$; $x = 2$

Factor the polynomials completely and solve for the given variable.

16.) $y^4 - 3y^3 = 0$

17.) $5w^4 + 50w^2 - 55 = 0$

18.) $x^6 - 4x^4 - 9x^2 + 36 = 0$

19.) $x^4 - 81 = 0$

20.) $x^3 - 27 = 0$

Chapter 5 Test Part 2

Name_____ Date_____

Graph

1.) $f(x) = \frac{1}{6}(x+2)(x-3)^2$

Divide using polynomial long division.

2.) $(x^3 + 3x^2 + 3x + 2) \div (x - 1)$

3.) $(x^3 - 4x + 6) \div (x + 3)$

Divide using synthetic division.

4.) $(2x^2 + 2x - 17) \div (x - 3)$

5.) $(x^4 + 4x^3 + 16x - 35) \div (x + 5)$

Given polynomial f(x) and a factor of f(x), factor f(x) completely.
6.) $f(x) = x^3 + 6x^2 + 5x - 12$; x+4

List the possible rational zeros of the function using the rational zero theorem.

7.) $h(x) = 2x^3 + x^2 - x - 24$

How many solutions will the following polynomial have?
8.) $f(x) = 7x^5 - 2x^3 + 8x^7 - 2x + 8$ **9.) $f(x) = 2x^2 - 6x + 1$**

Find all zeros of the polynomial function.
10.) $g(x) = x^3 - 31x - 30$

11.) $h(x) = x^4 + 4x^3 + 7x^2 + 16x + 12$

Write a polynomial function *f* of least degree that has rational coefficients, a leading coefficient of 1, and the given zeros.

12.) 4, -2, 3

13.) -1, 3, 5i

Write a cubic function whose graph passes through the given points.

14.) (-5,0), (0,0), (1,12), (6,0)

Estimate the coordinates of each turning point and state whether each corresponds to a local minimum or a local maximum.

15.)

Algebra 2 Chapter 6 Quiz

Name_____ **Date**_____

Rewrite the expression using rational exponent notation.

1.) $\sqrt[5]{6}$

2.) $\left(\sqrt[3]{10}\right)^{7}$

Rewrite the expression using radical notation.

3.) $7^{\frac{1}{3}}$

4.) $21^{\frac{9}{4}}$

Simplify Completely.

5.) $\sqrt[6]{256}$

6.) $6\sqrt[3]{5}+4\sqrt[3]{625}$

7.) $\left(12^{\frac{3}{5}} \bullet 8^{\frac{3}{5}}\right)^{5}$

8.) $\sqrt[3]{4x^{3}y^{5}} \bullet \sqrt[3]{12y^{2}}$

Let f(x) = $4x^{-1}$ and g(x) = 5x – 2 . Find the following.

9.) f(g(x))

10.) g(f(x))

Chapter 6 Test

Name_____ **Date**_____

Rewrite the expression using rational exponent notation.

1.) $\sqrt[8]{7}$ **2.)** $\left(\sqrt[5]{6}\right)^3$

Rewrite the expression using radical notation.

3.) $9^{\frac{1}{3}}$ **4.)** $23^{\frac{7}{4}}$

Simplify Completely.

5.) $\sqrt[4]{2592}$ **6.)** $5\sqrt[3]{3}+6\sqrt[3]{192}$

7.) $\frac{2}{\sqrt[4]{3}}$ **8.)** $\sqrt[8]{\frac{x^{16}}{y^{56}}}$

9.) $\left(5^{\frac{3}{7}} \bullet 3^{\frac{3}{7}}\right)^7$ **10.)** $\sqrt[3]{28x^5y^8} \bullet \sqrt[3]{2y^2}$

Let f(x) = 3x - 1 and g(x) = 6x +4 . Find the following.

11.) f(x) + g(x) **12.) f(x) – g(x)**

13.) f(x) • g(x)

14.) $\frac{f(x)}{g(x)}$

Let f(x) = $3x^{-1}$, g(x) = 2x – 7, and $h(x) = \frac{x+4}{3}$**. Find the following.**

15.) f(h(x))

16.) f(f(x))

17.) f(h(2))

18.) g(f(-1))

Verify that the following are inverses.

19.) f(x) = 4x + 9 and g(x) = $\frac{1}{4}x - \frac{9}{4}$

Graph. State the domain and range.

20.) $y = 4\sqrt[3]{x-4} + 5$

21.) $y = \frac{1}{2}\sqrt{x}$

Solve the following equations for x.

22.) $-4\sqrt[3]{x+10} + 3 = 15$

23.) $(3x+5)^{\frac{7}{3}} + 22 = 150$

24.) $x - 6 = \sqrt{3x}$

25.) $\sqrt{3x-8} + 1 = \sqrt{x+5}$

Bonus: Simplify Completely $\left(16^{\frac{5}{9}} \bullet 5^{\frac{7}{9}}\right)^{-3}$