

THE EFFECTS OF PROJECT-BASED LEARNING ON STUDENT ACHEIVEMENT
AND MOTIVATION IN REMEDIAL HIGH SCHOOL ALGEBRA

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2014

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July 2014

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ABSTRACT

Research was conducted to look into the effects of project-based learning on student achievement and motivation in a remedial high school algebra classroom. Throughout the 12 week research period, 13 projects or activities were included in the algebra curriculum. Projects included card games to help reinforce integer operations, order of operations puzzles, equation bingo, and six teleconferences with NASA engineers about applications of mathematics outside of the classroom. Through student surveys, interviews, and summative assessment scores, in addition to a classroom observation journal by the teacher, data was collected on the effects of project-based learning. The data showed an improvement in pre and post test results. The increase was a positive outcome of the research, but was not substantial enough to prove project-based learning in high school algebra is the most successful way to teach the material. It was found students who have extrovert personalities are more receptive and benefit more from project-based learning. Introvert personalities struggle with project-based activities due to social anxiety preventing them from fully participating in the activity. The results of the data analysis did show a substantial increase in students' attitudes towards math. By the end of the treatment students made positive comments concerning math and wrote about how math is important for their futures. The students who made the positive comments were more likely to complete assignments and study to understand the material. Overall, the research showed project-based learning as being a good teaching tool to help motivate students to learn.

INTRODUCTION

Mathematics is one of the most feared subjects currently taught in schools today. I have completed my fourth year of teaching math, and I am constantly met with students who have low confidence in their mathematical ability. Mathematics classrooms have the reputation of being boring and difficult. I decided to become a math teacher because I want to change this perception. As a teacher, I want to show my students' math can be worthwhile, challenging, as well as helping to prepare them for their future. Mathematics is more than number crunching and the memorization of algorithms. The described beliefs led me to pursue an action research project on the effects of project-based learning on student achievement and motivation. After introducing hands on problems, and real world application of mathematics, the students will have a better understanding of how math is applied in the real world.

When students comprehend the importance of mathematics, motivation increases as student confidence grows. Student engagement is a challenge for any teacher, but mathematics is often compared to teaching a foreign language. It is a subject which has a language all its own. The project-based learning research will provide new strategies to keep students involved in their own learning, resulting in increased learning and motivation to not only understand math, but apply it in life as well as the classroom. Consequently, this may not be true for all students, which makes additional research necessary. Different learning styles are considered throughout the research by identifying students who excel in project-based learning, as well as those who dislike this method of instruction. Lesson plans can be easily adapted with the new knowledge and research. Student centered curriculum will put the focus where it should be, on student

achievement and progress. As a teacher, the research allows for an understanding of differentiated learning and its impact on project-based learning. Students need to become the focus of education, as opposed to the content or curriculum.

Project-based learning enhances the learning experience for students. I have incorporated project-based learning activities into a remedial algebra essentials class in a rural southern Idaho high school. Algebra essentials is a class developed to prepare incoming freshmen for high school algebra. In algebra essentials, a review of basic number operations, fractions, integers, and solving equations make up the first trimester of the three trimester algebra course at the high school. Through the action research, I have provided project-based learning experiences for these students at least once a week for a ten week period. Prior to the treatment, the first two weeks of the 12 week trimester were used to collect data on student conceptual understanding and motivation.

Research Questions:

- How does project-based learning impact student motivation in a remedial algebra essentials class?
- What are the effects of project-based learning on student conceptual understanding in remedial algebra essentials?
- Do the effects of project-based learning on student motivation and conceptual understanding differ between boys and girls learning styles in math?
- What are the impacts of project-based learning on the teacher on a daily basis?

The research questions have guided me through the planning and implementation of the treatment. Through the planning stages of the action research project, I used the research questions to focus the instruments and specific data sets. While implementing

the treatment, I kept the research questions in my journal as a bookmark. This strategy allowed me to remain focused on the goals of my research.

CONCEPTUAL FRAMEWORK

Project-based learning provides an approach to education allowing students to learn through teamwork and problem solving using scientific methods. This strategy of project-based learning enhances a students' sense of achievement in learning, and motivation for future learning (Tseng, 2011). It is important to consider motivation in learning because a student's perspective of themselves as a learner affects how and why they work on challenging activities, which will affect whether they welcome or avoid challenges (Meyer, Turner, and Spencer, 1997). Challenging project-based activities are beneficial to student learning and engagement when done correctly.

Meyer et al. (1997) introduced an important issue of different motivation and self-efficacy levels in students and its effects on achievement. The research was conducted in a classroom of fifth and sixth grade students. The focus of the research was on the reactions of different students when presented with a geometry project of building a kite. The authors discussed three types of students; academic risk takers, achievement oriented, and performance oriented. The academic risk taker thrives in a project-based learning atmosphere because they are not afraid to fail. These students learn from their mistakes, and in this study worked to make the best possible kite. The achievement oriented student focuses more on getting the project done and getting a good grade. This type of student is afraid to make a mistake, and will take the easiest route to solving the problem. In this study, the achievement oriented students made plain kites and were bored with the activity because they finished early.

The last type of student was the performance-oriented student. This type of student focuses less on the learning, and more on whether they are keeping up with their classmates and if the teacher approves of their ideas. Performance-oriented students tend to fear project-based learning, and are unable to focus on the academic side of the activity. This article brought to my attention some difficulties students might face in a project-based learning environment. I made the assumption all my students would benefit from a hands-on experience with math. However, now I am realizing it will be important for me to identify the different type of learners within my classroom, so I can provide the necessary support during projects. Even performance oriented students can be successful in a project-based learning environment, but they may need extra support to be successful.

Another study relating to the action research project was conducted in Taiwan, and highlighted attitudes towards STEM, Science, Technology, Engineering, and Mathematics, in a project-based learning environment. The researchers found integrating the subjects helped enhance the students' sense of achievement in learning and improved learning attitudes. Thirty, first year college students with engineering backgrounds were invited to participate in the study during their winter break. They were broken into five groups and asked to build a multi-function electric vehicle. The researchers used surveys and interviews to record and analyze students' attitudes. They found prior to the project, technology was the most popular subject. After the project, engineering was the new favorite subject, suggesting the project-based activity did affect the attitudes of the students. In both the pre and post surveys, mathematics was last on the list (Tseng, 2011).

The researcher delved deeper into the subject of math in a qualitative manner. From the interviews, they found the students suggested the interest in mathematics increased with age and the understanding of the importance of math (Tseng, 2011). These students were in college studying engineering, with math as a fundamental part of their program, which means they will learn it even if it is difficult. The researcher went on to state in the article, educational authorities need to increase the effectiveness of teaching techniques in math, and increase the interest in the subject. I agree, something needs to be done to change the attitude towards mathematics. It is my hope to contribute to this change of attitude by incorporating project-based learning into my classroom.

Attitude and self-efficacy are major factors in students being successful in school. With good teaching strategies these factors will be culminated and used to create success in students. A good teaching strategy is the awareness of ethno mathematics, the study of mathematics from the perspective of various cultures in which mathematics has risen. This means teachers should use examples relevant to their students, as well as being aware math is cumulative and depends on well-defined predecessors (Ralston, 2010). It is important to understand students' cultural backgrounds as well as their different learning styles. The Howard Gardner's Multiple Intelligence Model is used by educators for researching different learning styles. In Gardner's theory, the belief the human being is capable of multiple information processing, helps us better understand different learning styles. These intelligences include logical-mathematics, linguistic, musical, spatial, bodily kinesthetic, interpersonal, and intrapersonal (Kiang, 2010). Unfortunately, most educators only focus on visual, auditory, and kinesthetic learning styles and traditional

school is mainly catered to the visual and auditory learners. The incorporation of different types of projects in the math classroom will extend to a variety of learners.

There are multiple approaches to teaching mathematics. The traditional approach to teaching math is to teach enough mathematics for the student to be successful in the next course. The courses and concepts themselves tend to be isolated, and students are expected to learn the material and be ready to move on to the next topic. It is the duty of the teacher to present the material to the students. A more constructivist approach to teaching math provides a greater student-teacher interaction, and a larger focus on real-life problem-solving. Another focus of the constructivist approach is collaborative learning. The teacher focuses on an integrated curriculum and provides rigorous problem solving activities requiring collaboration (Bart, 2010). I find myself falling into the trap of the traditional approach to teaching math. The constructivist approach of collaborative learning will fit into the action research project of project-based learning.

