Project-Based Learning and its Effect on Motivation
In the Adolescent Mathematics Classroom

by

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August 2011

A thesis submitted to the
Department of Education and Human Development of the
State University of New York College at Brockport
in partial fulfillment of the requirements for the degree of

Master of Science in Education
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Chapter One: Introduction

As the world becomes more and more technology-driven, it is becoming imperative that individuals are prepared to compete in this marketplace. For individuals to obtain successful careers in the current and future economy, they must be skilled in mathematics. Mathematics is taught throughout the education of children, but many times, students experience difficulty with the content, which may cause them to lose interest and become avoidant of learning math. These factors can create a deficit in mathematics ability, which may in turn result in future struggles whether in college or in the workforce.

Problem Statement

Adolescent students in mathematics classroom often feel unmotivated for a variety of reasons. One of these reasons could be the mundane, repetitive nature of the current teacher-centered instructional style prevalent in high school math classrooms. Project-based learning, an instructional method based on authentic problems and group collaboration, may be a solution for the ordinary, everyday traditional teaching methods that so many students are accustomed to. Problem-based learning may be the means to engage students, who may have otherwise become disengaged from the classroom learning environment.
Significance of the Problem

As students go through the education system, teachers and administrators need to be concerned with students that appear to be unmotivated and have below grade level abilities. It is essential that all students graduate, and if students lack motivation, this goal may not be met. According to Banda, Matuszny, and Therrien (2009), “Increasing students’ motivation is a complex and ongoing process, especially for students… who have often experienced extensive failure with math in the past” (p.146). School professionals are constantly investigating methods to improve student motivation and help students to be successful in school. There has been much research conducted to investigate students’ motivational beliefs, but there has been little research done to investigate the affect of project-based learning on student motivation.

Purpose

The purpose of this research is to determine how teaching practices can affect students’ motivation and perceptions towards mathematics. Initial, closed-response evaluations will be used to get a baseline of students’ motivational beliefs and perceptions. The evaluations will specifically address the following factors: individual attitudes and beliefs, projected future plans, classroom environment and teaching methods, and perceived teacher support. The researcher will incorporate a project-based learning sequence into the current curriculum. Upon completion of the project, students will be re-evaluated by means of closed-response and open-ended
surveys on motivational levels. This information will help determine if teaching methods have any effect on students’ motivation to learn mathematics as well as whether or not teaching methods change students’ attitudes and beliefs about mathematics.

**Rationale**

High school mathematics teachers spend a lot of time working with students who have varying beliefs about the relevance and importance of mathematics. Because some students have had negative past experiences in math, some students are already lacking in content knowledge. This causes these students to have an even harder time catching up and learning the new material. These students will oftentimes become overwhelmed and “shut down,” which makes teaching and learning a constant struggle. The goal of the research is to determine what effect project-based learning has on motivational aspects of students. The results from this study can better inform educators on effectively reaching all students through varied instruction.

**Definition of Terms**

Project-based learning is an innovative teaching method that involves students completing authentic projects by working in small, collaborative groups. Project-based learning (PBL) is a student-driven, teacher-facilitated instructional method where students can investigate questions that pique their own curiosities, while still achieving academic goals. PBL can be interdisciplinary or involve only one content
domain. PBL has the potential to engage students' and allow them to work on contextualized problems, “which can support them in making connections between what they learn in school and their experiences outside of school” (Jurow, 2005).

The other component of the current study is motivational beliefs. Student motivation can be divided into two components: intrinsic motivation and extrinsic motivation. Intrinsic motivation comes from within the individual and can be further divided into subcategories such as the need to achieve mindset or the fear of failure way of thinking. Extrinsic motivation is fueled from outside sources, such as grades in schools, salary increases in the workplace, and other types of rewards. Many various factors can affect student motivation in the classroom. Students can be influenced by their own beliefs, by their cultures, by their classroom instruction, and by their teachers.

Research Questions

- What are students’ current levels of motivation and attitudes towards mathematics?
- To what extent does instructional style affect students’ motivation?
- Does the incorporation of project-based instruction, group activities, and hands-on experiences positively affect students’ motivation?

Summary

Motivation can be one of the key factors in students’ academic success. In order for students to achieve high levels of learning, students need to maintain high
levels of motivation. Teachers need to be aware of differing levels of motivation and be prepared to reach all students. One way of reaching out to all students is by using varied methods of instruction, including project-based learning. Project-based learning may have positive impacts of student motivation. The researcher in the current study is hoping to discover relationships between project-based learning and the effect of students’ motivation to achieve in mathematics.
Chapter Two: Literature Review

Project-Based Learning

According to Bell (2010), “PBL [Project-Based Learning] is a key strategy for creating independent thinkers and learners. Children solve real-world problems by designing their own inquiries, planning their learning, organizing their research, and implementing a multitude of learning strategies.” Project-based learning is an up-and-coming instructional strategy that can be incorporated into many different content areas and instructional units. “The NCTM claims, ‘Inquiry not only tests what students know, it presses students to put what they know to the test. It uses “hands on” approaches to learning, in which students participate in activities, exercises, and real-life situations to both learn and apply lesson content. It teaches students not only what to learn but how to learn’ (Wilhelm, Sherrod, & Walters, 2008). There is a large research base regarding project-based learning and the effect on student learning, as well as its effect on student motivation.

According to Larmer and Mergendoller (2010), there are seven essential components of project-based learning. Successful project-based learning first must spark the interest of the students and then incorporate driving questions to keep students’ interest. Allowing students to have their own voice and make their own decisions about the project foster individual learning and encourage inquiry so students can form their own driving questions. While working in groups, students learn and utilize valuable “21st century skills” including group collaboration,
communication, and critical thinking. The teacher’s role of facilitator involves providing feedback and allowing students to make revisions through means of rubrics and group evaluations. The final element of successful PBL is a “Publicly Presented Product” (Larmer and Mergendoller, 2010). This final element gives students the opportunity to take pride in their work and provides them with presentation skills that they will certainly use useful in the future.

Jurow (2005) quoted several researchers by saying “Research has suggested that project-based curricula have the potential to engage students’ interests and provide them with opportunities to work on contextualized problems, which can support them in making connections between what they learn in school and their experiences outside of school (Boaler, 1998; Blumenfeld et al., 1991; Brown, Collins, & Duguid, 1989)”. In Jurow’s study, the teacher-researcher introduced an architecture project to students. Students were required to build a research station in Antarctica that would be used for 20 years of research. The students were required to include floor plans, insulation, cost analysis, etc. This qualitative analysis described the outcomes of the project by use of recorded observations of the students. The results from the study revealed varying degrees of engagement with the project but overall seemed to be a productive alternative to daily, teacher-led instruction.

Wilhelm, Sherrod, and Walters conducted a study that incorporated an interdisciplinary project for pre-service teachers. The project integrated science and mathematics by focusing on the moon’s phases from an astronomic, geometric, and
trigonometric standpoint. Students kept journals about the lunar phases, met in
groups to discuss their findings, and participated in scaffolding lessons that
incorporating direct instruction. Throughout the instructional sequence, in additional
to the scaffolding lessons to provide the students with needed information, there were
milestones where the teacher gave feedback to the students. These components can
help a project-based instructional sequence to be successful. The results of this study
supported the idea that project-based learning "allows students to engage in
contextualized problem-solving, make connections across disciplines, develop
reasoning skills, and accurately represent and communicate concepts."

Ravitz (2010) investigated the cultures of three different types of schools,
based on differences in instructional practices. The three categories of schools
included traditional, comprehensive schools, small schools, and reform schools.
Reform schools refer to schools that are in the process of changing instructional
methods from traditional, teacher-centered instruction, to a curriculum that
encourages engagement, interactive instruction, and real-world experiences. "A key
feature of the reform models in this study is that they have embraced project-based
learning (PBL) as a central component of instruction in their models. This approach
uses "projects" as vehicles to encourage student motivation and to provide a means
for demonstrating and explaining what they have learned" (Ravitz, 2010).

The research was conducted by teachers completing surveys about their
individual and group processes (teacher culture). Teachers also completed surveys
about their students' individual group processing (student culture). Finally, teachers completed self-reporting surveys about their classroom instruction (inquiry practices). According to the responses from the surveys, teachers in reform schools had stronger teacher cultures and incorporated more PBL than teachers in other schools. In addition, student culture was strongest in reform schools. In reform models, teachers used PBL more than half of the time in more than 60% of the schools, compared with 18% at small schools, and 6% in comprehensive schools.

Cheng, Chan, and Lam (2008) investigated the effect of grouping on self-efficacy and collective efficacy during project-based learning. This study was conducted in middle-school classrooms with four different types of grouping (student-chosen, teacher-chosen, random assignment, and teacher combination of student-chosen groups). Surveys were given to students assessing their efficacy and group-processing and achievement was determined by students’ midterm exams. According to Cheng, Chan, and Lam (2008), in order for a group to perform successfully, the group must contain the following elements: positive interdependence, individual accountability, equal participation and social skills. In their study, Cheng, Chan, and Lam were concerned with the impact of heterogeneous grouping during PBL by specifically looking at individual, self-efficacy and group, collective efficacy. They hypothesized that higher achievers would have higher self-efficacy but lower collective efficacy, and lower achievers would have lower self-efficacy but higher collective efficacy. In general, the data from their research supported these hypotheses. The researchers also hypothesized that the higher quality
of group processing, the better the efficacy from high and low achievers. This was supported by the data.

Meyer, Spencer, and Turner (1997) were specifically interested in motivation and students learning strategies (academic risk-taking, self-efficacy) during project-based learning sequences. The researchers wanted to determine the role between preference for challenge and self-efficacy, goals, and academic strategies. The participants in this study were low achieving math students. Students were paired into boy-girl pairs based on risk-taking ability for a project consisted on geometry lesson on aerodynamics and kite building. Data was collected through, surveys, observations, and interviews, before, during, and after the kite project. The initial survey revealed that eight students possessed challenge-seeker behavior and six students possessed challenge-avoidant behavior. During the interviews, one of the challenge-seekers revealed that he thought that he learned more from harder tasks because easy tasks are just breezed through. One of the risk-seekers revealed that she didn’t mind making mistakes because she learned from them. The data from this study revealed that all students had the desire to be successful but all possessed different motivational constructs.

In a similar study, Ocak and Uluyol (2010) investigated how a project-based learning environment can influence components of intrinsic motivation, specifically interest, academic efficacy and cognitive engagement. According to the results of the study, Ocak and Uluyol found that PBL positively affected engagement and interest
in class. Students felt positive pressure to complete their assignments and PBL increased communication between group members.

Meyer, Spencer, and Turner (1997) suggested teachers need to have built in safeguards for students; teachers should to emphasize that improvement is just as valuable as final product and allow opportunities to discuss mistakes with peers. Collaboration can help student to take on challenges as opposed to shy away from them. "When projects are cognitively complex, they have the potential to help students learn because they must represent knowledge in a variety of ways, pose and solve real problems, and use knowledge to create artifacts... Projects also have the potential to frustrate students and send them searching for alternative paths" (Meyer, Spencer, and Turner, 1997). Teachers need to have ability to ask difficult questions in order to elicit strong, thoughtful responses from students.

Another study conducted by Doppelt (2003) also investigated the effect of project-based learning on low achievers. This particular study was geared towards promoting low achievers through the means of a five day summer program using PBL to teach curriculum for a series of electricity courses. The study took place over a three year time frame. Data was collected through analysis of students' portfolios, observation of class activities, interviews with students, teachers, and school management, achievement on exams, and project evaluations. From the data, most students revealed that they enjoyed PBL and indicated that they would put more effort in school the upcoming year. All students performed reasonable on the
matriculation exams at the end of the year. Results revealed that PBL increased student motivation and self-image. At the end of the three year intervention, 69% of the once “low-achieving students” were able to perform well enough to be eligible for further education in Israel.

Panasan and Nuanchalerm (2010) performed a study to examine the effects of inquiry-based learning and project-based learning on achievement. For the study, the researchers divided the participants into two groups of students (one group for IBL and one group for PBL). The participants took a pretest before the “new” teaching unit and then took a post-test after the teaching intervention. Each group took three types of achievement tests (achievement tests, analytic thinking test, and science process skills). Students from both groups performed about the same. The researchers concluded that both PBL and IBL are efficient and effective and have positive impacts on student learning in the science classroom.

Motivation

Motivation can be defined as the force that drives individuals to behave in a particular way. A variety of external influences, including cultural differences, family involvement, and classroom environment, can all impact students’ motivational beliefs. Individual beliefs and attitudes can also determine a person’s motivation. There have been numerous past studies conducted to contribute to the current research base on factors that affect student motivation.
External Influences

When children enter the traditional, public school system, they have limited experiences with formal schooling. The attitudes and opinions that children may have about school exist from experiences and conversations with parents, siblings, and other people, as well as from those limited educational experiences. However, as students progress through elementary school and enter into adolescence, they begin to formulate their own ideas about education. In high school, students encounter more challenging classes and experience more independence in terms of their own education. At this point, students are often developing their own goals, with varying degrees of influence from parents, peers, and teachers. Several of the major factors that affect students’ motivation include cultural influences, parental influences, and school influences.