To ensure learning, students must be given the opportunity to put their newly learned skills into action. The Common Core encourages students to reason abstractly and quantitatively, as well as, justify their thinking to others (Ediger, 2011). This article, on the Common Core, has guided me to the idea of adding a collaborative element to the projects. During the treatment period, my students worked in small groups through the projects and discussed any ideas, problems, and solutions. The collaborative environment will help students gain confidence in the justification of their reasoning. The collaboration piece of the project will allow me to guide and provide feedback when necessary to their responses. The main key to the success of the students is a positive attitude and atmosphere by all involved in the learning process.

A positive attitude toward mathematics is important due to the large number of capable students not pursuing a STEM related degree in college. According to a study conducted by the National Council of Teachers of Mathematics (2011), or (NCTM), research committee, one third of all students who complete calculus in high school take no math classes in college. This means a third of the arguably top high school math students are choosing other degrees, which do not require math, for graduation. Is this because of the negative attitude and reputation of mathematics? Historically, math focuses on mastering processes and algorithms. In the typical classroom, the students were not engaged and often forgot topics from one year to the next. This lethargic method of teaching math needs to change, and every student in any math class should engage in reasoning and answer justification. This will better prepare them for their next mathematical experience, whether it is in college or on the job (NCTM, 2011).

A study by Art Markman shows more men than women are majoring in math and engineering. This fact has led Markman and a group of researchers to explore why this is occurring. The group of researchers worked with 700 German students in grades five through eleven. The research was broken into two studies. The first study asked the students for their general level of math anxiety and then asked them to assess their anxiety twice during an exam. The second study, the students were also asked about their general level of math anxiety, and for their anxiety level during class. In both of the studies it was found girls, in general, had more math anxiety than boys. It was found when asked about anxiety levels during class or exams, both boys and girls had little anxiety in the moment. When the researchers compared the students math performances, it was found both boys and girls were doing equally well in their math classes. The main

difference found by the researchers, was boys consistently rated their competence at math higher than those of the girls. Basically, it was found girls have more math anxiety because they do not have confidence in their math skills (Markman, 2013). This research provided an insight into some reasons why more men than women pursue STEM careers. The article highlights the differences of how men and women think in terms of their mathematical capabilities. It is important as a teacher, to encourage and remind students they are smart and they can be successful. Project-based learning can help develop a positive attitude by allowing students an opportunity to learn and succeed in class.

Many students shy away from math because of the traditional approach to the teaching of mathematics. A change needs to be made. We need our top students to pursue degrees and careers related to the STEM field. Top students will be our future engineers, scientists, and inventors. These are important jobs in our society, and fewer students choose to pursue these jobs because it is too much math. Our approach to teaching needs to change, and I may not have the complete answer to the problem, but I am going to try and make a difference by trying something new. If I can encourage a few more students to engage in the idea math is not “too hard,” I can consider my project a success.

METHODOLOGY

When applying the treatment of project-based learning, it is important to display good teaching strategies. I did not do a project every day, this would have been too overwhelming for me and the students. For the treatment period of 10 weeks, I implemented 13 lesson plans containing interactive projects or activities. During the treatment, I applied appropriate research based teaching components of daily review, presentation of new content or material, initial practice with lots of teacher-student

interaction, feedback and corrections, and independent practice for mastery (Burns and Boice, 2010). These components were applied every day in my classroom. About once a week I interrupted this routine to encourage collaborative thinking and problem solving through projects and activities.

Project-based learning activities were implemented into the traditional algebra essentials curriculum developed by the schools math department. The activities are designed to allow students to discover why math works, as well as how it can be used in the real world. Some of these projects were skills based, and the others were career related. For example, one project the students really enjoyed and learned from was a card game called Zero. In this game students were asked to compete to see who could get a total sum closest to zero. The red cards represented negative numbers and black cards represented positive numbers. This game provided students the opportunity to visualize the difference of adding a positive number verse a negative number. When adding two numbers of the same sign, positive or negative, the students should add the numbers and keep the sign. For example, negative two plus negative three is negative five. The color of the cards helped students visualize the positive or negative value of the card and understand whether they should add or subtract to find the total value of multiple cards. Through the application of activities similar to the one discussed above, I analyzed the impact of project-based learning on students' conceptual understanding and overall grades. The lack of interest in the field of mathematics and poor conceptual understanding, leads me to the main focus of my data analysis, which is student engagement and motivation.

Each week I presented students with at least one hands-on or career focused activity. For the hands-on activities, I grouped the students together in groups of two to four students. Cooperative learning plays a key factor in project-based learning because it provides students the opportunity to discuss any ideas or misconceptions about the topic. After each project, all students were asked to complete a questionnaire on what they have learned and their level of engagement during the activity. An example questionnaire can be found in appendix A. On the days I was not incorporating project-based learning, I taught algebra essentials with a more traditional teaching method.

Algebra essentials is the first trimester of a three trimester freshman level math class. Therefore, those who are enrolled in my second trimester algebra essentials class have failed the same class first trimester and are now taking the class for a second time. I have researched the effects of project-based learning on the students who struggle or are unmotivated learners. One main project type I implemented this year is a collaborative completion of challenging problems involving order of operations, integers, and solving equations. Justification of problem solving strategies and results are skills which will be assessed by the Common Core Smarter Balance Assessment which was administered for the first time in the spring of 2014. This new assessment will assess students on more in depth and involved math problems than what students were accustomed to in the past. For students to be successful with the Smarter Balanced Assessment, they must be able to find math applicable to their lives and worthy of learning.

Math can be made more applicable to students by incorporating projects with a career focus. Minico High School is set up with teleconferencing equipment to be used for distant learning opportunities. With this technology, I have the ability to sign classes

up for free NASA lessons. The students interacted with NASA engineers and discussed how math and science is used in their careers. They participated in teleconferences about STEM careers, ratios and proportions, simple machines, the moon, and the space shuttle. The teleconferences helped open the student's eyes to how math and science can be used outside of the classroom. The NASA engineers did a great job of incorporating the math concepts we were currently learning into their own lessons. For example, when our class was learning about the space shuttle the NASA engineer worked with the students on how to use ratios and proportions to find the amount of fuel the space shuttle would need to reach certain distances. We also calculated the amount of fuel the space shuttle would need to lift specific cargo weights into space. These activities were great for the students to see how the math they are learning can and is used outside of the classroom.

The projects and activities have been incorporated into the lesson plans at least one time every week. Most weeks had one treatment day and four non-treatment days. The action research focused on how weekly activities effect student motivation and conceptual understanding. The mix of treatment and non-treatment will make it difficult to compare the differences between the two groups. Therefore, I decided to start the first two weeks of the trimester with no treatment. This time was used to conduct student interviews, student surveys, teacher journals, and collect information on conceptual understanding through assignments and assessments. After I established the baseline data, I began the treatment and continued the data collection process.

Instrumentation

Data collection is a vital part of the treatment portion of the action research project. To gather more ideas on data collection and analysis, I reviewed a dissertation

studying the effects of project-based learning on middle school students. The treatment was applied two to three times a week through group projects for twelve weeks. The researcher collected qualitative data by a triangulation of observations, surveys, and interviews. Quantitative data was based off performance on chapter assessments, project grades, and student responses on a Likert scale questionnaire evaluating change in motivation. The researcher used pre and post test scores to compare and assess student growth within each unit (Yancy, 2012). This research provided me with good ideas for data analysis to apply to the action research project.

A Master's of Science of Science Education capstone paper on the effects of inquiry instruction on problem solving and conceptual knowledge was used to help collect ideas for data collection and analysis. The purpose of this capstone was to study the effects of inquiry based instruction through labs and projects. After each lab or activity the author had the students write a lab report. The report was used as qualitative data and allowed the author to assess the student's conceptual understanding. The lab report provides the students the opportunity to justify their answers, a component of the Common Core standards. The author used figures and graphs to show quantitative data results of different concepts taught. This allowed the author to show inquiry based instruction was successful for some topics not all (Rust, 2011).

A math motivation survey was administered to the students within the first week of class. The survey was also given to the students at the middle and end of the treatment period. The results were used to assess student attitude and motivation towards mathematics and any changes in responses from pre to post treatment. Personal interviews were conducted with six students at the beginning, middle, and end of the

treatment. The interviews were designed to allow the students to share ideas and opinions on how they learn best and the effectiveness of the projects and activities. Students were selected for interviews by their performance on the pre-assessment. The class was divided into three groups, high, middle, and low scores. A boy and a girl from each group was selected for interviews throughout the treatment period, for a total of six students to be interviewed. The interview questions and the students' surveys can be found in appendix B.

To insure validity and reliability of the action research, a wide variety of data sources have been incorporated throughout the treatment. The strategy has allowed me to ensure data collection has proper triangulation to ensure validity. Furthermore, my husband, a doctoral student in psychology, helped develop the math motivation surveys. The survey examines the level of student frustration in math and their thoughts of overcoming the challenges. The survey allows the students to explain why they like or dislike math. My husband has been a key component in assisting me in deciphering the collected data. A coworker has been gracious enough to sit in on multiple classes during the treatment. These two people have been a valuable asset in discussing the results and insuring the reliability and validity of the data. The following table shows the research matrix developed to ensure proper data collection, triangulation, and validity of the action research questions.

Table 1
Research Matrix

Research Questions	Data Sources				
	1	2	3	4	5
	Math Motivation Survey (Pre/Post)	Student Interview	Teacher/ Colleague Journal	Student Work/ Project Reports	Summative Assessment
What are the effects of project-based learning on student conceptual understanding in remedial algebra essentials?			X	X	X
How does project-based learning impact student motivation in remedial algebra essentials?	X	X	X		
Do the effects of project-based learning on student motivation and conceptual understanding differ between boys and girls learning styles in math?	X	X	X	X	X
What are the impacts of project-based learning on the teacher on a daily basis?		X	X	X	

The action research for these questions has been conducted throughout the second trimester. The trimester was 12 weeks long, November 19th to February 27th of the 2013-2014 school year. The first two weeks consisted of traditional teaching with baseline data collection. Week three through week 12, the treatment was implemented and data was collected. Throughout the entire process of action research, I have created a teaching journal recording many observations including student reactions, my thoughts of the treatment, and student engagement. I have a colleague who volunteered to observe my

classroom and record her observations in a journal. Data collection has also been collected through summative assessments which occurred about every two weeks. These assessments have helped analyze the effect of project-based learning on a student's conceptual understanding.

The data was collected at Minico High School, a rural school in southern Idaho with 40% of the students of Hispanic or Latino origin. Minico has 56% of our student population on free and reduced lunch (Minidoka, 2013). The sample group consisted of 26 students, 23 freshmen, two sophomores and one junior. Within the 26 students, three are English as second language (ESL) students, and three are special needs students on individualized education programs (IEP). The junior is in the ESL program, on an IEP for math, and did not pass the class in her two attempts during her sophomore year. The class is made up of 14 Hispanic students and 12 Caucasian students, ten boys and 16 girls. The school's student population is composed of families who work in agriculture. The algebra essentials class is the first required math class of high school. The prerequisite for this class is eighth grade math or high school pre-algebra for IEP or ESL students. All 26 of the students have taken and failed this course previously. The two sophomores have failed this class three times, twice their freshman year, and once first trimester of their sophomore year. This population of students in my remedial algebra essentials class has grown accustomed to failing math and has a low confidence level in their mathematical ability. Many of these students say, "I do not like math, I am not good at it." This low confidence, and acceptance of failure, has dramatically lowered their motivation to do well in math.

The study design for my research was reviewed by the Montana State University Institutional Review Board (IRB), and was granted IRB exemption on October 31, 2013. A copy of this exemption approval can be found in appendix C.

DATA AND ANALYSIS

Through personal interviews and classroom observations I found an overwhelming dislike toward math in general. When asked “Do you like math?” on the pre-treatment motivation survey, 13 students answered no and the other 13 responded yes and no ($N=26$). When asked to explain their responses 16 students wrote about how they do not like how difficult math can be at times. One student summed up the common belief well with the comment, “I like math class because it is a challenge, but then I hate it because I struggle.” Through teacher observations and journaling, I found many students would work and try to understand the concept, but were quick to quit when they became frustrated.

Summative assessments were a key part to analyzing the research results of the effects of project-based learning on students’ conceptual understanding. Alone, the summative assessment results do not reveal a positive result of project-based learning. Figure 1, shows the results of the class averages of all of the unit tests given in the trimester. The first two assessments, the pre-test and the fractions test, were given prior to treatment. The remaining five assessments were given throughout the treatment period.

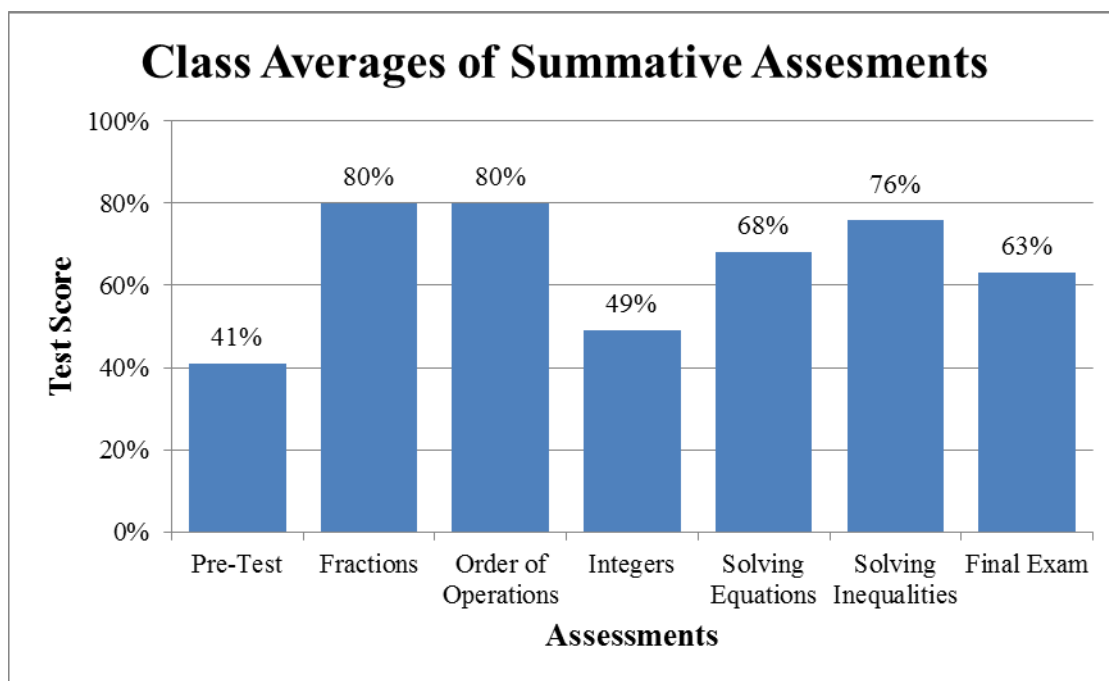


Figure 1. Class Average Summative Assessment Scores by Unit, ($N=26$).

The pre-test was given within the first week of the class and covered the topics students will be learning throughout the trimester. The class average for pre-tests is expected to be low because they cover topics which have not been taught. This class was in the unique position of this not being the first time tested on the material. Of the 26 students in the class, 23 were taking the class for the second time, one for the third time, and two students were now in the class for the fourth time. All 26 students had failed algebra essentials first trimester and were now in the class again second trimester.

The first two units of the trimester, fractions and order of operations, had the highest class average test scores with 80 percent on both tests. The fractions unit was presented prior to treatment and order of operations was the first unit taught with the application of project-based learning. If summative assessments were the lone indicator of conceptual understanding, one might think students would be better off with a more traditional

approach to teaching instead of project-based learning. After completing this research I do not find this to be true. Three students in the second trimester algebra essentials class also took first trimester algebra essentials from me. These students failed my class first trimester under a traditional teaching approach. I used these three specific students to look at how their conceptual understanding changed from first trimester to second trimester with the implementation of project-based learning into my curriculum. All three students increased their conceptual understanding and passed the class second trimester. Figure 2, shows student one struggled more in trying to increase his conceptual understanding. Students two and three had more success increasing their understanding throughout the trimester and treatment period. Student three had a unit where her conceptual understanding decreased. First trimester she earned an A and second trimester a B. I believe the decrease in test score was due to her becoming bored throughout the unit studying something she already knew and understood. When student three was asked about how she did this trimester she said, “I was a much better student this trimester and actually did my work. It was easier and I feel like I improved a lot.” In the past, she was a student who would do little classwork and would fail most of her tests.

Student one, had two sections of decreased conceptual understanding during the treatment period. This showed the treatment may work well for some students, but not all. Student one is a student who struggles with memory tasks and finds it difficult to remember skills learned from day to day. This student requires lots of repetition and one on one attention to ensure he is focused and learning. When asked about how this trimester was going the student responded, “I think it is going good, I get what we are doing.” But when I assess his understanding through formative assessments during

lessons, it is clear he does not understand. The student really struggled because he did not know when he was correct or incorrect in his understanding of the material. Project based activities were frustrating for this student because he would come up with solutions he was positive were correct and would become frustrated with me when I told him they were incorrect. I found this student had the most success and least frustration, when he came in before school and was able to receive one-on-one tutoring with me. A project-based learning environment was not conducive to his learning style needs. The activities provided multiple distractions which broke his focus and decreased the amount of skills he was able to learn.