Cultural Influences

Gender stereotypes exist in almost all cultures mainly because of traditional roles of the specific genders. These gender stereotypes often appear in the classroom. According to Skaalvik and Skaalvik (2004), mathematics is viewed as a masculine domain, whereas the languages tend to be viewed as a more feminine domain. In the educational practice, this may be seen when male students describe themselves as more mathematical and have more motivation to achieve in mathematics. Conversely, female students may orient themselves closer to reading and language and tend to be more motivated in these domains. These stereotypes may limit
students’ motivation to participate in the “other” domains. “People are motivated to undertake activities that they feel capable of performing and tend to avoid activities that they are less confident that they will master” (Skaalvik, p. 242). Although this is a tendency of human nature, it is important for teachers to help to break down gender stereotypes and cultural stereotypes and encourage all students to challenge themselves into participating in classes outsides of their “comfort zone.”

Skaalvik and Skaalvik examined these gender stereotypes in a study in Norway. Skaalvik and Skaalvik found that their data was consistent with traditional roles. The male students had higher self-concept than female and females were more motivated to achieve in their language classes (Norwegian). A major finding that was discovered in this study was that male students had higher self-perceived abilities and intrinsic motivation in math, and female students had higher self-perceived abilities and intrinsic motivation in language.

Other differences that affect motivation include the cultural value of education. Tsao (2009) examined the differences between Taiwanese and American students’ perception of mathematics. In Taiwan, personal advancement is very closely linked to academic achievement, which leads to a great value of education. In the United States, a differing value for education exists. The educational system in the United States values experiences that will make a child more creative and confident, with the expectation that self-confidence will facilitate future learning (Tsao, p. 207). Tsao found that students in Taiwan were more motivated because
math is required or because of a fear of punishment. The American students in this study revealed that they are more influenced by positive motivation such as a desire to succeed. This study provides a few important aspects to consider when teaching students, including the idea that all students have different backgrounds and different educational values.

Urdan, Solek, and Schoenfelder found that different cultures had different definitions of success. In their study, there were also differences in achievement that appeared to follow cultural lines; the high and middle achievers tended to be from Asian or Asian American families, and the lower achievers were more likely to be Latin American or 3rd generation Americans. This difference could be the result of the cultural groups' definition of success.

**Parent Influences**

Parent involvement in students’ educational activities can be defined by, but not limited to, involvement in school activities, participation in parent-teacher interactions, assistance with homework, and supporting the child’s academic development. Levpuscek and Zupancic (2009) investigated the effect of parental influence on the motivational beliefs of students. One major result of their study was that parental academic pressure negatively related to students motivational beliefs about mathematics and their math achievement. A similar study by Urdan, Solek, and Schoenfelder revealed similar findings. These researchers found that family influence can take on many different forms and have varying degrees of strength.
Sources of motivation can include parents, grandparents, siblings, and other family members. In this study, feelings towards families influence ranged from grateful to resentful, warm to hostile, and burdened by expectations and responsibilities.

**Teacher Influences**

According to Levpuscek and Zupancic, students' ratings of teacher's academic support had a positive impact on goal orientation and math achievement. A profound result that was discovered is:

> "Early adolescents who perceive their teachers as taking into account the students' basic psychological needs of relatedness and competence, and imposing positive demands on students' academic work, show more positive motivational beliefs and achieve higher grades in math. The students assessing their math teacher as responsive, helpful, and recognizant of good work tend to perform better in math than their classmates who rated the teacher to be less supportive." (p. 562).

In sum, math teachers' classroom behaviors can have great impacts on students' motivation, which indirectly contributes to students' achievement. It is imperative that teachers reflect on their classroom behaviors and methods to foster an environment that will help all students to succeed.

Another impact that can affect student motivation is the type of classroom instruction. In one study performed by Cotic and Zuljan (2009), problem-based mathematics instruction and traditional instructions were compared to see if there was any effect on students' academic motivation and achievement. The data obtained
from this study revealed that both groups experienced positive motivation, despite the
difference in teaching style.

Middleton and Midgley (2002) looked beyond the obvious factor of
motivation, into further aspects of self-efficacy, attitudes, and perceptions of
classroom environments. Prior research has been conducted on the effects of
classroom practices, such as incorporating challenging work and prompt feedback to
students, but what may be more meaningful is student perception of the classroom
practices. One interesting result from the data obtained was the perception of a press
for understanding. This seemed to be more beneficial for girls than for boys.
Questioning at a deeper level, requesting explanations, and requesting thoughtful
engagement are all positive teaching practices that can be implemented and can affect
students’ behaviors. When conducting future studies, other researchers can consider
these aforementioned strategies to gain further data on the subject of student
perceptions.

Aspects of Motivation

Although there are many outside factors that can affect a student’s motivation,
all of these aspects help to form a student’s personal motivational beliefs. There are
many aspects of a person’s individual learning style and personality that can affect
the learning process. Some of these factors include self-competence, self-regulation,
self-efficacy, anxiety.
Kesici & Erdogan (2009) conducted a study to investigate whether motivational beliefs and self-regulatory behaviors have an effect on college students' math anxiety. One major result from this study was that test anxiety and self-efficacy are significant predictors of college students' math anxiety. Students with emotional and behavioral disorders have higher test anxiety than students of average achievement. Although math anxiety can cause students to have negative motivational beliefs in mathematics, if students can recognize this weakness that they possess, they may be able to incorporate positive self-regulatory behaviors. These self-regulatory processes reveal a student's motivation to be successful.

Cleary and Chen (2009) completed a similar study at the middle school level. Motivation and self-regulation are two major aspects in a students' learning process. Students with higher levels of motivation and better self-regulatory strategies would be assumed to have higher achievement levels. One interesting result from the data obtained was that student motivation and self-regulation varied across grade levels and math course, but the importance of these strategies will increase for more demanding courses. If students can learn to recognize positive and negative learning behaviors, they may be more able to reach success, than if they do not take the time to self-reflect. If teachers can teach positive self-regulatory behaviors to those students who may experience difficulty, perhaps these students can become more successful.
Another study was conducted to consider the differences between math self-concept, math self-efficacy, and math anxiety across different cultural groups. These researchers found that math anxiety is strongly correlated with math scores, more so than with math self-concept and math self-efficacy (Lee, 2009). Another finding was a positive relationship between math self-efficacy and math scores, whereas a negative relationship was found between math self-concept and math scores. Beliefs and perceptions of mathematics vary greatly between different countries and cultures, as shown in this study. Certainly these perceptions of math have an effect on individual student motivation. Even within the United States, different cultural and personal beliefs about education may be evident in diverse student populations.

*Why is motivation so important?*

Motivational constructs, general intelligence, and prior school performance are believed to affect future school achievement. Steinmayr and Spinath investigated this topic by asking questions regarding self-perception, goals, and values towards math in additional questionnaires. The researchers’ hypothesized that the students’ achievement motives, goal orientations, self-concepts, and values help to predict future success in math more so than general intelligence alone. According to the results from the study, the different motivational variables (hope for success, fear of failure, need for achievement, etc.) greatly contributed to the prediction of school achievement. Whatever means of motivation pushes students, it is clear from this study that there is a large impact of future success. Teachers should be aware of
individual students’ motivational beliefs and attempt to encourage those students that seem to be unmotivated.