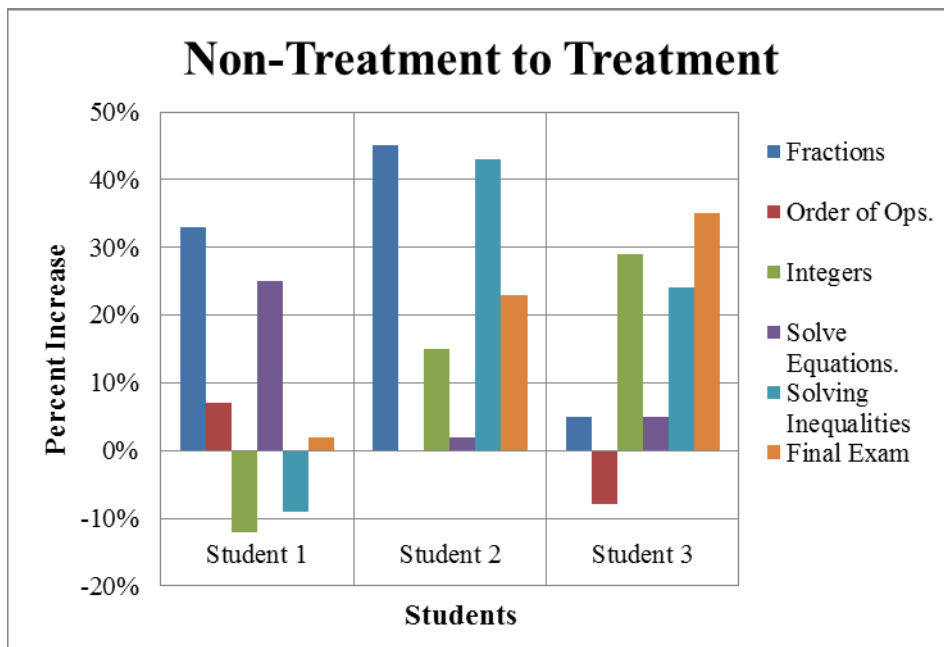


Figure 2. Percent Increase in Unit Summative Assessments from First Trimester to Second Trimester for Three Students, ($N=26$).

The students had a second opportunity to learn the material second trimester with a new approach to teaching. Two of the three students had a substantial percent increase in the first non-treatment test on fractions. The third student scored an 80 percent on the test

first trimester, therefore, making it difficult to obtain a large percent increase. Through classroom observation, the work ethic of these three students was noted throughout the first unit. Like the other students, they worked hard to remain engaged in the lessons and to complete the assignments. Many of the students in the entire class, were upset at failing first trimester and wanted to pass the class. One student commented, “It is embarrassing to be in this class with younger kids.” The common attitude was to get the work done so we do not have to do it again next year. These actions and feelings contributed to the higher scores on the fractions assessments. This attitude began to become less noticeable throughout the entire class, as the trimester went on and I had to work harder to keep the students engaged in the lessons.

The three students who took my class both first and second trimester showed improvement in their assessment scores. Student two did not take the order of operations test first trimester, therefore she had no percent increase to compare in this section. Student one had a 12 percent decrease in his integers test score. The class average of this test was a 49 percent, showing the treatment method was not effective in this unit. The treatment used in this unit focused on a card game which worked on adding and subtracting negative numbers, the activity can be found in appendix A. After the instrument implementation, I found my students had a good understanding of integer operations for simple problems. My project-based learning activities were lacking in the more complex problems the students are expected to know and understand. The students missed the problems on the test which incorporated both integer operations and order of operations. I feel the poor performance on the test was due to the mistake of not developing an additional activity with the appropriate multi-step problems needed to

develop the necessary skills. The treatment in this unit proved effective in teaching the students the basic rules of integers but it needed to be made more challenging to meet the required state standards.

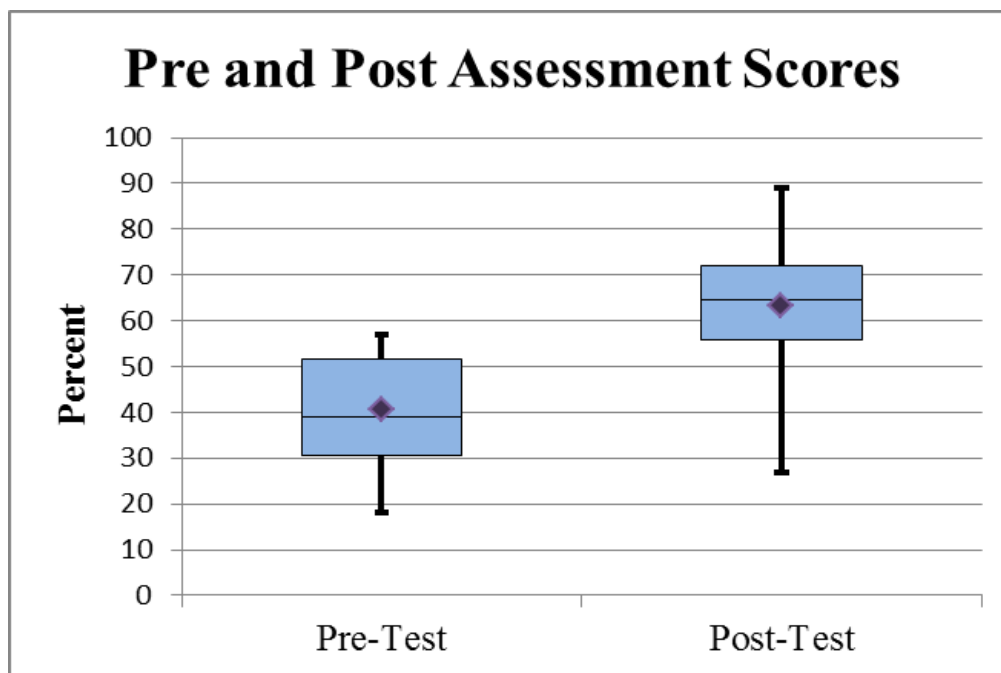


Figure 3. Pre and Post Assessment Scores, ($N=26$).

The class averages of the overall unit summative assessments may not be high, but in the end my students did show an increase in conceptual understanding. Figure 3 shows a majority of the class scored between 30 and 50 percent on the pretest. The posttest proved to have an increase, with a majority of my students scoring between 55 and 72 percent. The spread of standard deviation decreased from pre to posttest decreased, yet the range of scores increased. I had a majority of my students make an increase in their understanding, yet I still had a few students who struggled and scored low on the pre and posttests. When comparing pre and post assessment results 19 students showed 20 percent or more increase in conceptual understanding ($N=26$). It was found 60 percent of

boys ($N=10$) and 75 percent of girls ($N=16$) increased their post test scores by 20 percent or more. The pre and post tests used in the data collection were the same test administered as a check for understanding at the beginning of the trimester and a final exam at the end of the trimester. The assessment can be found in appendix D.

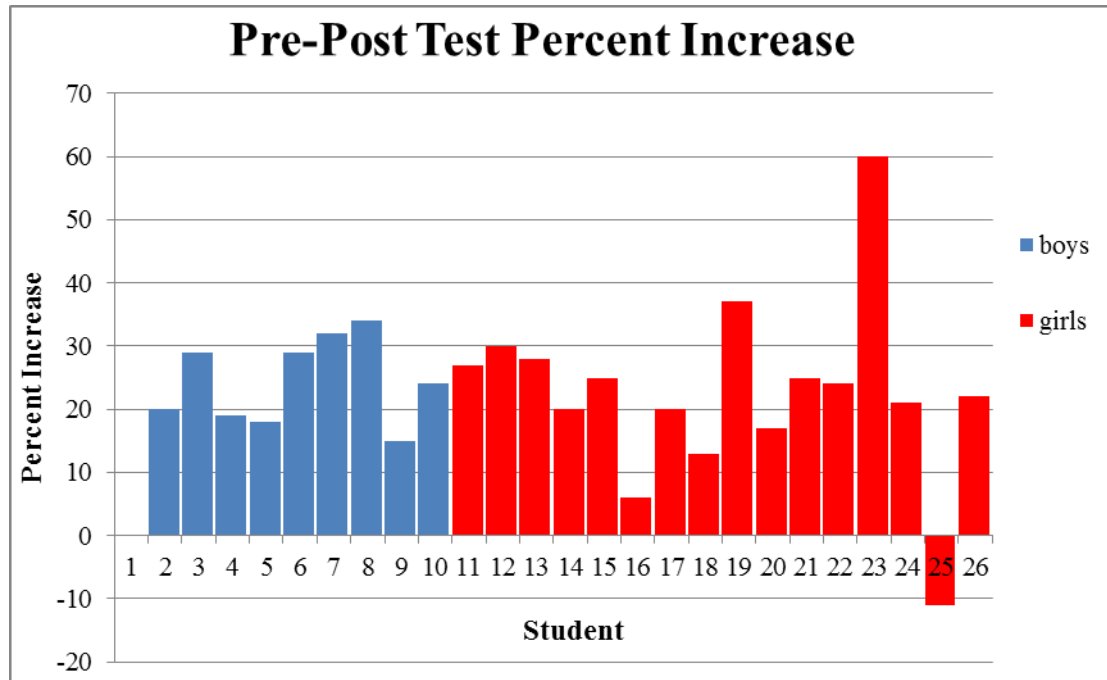


Figure 4. Pre and Post Assessment Percent Increase, ($N=26$).

The pre and post assessment percent increase data identified three major outliers. Figure three, shows student one received a zero percent increase in score. Student one was a young man who began the class with high test scores and conceptual understanding but quickly began to struggle at the introduction of equations. When asked to comment on his thoughts about math his most common response was, “I hate math, it is boring.” This was a student who constantly had a negative attitude and did not want to engage in lessons or activities. Throughout my teacher observation journal I find multiple instances of him being engaged in the project-based activity of the day, but would respond to

project reports with responses like “nothing” or “boring.” An example project report can be found in appendix A. Student one did not show an increase in conceptual understanding through the implementation of project-based learning. My observations showed the student actively participated in the project-based activities but rarely took notes or completed any classwork or assignments. Student one benefited from project-based learning because these were some of the only lessons the student actively participated. Zero percent increase in conceptual understanding was a result of not participating in non-project-based learning lessons and assignments.

Another outlier was a young lady, student 23, who increased her post assessment score by 60 percent. This student is a junior who is in the ESL program, English as a second language, as well as on an individualized educational program, IEP. When talking to this student she clearly states, “I hate math,” but she is embarrassed to be in this class with freshman. This student worked hard throughout the trimester and actively participated in all of the traditional lessons as well as the project-based lessons. The hard work paid off for this young lady and she was able to learn the material and increase her final summative assessment score by 60 percent.

A third outlier was identified in another IEP student, student 25, her final summative assessment score decreased by 11 percent. This young lady is quiet and does not interact well with other students, she can be classified as an introverted personality. I noticed she was more content working alone in the traditional teaching style. When she was asked to work with other students in a project-based learning style she would shy away from the activity and would not fully participate. I feel this student did not benefit from a project-based learning style because she was too shy to take advantage of the

opportunity. This was proven after comparing her responses to the survey question about getting frustrated with math, the survey can be found in appendix E. In the pre-treatment survey she responded she rarely gets frustrated because “I ask for help when I don’t understand.” Her response in the post treatment survey was vastly different when she responded getting frustrated very often because “I get frustrated when I do not understand the math because I am so slow at math and people get it before I do.” It is clear from this change in attitude not only did her conceptual understanding decrease, so did her confidence and motivation to do well. Project-based learning is a good teaching strategy, but it is important to remember it is not effective for every student.

Student motivation was another main focus of the research conducted in the algebra essentials classroom ($N=26$). Student motivation is difficult to measure and required a lot of student input through personal interviews, survey, and questionnaire responses. Student motivation was recorded through a teacher observation journal, documenting student reactions and behaviors to a variety of lessons and activities. A motivation survey was administered at three different stages of the action research. One of the most revealing and interesting was the last question of the survey. “Do you like math?” The other survey questions only showed minor shifts in answers, but a major shift in answers was found in the responses to this question.

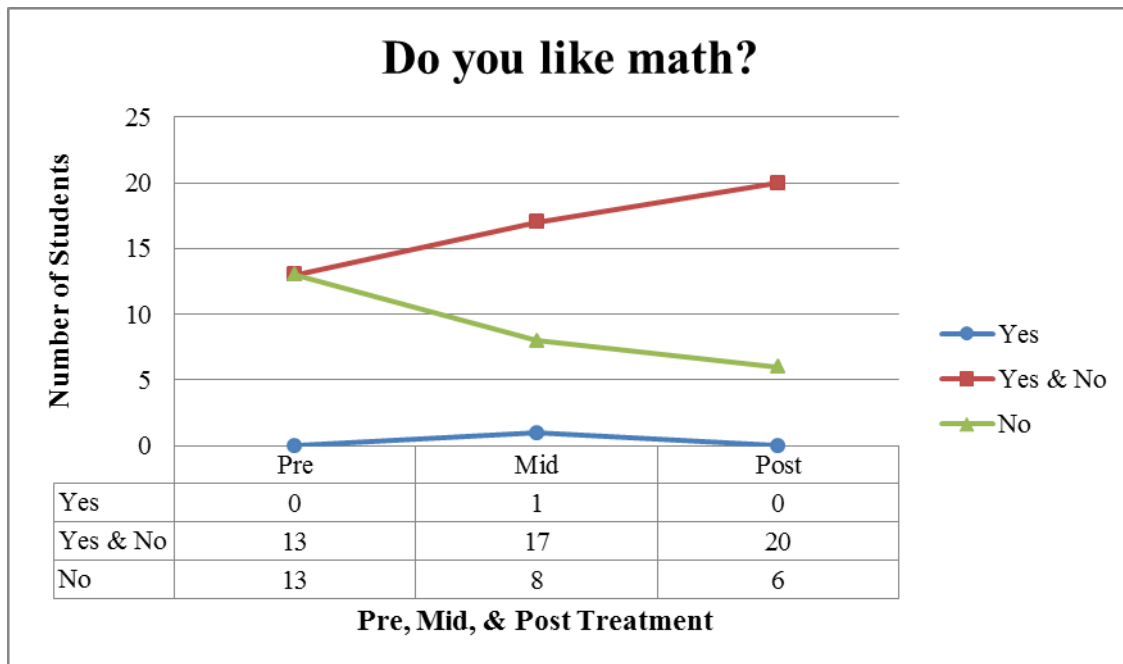


Figure 5. Motivation Survey Responses to the Do You Like Math Question, ($N=26$).

The class began the trimester split exactly in half, 13 students did not like math, 13 students responded yes and no, and zero students claimed to like math. The trimester began with 50 percent of the class disliking math and when asked to explain why many responded with statements like, “I struggle with math, I hate doing the work and it is frustrating to me when I do not understand.” By the end of the trimester there was a shift in the student’s responses. Six students still responded they did not like math, but 20 students said, yes and no, to liking math, this is an increase of seven students ($N=26$). One student who made a shift in his feelings towards math was one of the ESL students. This student struggled with math and the language, making school more difficult for him. In the pre-treatment survey he responded, no he did not like math because, “I am not good at math.” By the end of the trimester his attitude changed and he changed his response to yes and no because, “Sometimes it is easy for me to understand it but

sometimes it is hard to understand some of the problems.” This student still struggles but his attitude change from the beginning of the trimester. At the beginning of the trimester he was a behavior problem and would be off task frequently. By the end of the trimester he was more focused and performed better on his assignments and assessments. This student began the trimester with a negative attitude towards math and a score of 39 percent on the pre-test. By the end of the trimester his attitude shifted to a more positive one and he scored a 73 percent on the final summative assessment. This student was proud of his score and was able to leave the class with more confidence in his mathematical abilities. The student’s confidence in his mathematical ability increased, leading to a higher motivation level to do well in the class and on the final summative assessment.

The math motivation surveys were assessed using a Likert scale. Each selection was assessed a point value one through five. The questions were broken up into two categories for analysis. The first group of questions consisted of question three, and questions five through eleven. These questions were focused on positive attitudes; a high score represents a positive response. Questions one, two and four represented negative responses and a high score for these questions represents negative attitude and motivation toward math. The negative attitude questions focused on feeling nervous or anxious when beginning a new class or taking a test. It also addressed the frustration level of students in math. I found the responses to these questions did not change from pre to post treatment. The Likert score for both pre and post treatment surveys were 3.0, which represented a response of sometimes. This response meant the students on average sometimes feel

nervous, anxious, and frustrated about math and the action research treatment did not change these feelings.