Yunus and Ali (2009) found that for the participants in their study, overall motivations were high, and the majority of the participants possessed a high level of effort. Another surprising result was that “female students have higher level of effort and self-efficacy and have lesser worry in the learning of mathematics” (Yunus and Ali, 2009). The results also showed that there was a positive relationship between effort, self-efficacy, and motivation with academic achievement. Because of the strong correlation with motivation and achievement, it is vital that teachers find ways to increase motivation in all students, not only to enhance their educational experiences, but to ultimately help them to achieve success.

Conclusions from the Literature

Motivation can be the factor that makes or breaks a student’s success in school. There is a very strong correlation with motivation and achievement (Yunus and Ali, 2009); therefore, teachers need to find ways to keep students positively motivated. Not only does motivation affect current achievement, but according to Steinmayr and Spinath (2009), motivation plays a large role in future success. Teachers should be aware of individual students’ motivational beliefs and attempt to encourage those students that seem to be unmotivated.

Although teachers cannot control outside influences, such as cultural beliefs and family influence, teachers can educate themselves about these differences to have
a better understanding of individual differences in student motivations. According to Tsao (2004), beliefs and perceptions of mathematics can vary greatly between different countries and cultures. Other previous research has revealed the evidence of gender and cultural stereotypes in regards to mathematics and achievement (Skaalvik and Skaalvik, 2004; Urdan, Solek, & Schoenfelder 2007). Different cultures have different definitions of success and different perceptions of who can be successful in mathematics.

Despite the many aspects of a student’s life that teachers cannot influence, teachers can monitor the interactions that occur in the classroom. From block scheduling to teacher behaviors to different styles of instruction, all of the interactions that occur in the classroom can affect students’ motivation and attitudes (Cotic & Zulijan, 2009; Levpuscek & Zupancic, 2009; Middleton & Midgley, 2002). Although motivation is a complex and multi-faceted characteristic of a student’s belief system, it is imperative that teachers are aware of the different factors affecting motivation as well as strategies to increase positive motivation in all students.
Chapter Three: Applications and Evaluation

The objectives of the current study are to determine how motivational beliefs and attitudes affect mathematics achievement and determine the effects of project-based instruction on these attitudes and beliefs. The sample of students in this study is a small representation of the overall student population, but the insight provided by these students may inform the researcher of current trends in student attitudes towards learning mathematics and may also help the researcher to inform future instruction.

The participants for the study were a sample of convenience. The participants were students currently enrolled in the geometry course at a rural high school. There are approximately 55 students enrolled in the course, but only 35 students returned the required consent forms to be official participants. The data collected is representative of these 35 students. Of these students, there is a wide-range of abilities. Based on the teacher’s ranking, six students were ranked as low-achievers, fourteen students were ranked as average-achievers, and fifteen students were ranked as high-achievers. Although the majority of the students were general education students, there were three students that were students with special needs (two students were IEP students, and one student possessed a 504 plan). Although thirty-five students turned in parental consent forms, the almost half of these students were high-achievers; on the contrary, only six low-achieving students turned in consent forms. This may result in skewed results.
For the current study, I used a mixed-methods approach to data collection in order to achieve the goals and objectives of the research questions. Before beginning the project-based unit, participants completed a closed-response survey assessing their current attitudes and beliefs towards mathematics. This initial evaluation was used to get a baseline of students’ beliefs towards math achievement. This information was also considered when assigning students to groups for the project that they would be completing.

The closed-response survey was divided into five different components, and there were four or five questions pertaining to these different components. The first category for the survey was Learning Style and included five items on the questionnaire. Category Two, Math Anxiety, included four items. Teacher Perceptions was the fourth category and included five items on the survey. The fourth category was Self-Efficacy; this category included four items. The final category, Internal Motivation and Personal Beliefs, was a mix of several different concepts and included five questions. This Motivation and Attitude Scale included items such as, “I would rather complete a project or make a presentation than take a test in math class.” and “Performing many examples helps me to learn new concepts in math.” The goal of this closed-response survey was to get an idea about how students feel about mathematics and what affects their beliefs regarding mathematics. For the complete survey, see Appendix A.
After the initial baseline survey, the teacher and students engaged in a three-week project-based instructional unit. The unit involved students creating a “School of the Future.” Before students were placed into groups, the teacher described, in detail, the project that students would be completing. The teacher explained that students would be participating in a real-life application of the content they were learning, specifically involving three-dimensional solids, surface area, similarity, and scale factors. Students would also apply specific calculations to determine the cost of their school designs. Each team would create a unique site plan, floor plan, and scale model of their future school. Students were encouraged to think “outside of the box” and include futuristic design layouts or classroom structures that would make their school more appealing to future students. During the unit, students would learn relevant material through scaffolding lessons, and then work in their cooperative groups on aspects of their assignment. For example, one aspect of the project requires students to calculate the cost of their buildings based on square footage calculations. In order to provide the students with the knowledge they need to perform these calculations, the teacher taught them how to calculate the area of a floor of a building. To keep calculations relatively simple, the teacher gave students a set cost per square foot to use during their project calculations. Students practiced these calculations with their groups on a practice worksheet. For a full project description and rubric, see Appendix B.

Students were placed into groups with each group consisting of three or four students. For the treatment, I used different grouping methods in each of my three
section of geometry. Students in one class period were assigned to heterogeneous
groups based on ability and motivation levels; in another class section, students were
assigned to homogeneous group based on ability and motivation levels; in the third
class period, students chose their own groupings (which resulted in groups with
varied ability-levels and motivation-levels).

Throughout the project-based unit, the researcher made observations and
recorded information from the groups during in-class work sessions. At the
conclusion of the unit, students presented their projects to the rest of the class.
Students then completed open-response questionnaires about their experiences with
the project-based unit. The open-response questionnaire included items to evaluate
the students’ likes and dislikes of the project and the group setting, as well as how
these factors affected their learning and motivation. In addition to completing the
project, students also completed a formal unit test to assess their learning of the
required content for the upcoming high-stakes Regents exam.