The second grouping of questions represented a more positive attitude toward math and covered topics related to enjoying the challenge of learning, working through problems independently, reasons to do well in math, and future goals in math. The pre-treatment Likert score was 3.125 and the post-treatment score was 3.35. The score shows a slight increase in positive answers after the treatment. The largest increase was found under the question, "I think about what math classes I will need for the future." At the beginning of the trimester the Likert score was 2.3 and by the end the score increase to 3.2. Two represented a response of rarely and three represents sometimes thinks about what math classes needed for the future. The student's responses showed they are now thinking more about their future at the end of the action research. Many of the students would agree with the student who at the end of the trimester said, "I do not really like math because I do not like doing math. But I do kind of like it because it will help me get my dream job." Throughout the trimester we had teleconferences discussing how math can be used outside of school, including future careers. The data shows the discussions have encouraged more students to begin thinking about their future. The focus of many of the project-based lessons throughout the trimester was to help increase student motivation by showing the students how the math can be applied in their future.

Another aspect of the action research project, delves into the effects of project-based learning on student motivation and conceptual understanding on boys and girls in a remedial algebra essentials classroom. The motivation survey was used to compare the

responses between the boys ($N=10$) and girls ($N=16$) in the algebra essentials classroom.

The figure below represents the positive attitude questions of the survey.

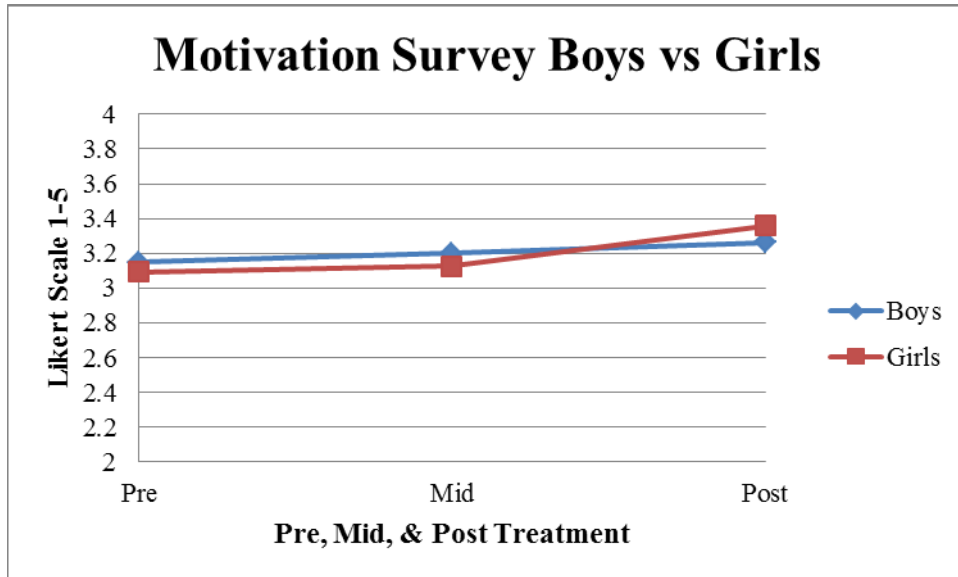


Figure 6. Pre, Mid, and Post Treatment Motivation Likert Survey Responses to Questions Three, and Five through Eleven, ($N=26$).

The motivation survey was administered three times during the trimester ($N=26$). Figure five shows the average Likert score of the boys and girls in the class. At all data collection points the boys and girls provided similar responses to the questions. The girls had a larger increase in positive responses than the boys, but the difference is too small to determine a difference in the effects of project-based learning on student motivation.

The same conclusion was come upon through classroom observation of the students during project-based lessons. When watching the students during the activities all students were participating but not all were completely engaged in the lesson. It was noted students who tend to have a more competitive or extroverted personality had more engagement in the activities. Those students, who seem to be unable to sit through a lecture, did well when the lessons were built around projects and activities. One of the

students interviewed throughout the treatment who had an extroverted personality commented, “I liked the card games we play because I learned a lot and it was fun.” This student was mentioning the zero card game lesson, found in appendix A. This game allowed students to interact and compete with one another while they were practicing their integer operation rules. Students who have a more introverted personality participated in the activities, but they did not seem to enjoy them like extroverted personalities. The extroverted personalities were not afraid to make a mistake. Introverted students did not want to participate in the activity partially because they did not want to make a mistake. Many of these students had to be told multiple times to put their calculators away. From observation, I was able to see the students were not trying to cheat, they just wanted to make sure they were saying the right answer.

Summative assessments were used to assess the effects on boys and girls conceptual understanding through project-based learning. The summative assessment scores were averaged for the ten boys and the 16 girls. A pre and post test were used to compare the class averages among sexes as well as the percent increase.

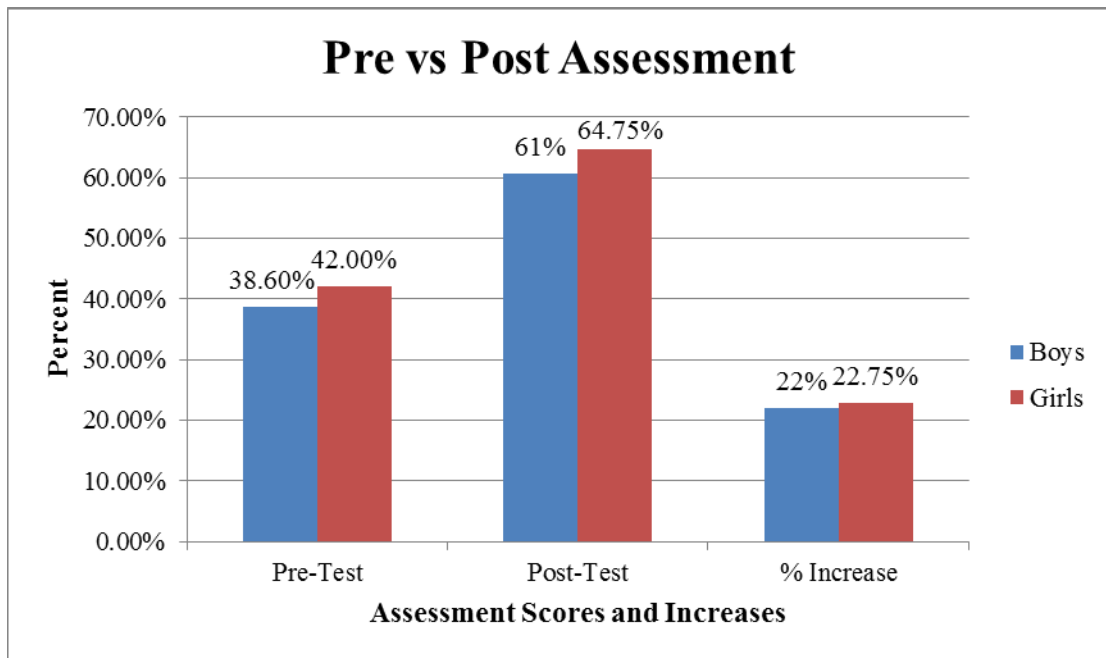


Figure 7. Pre and Post Summative Assessment Comparison of Boys Verse Girls, ($N=26$).

Figure six shows the comparison of the average summative assessment scores of the boys ($N=10$) and girls ($N=16$) in the classroom. On average the girls scored slightly higher than the boys. When finding the actual percent increase from the pre assessment to the post assessment it was found the boys increased by 22 percent and the girls increased by 22.75 percent. The percent increase is too small to determine project-based learning is more effective for girls than boys. From the data gathered from the summative assessments, motivation surveys, classroom observations, and student interviews, I conclude, project-based learning does not affect boys and girls differently. Action research has proven project-based learning has a larger difference in effectiveness between introverted and extroverted personality types. In the future I will need to change my focus from gender to personality types while developing project-based lessons.

INTERPRETATION AND CONCLUSION

Action research has been conducted to discover the effects of project-based learning in a remedial high school algebra essentials classroom on student conceptual understanding and motivation through action research. Project-based learning provides a safe environment for students to collaborate over mathematical concepts and justify their ideas to others. While project-based learning appears to be a wonderful teaching tool, like any teaching tool, it must be used correctly. Teachers must be aware of their students learning styles and cultural differences in order to identify which students will need extra support.

Through action research I found students who need extra support in these activities are those who have introverted personalities. One of the action research questions focused on the differences between the effects of project based learning on boys verse girls. Instead of finding a large difference between genders, I found the difference occur between personality types. Introverted students tend to be shy and have trouble interacting with their peers in a productive manner. I found, through my teaching journal, it was always the same students who struggled or did not fully participate in the activities, as well as the students who really enjoyed the activities. These students could easily be identified by their personality types. In reference to figure 4, student 25 was a young lady who had an introverted personality. Student 25 was the only student who had a negative percent increase from pre to post summative assessment. Project-based learning and collaboration was unsuccessful in some cases with introverted students because they are afraid to make a mistake or to be wrong in front of their peers. I found the introverted students still benefitted by the activity because they were great listeners

and observers. The introverted students were more successful when grouped with extroverted personality types because the students would learn through observation. The activity was unsuccessful when introverted personalities were grouped together because no one would fully engage in the activity and learning through observation was no longer an option.

Overall, I have found many students have the best of intentions and they want to learn. Many of these students will admit they enjoy learning math and it can be fun at times. I have also learned students are fragile learners. When they become stumped or confused the learning process is halted for them. The student can become overwhelmed due to the fact math keeps building upon itself, and they are still trying to understand the basics. Student five, is a young man who struggles with math and was working hard to understand the basics (see figure 4). This student began the trimester with the attitude, “I like math but I get frustrated and then I don’t do it.” Through observation of this student, I learned this student would quickly become overwhelmed with the assignments and quit. Project-based learning was a great teaching tool for this student because it provided an opportunity for extra practice and peer discussions to help solidify his learning. If a teacher can help the student through this confusion the student can get back on track. By the end of the trimester the student was doing better and found an increase of 18 percent between his pre and post summative assessment. I have found project-based learning has increased student motivation and attitude to do well in class. The data has shown, after project-based learning treatment was implemented, students became positive toward math. By the end of the trimester nine out of twenty-six students wrote about how they like math sometimes and it can be fun. Student five from figure four, even went as far as

to say, “I hate doing the work but I love learning it sometimes.” Project-based learning has provided me, the teacher, another opportunity to increase student confidence and positive attitude towards mathematics.

Action research exposed the effects of project-based learning on student motivation. In response to the first action research question, I have found the students motivation has increased after participating in the action research conducted on project-based learning. At the end of the treatment students began not only commenting on how they sometimes like math, they commented on how it is important for their future. The students were starting to learn and realize how math can be used outside of school. One student said, “I am going to need to learn this stuff if I want to get anywhere in life.” These are students who have started their high school math career by failing an introductory math course. For many of these students it was not because they were not smart enough, after working with these students I learned they were smart enough to be successful. The students failed first trimester because they saw no purpose or value to do the work. The action research on project-based learning provided the students the opportunity to participate in activities to get them thinking about the future as well as make learning more interactive. Periodically, I would record in my teaching journal classroom engagement levels during different instructional practices. I found a typical lesson delivered through lecture has approximately 15 out of 26 students listening and being engaged in learning at a time. When the same data was collected during a project-based learning activity all 26 students were engaged and participating. I had two students, student four and student 24, who were introverted and felt school was pointless and could not wait to be done (see figure 4). These two students would rarely do their homework

and would almost never take any notes without prompting from a teacher. On the other hand, the two students would participate in the project-based activities. No, they would not be fully engaged and excited about the activity, but they were at least participating in the game or activity enough to help their partners. These students would be actively listening and observing the actions of their peers. The two students were able to obtain a percent increase of nearly 20 percent in their summative assessment scores. Student four and 24 were students who seemed bored with school and did not want to take part in the daily lessons of the math classroom. The project-based learning activities motivated them to participate in their education. Therefore, I concluded project-based learning helps increase student motivation to learn math in a remedial algebra essentials classroom.

In response to the first action research question looking into the effects of project-based learning on students' conceptual understanding, the data did not provide overwhelming evidence proving project-based learning dramatically increased student learning. The data did provide evidence of increased learning and conceptual understanding. In the integers unit the learning was not evident at all (See figure 1). As the teacher, I will and did take the blame for the poor assessment scores. The focus of this unit was integers operations including multiple step expressions using order of operations and fractions. The project-based activities only incorporated one step expressions or simple two step expressions. I failed to put enough emphasis on the importance of the more complicated expressions. This has taught me to not become too wrapped up in the projects themselves. I need to keep my focus on the standard the students will need to achieve at the end of the unit. After this mishap, the students began doing better on the summative assessments. The students took the final exam, the same assessment as the

pre-test, and on average increased their scores by 22.4 percent. The percent increase shows the students learned and increased their conceptual understanding, but the percent increase is not large enough for me to say, project-based learning is more effective than a traditional teaching style. The three students who failed my class first trimester all passed the class the second trimester and had more success with project-based learning. One of the three even increased her final exam score from first trimester by over thirty percent after taking the class again with project-based learning. Overall, I conclude, project-based learning increased student conceptual understanding but not significantly more than a traditional teaching approach.

The third action research question looked into the effects project-based learning might have on the conceptual understanding and motivation of boys and girls. Overall, I found no evidence proving any differences between the effects on boys and girls of motivation or conceptual understanding after treatment. The difference was found in the attitude and participation amongst the different personality types of the students. Extrovert personalities were constantly engaged and participating in the projects and activities. Many of them would ask me as they came into class if we were going to do another fun activity. These students were excited about learning when it was hands on and interactive. Students with a more introvert personality needed more encouragement throughout the projects to ensure full participation. One of these students commented, "I like math classes when I can listen to my music and just work." This young lady always did what was asked of her and participated in the projects but she was never fully engaged.

The fourth action research question was focused on the impact of project-based learning had on myself as the teacher. Not only was I able to develop new interactive lesson, but I was able to analyze the effectiveness of the lessons. I learned how to better observe the learning styles of my students and to adjust particular lessons with my students needs in mind. This action research taught me to pay more attention to personality types and how to differentiate my lessons.

VALUE

This action research project has allowed me the opportunity to put in the necessary time and effort to accomplish one of my first goals in becoming a math teacher. My main goal in teaching mathematics is to change negative attitudes toward math. I want my students to realize math is not a useless subject, not only worthy of learning, but challenging in a positive way they will welcome. I decided to be a math teacher because it would be a challenge, not because it was going to be easy. The research conducted throughout the trimester allowed me to try new project-based lesson ideas and analyze their effectiveness. Throughout the process, I made mistakes as well as saw successes.

I found the classroom environment was positive and interactive when project-based lessons were applied. My students welcomed the break from pencil and paper assignments and were engaged in the learning process. Some students, especially those with extroverted personalities, found the projects and the math fun. The results found the students' conceptual understanding was not as high as I had hoped. This showed me the importance of balance in the curriculum. It is important to keep the students engaged and active in their learning through project-based learning, as well as provide students with the opportunity to practice the skills through repetition and book work. With a proper

balance the students will be able to build a base of mathematical knowledge to ensure conceptual understanding.

The action research has been the beginning of project-based learning being implemented in my classroom. I plan to continue to explore new project-based lessons in my future teaching career. The research proved the influence projects can have on student attitude and motivation to learn. Action research proved project-based learning is not the cure to unmotivated students either. Project-based lessons are a tool teachers can use to help increase student motivation and conceptual understanding. I plan to continue looking into how to better incorporate project-based lessons into my classroom and teaching.

Next year I will continue to implement project-based learning into my classroom. I will learn from my mistakes this trimester and stay more focused on the desired learning outcome and the standards. I found in the units the students did poorly, like the integer unit, I was too focused on the projects I could incorporate into the lesson. I have learned the value of projects and the negative effects of too many projects. With this in mind I will create unit plans in the future which provide a good balance between different teaching approaches. I will develop standard driven lessons throughout the entire school year incorporating project-based learning.

Next year I hope to learn how project-based learning would affect non-remedial students. My research is just a small portion of the effects of project-based learning can have on student motivation and conceptual understanding. The data proved to me the students gained conceptual understanding while taking my class. As the researcher, I am curious if some of the increase is due to the fact the students have already taken the class and seen the material once before. I plan to continue my research in the future exploring

the effects of project-based learning with difference student populations. Next year I will be teaching an accelerated math class and will implement many of the same activities as well as some new ones into my curriculum. I am curious to compare my data results between the two classes.

I would like to explore further the differences of learning styles related to personality types. This aspect of my research was an unexpected result. I originally thought I would find a difference between boys and girls with the effectiveness of project-based learning. I plan to continue looking into the effects of project-based learning in the future but will focus on how to better help students with introverted personalities.

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APPENDICES

APPENDIX A
ZERO CARD GAME INTEGER ACTIVITY

ZERO!

This is played like Blackjack.

Black cards are POSITIVE numbers.

RED cards are NEGATIVE numbers.

GOAL: Get as close to ZERO as possible

How to Play:

1. Each player gets dealt two cards, one face up and one face down.
2. Everyone at your table can see the face-up cards, but only the player gets to see their own face-down cards.
3. Each player can be ask to “hit me” if you would like more cards.
4. You can have up to FOUR cards total.
5. You must use ALL of the cards that you ask for!