Each of the different components of the study will provide the researcher with
varied data all giving insight into students’ beliefs about mathematics. The closed-
response survey will inform the researcher as to what aspects have a strong effect on
students’ beliefs and motivational views towards math. The researcher will be able to
generalize about the “big ideas” that influence students and their attitudes regarding
math achievement. For example, do students have diverse learning styles and are
they open to different instructional methods? Are students affected by math anxiety,
which can in turn affect their attitudes towards math? These questions will hopefully be answered through the closed-response survey. Then, keeping this data in mind, the researcher can teach using varied instructional methods during a project-based unit and determine if the students’ attitudes and beliefs can be affected. For example, did students enjoy a real application of the mathematical content during the project-based unit, or do they prefer traditional direct instruction? Would students rather be accountable for only themselves, or did they gain real life experience from the group concept? The purpose of the open-ended survey is to determine if any change has occurred in students’ motivational beliefs and attitudes,

See Appendix A for the complete Motivation and Attitude Scale (closed-response survey) and Open-Ended Survey. In addition, Appendix B includes a project description, a sample lesson, and the rubric on which students’ projects were assessed. The formal Unit Assessment is contained in Appendix C.
Chapter Four: Results and Analysis

In this study, the researcher gathered data through a variety of sources. The data from the initial, closed-response survey was analyzed by comparing means by topic and gender. Figure One includes the averages by category. From this data, it is clear that Math Anxiety, Category 2, had the lowest average for responses, and Category Three, Teacher Perceptions, had the highest average responses. The relatively high average for Category Three indicates that most students feel that they feel supported by their math teachers. The relatively low average for Category Two indicates that most students are minimally affected by math anxiety.

![Overall Averages by Category](image)

Category One also had a relatively high average response. These results from Category One, which assessed students’ individual learning styles, suggest that students possess many diverse learning styles. Category Four had a relatively low average response. Category Four was meant to evaluate students’ levels of self-
efficacy towards mathematics. The relatively low average response indicates that students do not always feel confident and capable when completing mathematics problems or considering future math classes.

The researcher also compared the average responses based on gender. This data is shown in Figure Two. The first column represents the data from the male students' responses, and the second column represents the data from the female students' responses. From this chart, it is clear that there was not any significant difference in average responses by category between male and female students.

![Averages by Category and Gender](image)

Figure Two

Item sixteen from the survey had the overall highest average response (3.6). This question stated, “My teacher is available for extra help in case I don’t quite get it the first time.” Another item with a relatively high average score was item four (average of 3.56), which read “My math teachers have helped prepare me for success
in future math courses.” Item four and sixteen were both from the Teacher Perception category. These two items suggest that students feel supported and encouraged by their math teachers; students who feel supported by their math teachers are more likely to show positive motivational beliefs and perform better in math class (Levpuscek and Zupancic, 2009).

Another question with another high average score was item two (average of 3.49); item two read as follows, “Performing many examples helps me to learn new concepts in math.” This item indicates that students see the value in completing many examples to practice applying new concepts. This supports the idea that students need repetition of concepts in order to learn, which is a characteristic associated with traditional instruction.

Item twenty-one from the closed-response survey had the overall lowest average response (2.0). This item stated, “I like to try and solve math problems outside of math class.” This indicates that most students do not have an internal drive to practice recreationally mathematics. Items fifteen and twenty-two also had relatively low average scores, 2.1 and 2.4, respectively. Item fifteen stated, “I like to go up to the board and answer questions/present solutions in math class.” Item twenty-two stated, “I like to discover new concepts for myself.” These three items all involve personal attitudes, learning styles, and motivational beliefs. The results from these three items suggest that many students would rather not have to actively pursue learning but instead have ideas presented to them. This perhaps suggests that students
are accustomed to traditional teaching methods and less comfortable with
differentiated instruction such as project-based learning.

The final item of the survey said, “During a typical math class, I feel very
motivated to work hard and achieve success.” Students chose from Likert-scale
responses (Strongly Agree to Strongly Disagree) and then were asked to explain their
answer in their own words. The researcher coded the answers into positive responses
that indicated why students were motivated and negative responses that indicated why
students were unmotivated.

Some of the explanations that explained why students felt unmotivated
included that some students get distracted and do not always pay attention. Other
students indicated that they are not always awake in the morning (when they have
math class), which causes them to feel not as motivated. Several students suggested
that when they do not understand the difficult material, they feel less motivated to
achieve. A few students stated that they feel that some of the math concepts that they
are learning are pointless. Several students indicated that there are so many other
outside factors affecting them that they just cannot focus during class. Another
response that several students mentioned is that they feel bored. All of these
explanations indicated reasons as to why students did not feel motivated to achieve in
math class.

On the opposite end of the spectrum, many students indicated that they feel
highly motivated to work hard and achieve success in a typical math class. Some of
the reasons that these students used to justify their responses were to achieve high
grades and because they do not want to fail. In fact, the reference to grades was the
most common reason that students included. Many students referred to their future
plans and college as a source of motivation for them. On a similar note, one student
mentioned that she needs high marks in order to earn scholarships for college.
Several students revealed that they possess a desire to achieve in all of their classes,
including math. One student mentioned that he is naturally good at math, and another
student stated that she just enjoys completing problems. One student stated that she
enjoys the class and the teacher, which provides her with a source of motivation. One
final student mentioned that math is used every day, so she feels motivated to achieve
in math class.

During the unit, the teacher recorded students’ interactions during class
project time and made observations about student progress. The reason for these
observations was so the researcher could get candid responses from students to
supplement and support the data gathered in the surveys. These candid responses can
possibly provide more honest, direct thoughts from the students.

For some groups, there were a lot of positive comments and interactions that
occurred. Some of the positive observations that the teacher made are summarized in
the table below:

<table>
<thead>
<tr>
<th></th>
<th>I’m glad that we all have good ideas and we can work together.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>I have an idea how we can incorporate technology… [another student] Great idea!</td>
</tr>
</tbody>
</table>
3. Ok, I'll work on the 3D model and bring it in tomorrow so you guys can tell me what you think.

4. The floor plan looks good, but maybe we can add to it because we still have money to work with.

5. I like being able to do our own thing and not take notes like normal. This is sort of fun.

Table One: Positive Observations

In addition, there were some groups that had negative experiences in their groups. These observations are recorded in the table below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Our group would be better if we didn't have [name omitted] trying to boss everyone around</td>
</tr>
<tr>
<td>2.</td>
<td>This project is stupid; it doesn't even relate to math</td>
</tr>
<tr>
<td>3.</td>
<td>I wish that [name omitted] would come to school once in a while - he hasn't done anything.</td>
</tr>
<tr>
<td>4.</td>
<td>You and I have done everything... [name omitted] is so frustrating because he has done nothing</td>
</tr>
<tr>
<td>5.</td>
<td>I wish we had more guidance because I really don't know what to do.</td>
</tr>
</tbody>
</table>

Table Two: Negative Observations

Many of these comments were also mirrored in the students' group evaluations that were completed at the conclusion of the project.

The final, open-ended survey was administered at the conclusion of the project-based unit. The items on this open-ended survey assessed positive and negative feelings towards the project itself and the group arrangements for the project, as well as motivational attitudes before the project-based unit and during the project-based unit. The students were required to complete statements, such as, "One thing I liked about the project was..." After reading the students' responses, the
researcher coded the responses for each item and analyzed the responses to determine common trends in the responses.

Item one of the open-ended survey required that students elaborate on one aspect they liked about the project. The most common response from students was that they enjoyed working in groups on the project. Seeing a "real life application" and completing a "hands on" project were two other notions that were suggested. Other responses included that students enjoyed being creative and designing different aspects of their project. One student described the project as a "nice change of pace" from traditional day-to-day instruction. Another student made a similar comment and described the project as "better than taking notes."

Item two of the open-ended survey required that students describe one aspect they did not like about the project. The most common response from students was that they felt they did not have enough time to complete the project. Other students suggested that they were confused by the directions and the expectations. (Note: Several students were absent from class on the first day of the project when most of the directions and expectations were explained. This may have affected the students' opinion of the project because they missed this crucial class period.) Another comment was that students did not like their group arrangements.

Item three of the open-ended survey required that students explain one aspect they liked about their groups. The most common response from students was that they liked being able to share the workload. A similar thought mentioned by students
was they liked being able to share ideas and combine knowledge and resources. Several students mentioned that they liked having more freedom, and the project was more fun than day-to-day instruction. Effective grouping and helping one another in the group setting were two other ideas mentioned by students for aspects they liked about the group setting.

Item four of the open-ended survey required that students discuss one aspect they did not like about their groups. The strongest complaint about the groupings had to do with group conflict. Several students felt that not all group members contributed equally and not all group members had the same definition of quality. This was also seen in a study by Urdan, Solek, and Schoenfelder (2007). Urdan, Solek, and Schoenfelder found that different cultures had different definitions of success. In the current study, individual group members had varying acceptable levels of quality, and this could be the result of the individual’s cultural groups’ definition of success.

Another negative idea mentioned was that not everyone’s ideas were listened to in the groups. A final negative comment may support why several students had negative experiences; students were not allowed to choose their own groups. After reading these comments, the researcher tried to determine if there was a connection amongst this data. In general, it appears that students feel that if they were able to choose their own groups, they may not have had as much group conflict.
Item five of the open-ended survey required that students suggest one thing that would make the project better. The most mentioned suggestion was to allow students more time to complete the project. Other students requested a smaller individual project, rather than a large, group project. Other students suggested that they would have like to choose their own groups, which supports many of the ideas suggest in item four. The last two major ideas mentioned in responses to item five were contradictory in nature. One student suggested that they would have like more specific expectations, whereas another student suggested more freedom and less rules and expectations. This suggests that different students have different need in terms of structure for projects.

The last two items of the survey required students to rank themselves on their level of motivated to learn mathematics and then explain their ranking. The rankings were based on a five point Likert-scale from “Strongly Disagree” to “Strongly Agree.”

Item six asked students to rank their level of motivation before beginning the project-based unit. The average response from students was 3.4 (which is between neutral and moderately agree). Although the average response from the students was relatively neutral, there were many students that had higher and lower rankings. These higher and lower rankings were very interesting to investigate, especially after considering the students’ explanations.
The explanations from the students with higher levels of motivations varied from personal interest in math to competitive nature to do well and just a desire to achieve. Several students mentioned that they wanted to get good grades, and a few other students mentioned a future need for math as their drive to learn math. A few students specifically stated that they simply enjoyed learning math. Students that had lower rankings also had unique views as to why they felt less motivated. Several students mentioned that math is not fun and they find it boring. Other students stated that they do not use math outside of class, and they would rather be learning applied math.

The last item of the open-ended survey asked students to rank their level of motivation to learn math during the project-based unit. The researcher was interested to see if there was any change in students' perception of their own motivation before and during the project. The average response from students for item seven was 3.6, which is slightly higher than the average from item six. This indicates that students felt slightly more motivated during the project than they did before beginning the project.

In addition to considering the numerical rankings, the commentary associated with these rankings is vital to understanding the students' viewpoints. Students that assessed themselves as having a high level of motivation during the project mentioned very specific reasons for their level of motivations. Some of the responses included that students enjoyed the engineering and design aspects of the project;
similarly, another student mentioned that he had an interest in architecture and scale drawings. Quite a few students suggested that they enjoyed the new application and experiences that the project involved, and it was fun being able to be creative.

Students that had lower levels of motivation justified their ranking with comments such as the project stressed them out and they did not have enough time for the project. Other students with lower motivation levels indicated that they still do not like math, they are not good at math, or they still find no fun in learning math. This supports the idea that people tend to do things that they are good at and tend to avoid things that they are not as good at (Skaalvik and Skaalvik, 2004). These students indicate that they do not feel motivated towards math which may be a result of their limited ability. They may avoid math because of their weaknesses. Some of these students also stated that the project did not change their opinions about learning math.

After carefully considering students written responses to items six and seven, the researcher compared each students’ numerical ranking from item six (level of motivation before the project) and item seven (level of motivation during the project). The researcher was interested in comparing individual students’ rankings. Thirteen students perceived motivation level increased from their initial level of motivation to their motivation level during the project. Seventeen students level of motivation remained the same from item six to item seven. Five students level of motivation decreased between the two items.
Each group received a grade for their final project. One portion of this grade was a group-evaluation form that each student completed to assess each group member’s contribution to the final project. I chose to include this so that students could let me know what concerns they had regarding their groups’ functioning. The overall grade that each student received for the project was based on the teacher’s assessment using a rubric (see Appendix C) and the student’s evaluation based on the group evaluation forms (see Appendix C). The average grade for the project was a 90%. The highest grade earned by a group was a 97%, and the lowest grade earned by a group was a 78%. Students not only received a “grade” but also a written evaluation that included strong points of their project and weaker points of their project (see Appendix D for Exemplar Projects and a sample of a Completed Rubric with Written Evaluation).

Another interesting result from the project-based unit was the students’ many unique perspectives presented in the final projects. The main task that students were to complete was to create a School of the Future and represent this school using a site plan, a floor plan, and a three-dimensional scale model of a classroom. In addition, students also performed various calculations to come up with an approximate cost estimate for their school. One trend that emerged from many of the students’ ideas was that some students are very accustomed to “traditional” school structures. Several of the groups based their floor plans on the school that they attend or have visited.
A few of the groups were able to “think outside the box” and created more unique school structures. For example, one group created a school where each grade level had its own separate building and the buildings were connected through underground passages; this school complex also contained several “common” buildings that contained common areas like the administrative offices, gymnasium, and auditorium. Another group created a one-room “school” where all students sat and received their education from interactive, instructional helmets. In this school, there were very few adults present, and these adults were solely facilitators and monitors, not traditional “teachers” in the today’s sense of the word.

In addition to creating general building designs and the overall site layout of the school complex, students were also required to create three-dimensional scale models of their futuristic classrooms. Again, some groups tended to stay close to the current classroom structure that they are accustomed to: four walls and a door, individual student desks, some form of board, and teacher at the front of the classroom. However, several groups were able to modify a “standard” classroom but adding their own unique elements.