Winning The Round:

The winner of each round gets to be the dealer for the next hand

The person with the TOTAL closest to zero wins that round.

Winning The Game:

1. Take the absolute value of your TOTAL column each hand.
2. At the end of the game, add up the numbers in the absolute value column.
3. The person closest to ZERO of the Absolute Value column wins the game!

Your Name _____

Group Names _____

Circle the name of the winner of your group!

Round	Cards (write your cards here and the operation you used)	Total	Absolute Value
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
Add up all of the numbers in the absolute value column. The <u>sum</u> closest to ZERO			

APPENDIX B
INTERVIEW QUESTIONS

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Interview Questions: Prior to Treatment

- 1) How do you feel about math class?
 - a. What do you like the most?
 - b. What do you like the least?

- 2) What can you tell me about your past experiences in math?
 - a. Why do you feel this way?
 - b. Would you say your overall past math experience was more positive or negative?
 - c. Why?

- 3) How do you think you learn best?
 - a. Is there a teacher from your past experiences you feel like you learned a lot?
 - b. Why did you learn so well from this teacher?
 - c. What can I do to help structure the class so you can learn?

- 4) What do you hope to accomplish with this class?
 - a. Do you have an overall goal for this class? If so, what?
 - b. How far do you hope to get in your math career? Why?

- 5) Do you think math is an important subject that needs to be taught in school?
 - a. Why or why not?
 - b. Why do you think a lot of adults think math is an important class?

- 6) Is it important you do well in math class?
 - a. Why or why not?
 - b. Do you have other people encouraging you to do well? Who?

- 7) What can I do to help you be more successful in this class?

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Interview Questions: Mid-Treatment

- 1) How do you feel about math class so far this trimester?
 - a. What do you like the most?
 - b. What do you like the least?

- 2) How does this class relate to your past experiences in math?
 - a. Why do you feel this way?
 - b. Do you think this is a good or bad change for you?

- 3) How do you think you learn best?
 - a. Is there a lesson from this trimester you feel you really understood?
 - b. Why do you feel like you learned this lesson better than others?

- 4) What do you think about the different activities we have done this trimester?
 - a. Which one was your favorite? Why?
 - b. Which one was your least favorite? Why?

- 5) What do you hope to accomplish with this class?
 - a. Do you have an overall goal for this class? If so, what?
 - b. How far do you hope to get in your math career? Why?

- 6) Is it important you do well in math class?
 - a. Why or why not?
 - b. Do you have other people encouraging you to do well? Who?

- 7) What can I do to help you be more successful in this class?

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Interview Questions: Post-Treatment

- 1) How do you feel about math class this trimester?
 - a. What do you like the most?
 - b. What do you like the least?

- 2) How does this class relate to your past experiences in math?
 - a. Why do you feel this way?
 - b. Do you think this is a good or bad change for you?

- 3) How do you think you learn best?
 - a. Is there a lesson from this trimester you feel you really understood?
 - b. Why do you feel like you learned this lesson better than others?

- 4) What do you think about the different activities we have done this trimester?
 - a. Which one was your favorite? Why?
 - b. Which one was your least favorite? Why?

- 5) Do you feel like these activities helped or hurt your learning this trimester? Why?
 - a. What was your goal for this trimester?
 - b. Did you reach your trimester goal? Why or why not?
 - c. How far do you hope to get in your math career? Why?

- 6) Is it important you do well in math class? Why or why not?
 - a. Do you feel you did well this trimester? Why or why not?
 - b. Did you have other people encouraging you to do well? Who?
 - c. What did they do to help encourage you?

- 7) What can I do to help you be more successful in this class?

APPENDIX C
IRB APPROVAL



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MEMORANDUM

TO: Terina Konrad and Walt Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn CJ'*
DATE: October 31, 2013
RE: "The Effects of Project-Based Learning in a High School Intro to Algebra Classroom" [TK103113-EX]

The above research, described in your submission of October 31, 2013, is exempt from the requirement of review by Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or level of payment for benefits or services under those programs.
- (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

APPENDIX D

PRE AND POST SUMMATIVE ASSESSMENT

14. Evaluate this expression $-\frac{7}{12} \div \left(-\frac{7}{10}\right) = \underline{\hspace{2cm}}$ (2 points)

15. Evaluate this expression $\left(-\frac{2}{3}\right)\left(\frac{6}{7}\right) = \underline{\hspace{2cm}}$ (2 points)

Multiple Choice - Simplify each expression. (1 point each)

16. $6n + n + 3n$

- A) $10n$ B) $9n^3$ C) $10n^3$ D) $9n$

17. $7(2p + 3)$

- A) $14p + 21$ B) $14p + 3$ C) $35p$ D) $9p + 3$

18. $12 - 5(2t - 4)$

- A) $14t - 28$ B) $-10t - 8$ C) $-10t + 8$ D) $-10t + 32$

19. $\frac{48m - 15}{3}$

- A) $11m$ B) $16m - 5$ C) $16m + 15$ D) $16m + 5$

Solve each equation.

(2 points each)

20. $w + 9 = 14$

21. $a - 7 = 1$

22. $\frac{h}{9} = -3$

23. $-5x = -25$

24. $\frac{1}{6}(m + 12) = 14$

25. $6 - 2y = 7y + 13$

26. $7.45x - 8.81 = 5.29 + 9.47x$

27. A) What needs to be done in order to correctly isolate the variable "n" in this expression:

$n - x = t$

B) What is the resulting solution? _____ (2 points)

Multiple Choice - Solve each inequality. (1 point each)

28. $\frac{n}{3} \leq 12$

- A) $n \geq 4$ B) $n \geq 36$ C) $n \leq 4$ D) $n \leq 36$

29. $-4x \leq 16$

- A) $x \geq -4$ B) $x \leq -4$ C) $x \geq 4$ D) $x \leq 4$

30. $x + 1 \leq -5$

- A) $x \geq -4$ B) $x \leq -4$ C) $x \geq -6$ D) $x \leq -6$

31. $2x - 4 \geq -10$

- A) $x \leq -3$ B) $x \geq -3$ C) $x \geq 3$ D) $x \leq 3$

32. Solve and graph: $|5x - 3| \leq 7$ (3 points)

33. Short Answer: (3 points)

A) Given the inequality: $3z \geq 2z - 7$ Is $z \geq 7$ the correct solution?

B) Justify your answer, make sure to include examples, or counter examples to support your Argument. _____

34. Solve and graph this compound inequality: $-2x - 1 > 5$ or $2 \leq x - 1$ (3 points)

35) **Short Answer** (13 points): Read the following problem carefully. Select a variable and write an equation that represents the problem. Then solve the equation. Finally, write a paragraph explaining your thought process and justifying your answers.

You are buying a computer system. The total system costs \$1300, and includes a CPU, a monitor, and a printer. If the CPU is \$895 and the monitor is twice as much as the printer, what is the cost of the monitor? How much does the printer cost?

- A) Variable Representation(s): (4 points)
- B) Equation: (3 points)
- C) Solution Process: (3 points)
- D) Explanation/Justification: (3 points)

APPENDIX E

MATH MOTIVATION SURVEY

Pre-Treatment

Name: _____

Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

Directions: Circle the response that best matches what most describes you.

1)	I feel nervous when entering a new math class.	Never	Rarely	Sometimes	Often	Very Often
2)	I feel worried when I sit down to take a math test.	Never	Rarely	Sometimes	Often	Very Often
3)	I enjoy the challenge of learning math. Please give an example of why you answered this way?	Never	Rarely	Sometimes	Often	Very Often
4)	I get frustrated when I do not understand the math. Please explain why you answered this way.	Never	Rarely	Sometimes	Often	Very Often
5)	I can usually talk myself through the problems. Please give an example of how you do this.	Never	Rarely	Sometimes	Often	Very Often
6)	I try to do well in class to keep my parents happy.	Never	Rarely	Sometimes	Often	Very Often
7)	I try to do well in class to keep my teacher happy.	Never	Rarely	Sometimes	Often	Very Often
8)	I try to do well in class because I want to do well. How do <u>you</u> define doing well in math class?	Never	Rarely	Sometimes	Often	Very Often
9)	I think about what math classes I will need for my future.	Never	Rarely	Sometimes	Often	Very Often
10)	I set end of the trimester grade goals for myself.	Never	Rarely	Sometimes	Often	Very Often
11)	I can work through math assignments without a lot of help from my teacher.	Never	Rarely	Sometimes	Often	Very Often
12)	Do you like math class?	Yes	Yes & No		No	

Please use the back of the page to explain why you answered the way you did in question number 12.