One group created a more futuristic version of this typical classroom by including inclined floors so that all students can see the board (similar to a college lecture hall). Another group incorporated a modern twist to a typical classroom by including a “Smart Cube” in the center of the classroom. The group described the “Smart Cube” as a cube with the lateral faces being interactive “Smart Boards.” In
front of each “Smart Board” there are four to five student desks, and these students work as a group to complete the tasks presented on the “Smart Board.” In essence, this group incorporated innovative technology and cooperative group learning in their future school.

Some groups had even more creative ideas for their future schools. Several groups rearranged classroom structure by seating students at tables or other structures. For example, one group had students sitting in bean-bag chairs at individual work stations. Many groups suggested that in the future all students would have their own laptop to do their work. One group justified this by stating that in the future, people will be more environmentally conscious. By giving students laptops for assignments, they will not have to keep paper notebooks and print assignment. Instead, assignments would be submitted electronically, thus reducing the amount of paper being wasted.

Through this project-based instructional unit, students were able to use their imagination and individuality within their groups to complete the necessary tasks. One unanticipated result from this project-based unit was the amount of diversity in the students’ final products. Although some students created schools that resembled schools that are typical today, many students were able to create completely new and different structures. One reason that this diversity in the projects may have occurred is that students may interpret the task of the assignment differently. In addition, some students naturally possess more eccentric and different ideas.
In addition to completing the group project, each student took an individual formal, unit assessment. The average grade for the formal unit assessment was 80%. Last year, when I gave a similar assessment on the same content, the average score on the assessment was 77%. After determining the means of that data, I performed a t-test to analyze this data. A two-tailed t-test with an alpha value of p<.05 was performed. The outcome from this t-test was a p-value of .20. This indicates that the difference in the means is not statistically significant because the calculated p-value is greater than the accepted value (acceptable p-value, p<.05). This implies that there is no significant difference in the data sets, and the two groups of students performed relatively similar on the unit assessment.

The researcher also looked at the New York State Regents exam results of the two groups of students to see if there was a significant difference in the mean scores. The average score on the NYS Regents exam for the students in the year prior to the current study was a 72.5%. The average score on the NYS Regents for the students involved in the current study was 77.8%. After determining the means of that data, I performed a t-test to analyze this data. A two-tailed t-test with an alpha value of p<.05 was performed. The outcome from this t-test was a p-value of .019. This indicates that the difference in the means is statistically significant because the calculated p-value is less than the accepted value (acceptable p-value, p<.05). This implies that there is a difference in the data sets. This test would indicate that the students involved in the current study performed better and were higher achievers than the students in the previous year.
The two statistical tests performed in regards to the two different groups of students have contradicting results. The unit assessment t-test indicated that the students were at relatively the same performance level for this particular unit. However, the t-test results from the NYS Regents exam indicate that the students in the current study were higher-achievers on this overall, cumulative assessment.
Chapter 5: Conclusions and Recommendations

The current study involved an initial baseline survey, followed by an intervention. At the conclusion of the intervention, students were then surveyed again. Finally, students completed a formal unit assessment to determine the degree to which they learned the mathematic material presented in the project-based unit.

Before any intervention had occurred, the researcher took baseline assessment data by administering a closed-response survey. The goal of this survey was to discover any existing trends among students’ attitudes and motivational beliefs towards mathematics. Several trends emerged from this data. Most students feel supported by their math teachers. In addition, students revealed that they feel minimally affected by math anxiety. Other information revealed through the closed-response survey include that students possess many diverse learning styles and students have varying levels of self-efficacy towards mathematics. Other specific items suggested that some students would rather not have to actively pursue learning but instead have ideas presented to them. This perhaps suggests that students are accustomed to traditional teaching methods and less comfortable with new styles of instruction such as project-based learning.

The researcher compared the overall category results from the closed-response survey by gender. There were no obvious differences in the results when comparing the means. However, even through the means did not reveal any significant trends, this does not mean that individual students did not have vastly different results. Skaalvik and Skaalvik (2004) investigated gender stereotypes and found that although
gender stereotypes sometimes do exist, there are many students that do not fall into these stereotypes. The current research had similar results.

The last item of the survey asked students to determine their current level of motivation in math class and then explain their responses. Students’ levels of motivation varied across the students. Cleary and Chen (2009) had similar results when they discovered that student motivation and self-regulation varied among different students. In their study, Cleary and Chen looked at students across different grade levels. In the current study, students were all in the same grade level for mathematics.

The intervention for this study was the incorporation of a project-based instructional unit. The goal of a project-based unit, such as the School of the Future Project, is to create contextually applied mathematical activities in the classroom by incorporating authentic challenges and real-world problems. As discussed in the results, it was not an easy endeavor for every student to make this shift from traditional learning to this new project-based learning. Many students commented that they enjoyed the new context and liked the applied context of the mathematics. However, there were several students that had a difficult time with this project, possible because they were not accustomed to the newfound freedom that was offered to them. Although the students’ engagement in the School of the Future Project was varied, the experience presented through this project helped them use mathematics in a meaningful situation.
The project presented to students from the current study included all seven essential components of project-based learning (Larmer and Mergendoller, 2010). These seven components included catching student interest, driving questions, student voice and choice, valuable group cooperation skills, inquiry and innovation, teacher feedback, and a final presentation. By including all of these components, the current researcher was able to see the spark the students’ interest by first presenting the main idea. Students were then able to come up with their own ideas, develop their thoughts within their groups, strengthen their ideas through revision and group collaboration, and finally present their final product. All of these components created a unique learning opportunity to the students that helped them to become more diverse learners. Wilhelm, Sherrod, and Walters (2008) discussed that project-based learning “allows students to engage in contextualized problem-solving, make connections across disciplines, develop reasoning skills, and accurately represent and communicate concepts” (Wilhelm, Sherrod, and Walters). The results from the current study support this idea.

In addition to gathering data through means of surveys, the researcher also recorded observations of student interactions and presentations of projects. These observations varied in nature from positive to negative, specific to general, and related to many different components of the project. These observations revealed varying attitudes and levels of interest in the project. This was similar to the results found by Jurow (2005). Jurow found that students possessed varying degrees of
engagement with the project and that the project-based unit seemed to be a productive alternative to daily, teacher-led instruction.

The final, open-ended survey was meant to gather feedback from the students in regards to their experiences during the project. Students were asked to provide positive and negative feedback regarding the overall project and their group experiences. Overall, students appreciated the "real-world" application of the mathematical concepts and liked being able to be creative and use their own ideas. Some of the negative comments that students made about the project included that they felt that they did not have enough time to finish the project and that some students were confused by the directions. In regards to group arrangements, some of the positive notions included that students like sharing the workload, sharing ideas and resources, and that working in groups was fun. The most common negative view presented by the students was group conflict.

In the final, open-response survey, several students revealed that they experienced challenges when working in the group setting. In a study conducted by Cheng, Chan, and Lam (2008), the researchers found that the higher quality of group processing, the better the efficacy from high and low achievers. Perhaps the reason that some of the groups in the current study had challenges and/or negative experiences was due to poor group processing.

The final two items of the open-ended survey asked students to rank their levels of motivation before the project-based unit and during the project-based unit,
respectively. Before the project-based unit, the primary instructional method was teacher-led instruction. Many students revealed that their level of motivation increased or remained the same. In a similar study, performed by Cotic and Zuljan (2009), problem-based mathematics instruction and traditional instructions were compared to see if there was any effect on students’ academic motivation and achievement. The data obtained from this study revealed that both groups experienced positive motivation, despite the difference in teaching style. Another study by Ocak and Uluyol found that PBL positively affected engagement and interest in class. These results were replicated in the current study; this positive engagement and interest was revealed through these final two items on the open-ended survey. In another similar study, Doppelt found that most students enjoyed PBL and that they were more motivated to perform well in the upcoming year. This study revealed that PBL increased student motivation and self-image (Doppelt, 2003). These notions were seen in the current study. In the current study, many students revealed that they enjoyed working on the project and were more motivated during the project-based unit than before the project-based unit.

The final set of data gathered for this study was the results of the formal unit assessment. The students in the current study performed about the same as the students performed in the previous year on a similar assessment. This would suggest that traditional teacher-led instruction (which was used as the primary instructional practice in the previous year) and project-based learning (which was the primary instructional practice in the current study) are effective and have positive effects on
student learning. In a similar study, Panasan and Nuanchalerm (2010) found that both project-based learning and inquiry-based learning are efficient and effective and have positive impacts on student learning. This goes to show that there are many different instructional practices that can positively impact student learning.

Limitations

Although this study has resulted in a wealth of data and valuable results, there are some obvious limitations. Of the 55 students that were potential participants, only 35 returned the required consent forms. Of these students, many of them were highly-motivated, high-achievers. This could potentially affect the results from this study. In addition, 35 students is a relatively small sample. This sample is from a rural school district that possesses little diversity among its student body. This means that the results are not able to be generalized to the larger population. Another potential limitation involves the nature of the data collection. Much of the data for the current study was collected by means of self-reporting surveys. Whenever using self-reporting surveys or questionnaires, there is always a certain degree of limitation presented. Asking adolescent students to complete self-reporting surveys requires that they provide honest feedback, which puts the students in a state of vulnerability. This may affect their responses. In order to combat this limitation, the researcher made observations throughout the project-based unit to supplement the data gathered from the surveys. Any researcher using self-reporting surveys or questionnaires
should be willing to look at alternative sources of data to support and supplement the data from the surveys.

**Future research**

The results from this study emulate results from previous research. Although this is the case, it would be unfair to say that these results are generalizable to the general population of adolescent students. Because this study only involved one instructional unit, the data is somewhat limited. In the future, other researchers may want to incorporate several project-based units for different instructional units in math; this might give more telling data. Studies like this one need to be conducted in many other contexts and with other populations of students. In addition, future related research could include a multi-disciplinary project across several content areas and assess the learning in all areas. Another way to gather more data about project-based learning is by allowing students to create their own project, given a set of specific expectations.

**Final Remarks**

The goal of the current investigation was to determine the effect of project-based learning on the motivational levels of adolescent mathematics students. From this study, the researcher discovered that many students felt more motivated as a result of the project-based unit, whether because they enjoyed the group learning setting, the specific content of the project, or because they enjoyed the change from traditional instructional approach. Many other students stated that their motivation
was not affected by the project-based unit; their motivational beliefs and opinions remained the same. Very few students suggested that the project had a negative effect on their motivational beliefs. This suggests that overall, project-based learning is an effective instructional method as well as a positive way to motivate most students.

Various teaching methods have their own value and place in the modern classroom. Traditional, teacher-led instruction, cooperative group learning, and project-based learning are a few of the more common teaching strategies seen in today’s classroom. Each of these methods has its own positive and negative aspects that make it a quality learning experience for students. Teachers need to be aware of new, innovative teaching methods and push themselves to vary their instructional methods and incorporate diverse learning experiences for their students. By creating learning experiences that are fresh and exciting, teachers will improve their practice, and students will hopefully maintain the desire to learn and the motivation to be successful.
 References


Appendix A - Surveys
Motivation and Attitude Scale

Demographic Information

Gender ______________________ Age __________________

Please make every effort to provide complete and accurate information for each question in this questionnaire. Circle the answer that best describes your feelings towards the statement.

1. I work hard to be successful in math because I will need to use math in my future.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

2. Performing many examples helps me to learn new concepts in math.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

4. My math teachers have helped prepare me for success in future math courses.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

5. I feel more motivated when we are doing group activities in math class.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

6. Math class stresses me out.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

7. My teachers have encouraged me to take more math courses in the future.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

8. I think I could handle more difficult math.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

9. I learn better when working in groups in math class.
   Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree

10. I feel nervous when the teacher calls on me in math class.
    Strongly Agree  Moderately Agree  Moderately Disagree  Strongly Disagree
11. I would like to avoid math in college.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
12. If I can't find the solution to a math problem, I feel defeated.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
13. Math teachers have made me feel I have the ability to go on in mathematics.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
14. I become anxious and forget important concepts during a math test.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
15. I like to go up to the board to answer questions/present solutions in math class.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
16. My teacher is available for extra help in case I don't quite get it the first time.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
17. I will keep working on a problem until I get it right.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
18. I would rather complete a project or make a presentation than take a test in math class.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
19. My teacher is genuinely interested in seeing me be successful in mathematics.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
20. I do not like to ask questions in class because I don't want to look dumb.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
21. I like to try and solve math problems outside of math class.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
22. I like to discover new concepts for myself.  
   | Strongly Agree | Moderately Agree | Moderately Disagree | Strongly Disagree |
23. I am sure that I can solve most math problems.

Strongly Agree    Moderately Agree    Moderately Disagree    Strongly Disagree

24. During a typical math class, I feel very motivated to work hard and achieve success.

Strongly Agree    Moderately Agree    Moderately Disagree    Strongly Disagree

Please explain your answer to question 24 on the lines below:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Open-Ended Survey

1. One thing I liked about working on this project is ________________

2. One thing I didn’t like about working on this project is ________________

3. One thing I liked about working in groups is ________________

4. One thing I didn’t like about working in groups is ________________

5. One thing that could be done to make this project-based unit better would be _______

6. Before completing this project, how would you rate your level of motivation to learn mathematics?

   Highly Motivated    Motivated    Neutral    Unmotivated    Very Unmotivated

   Please explain your answer to question 6 on the lines below:

   ___________________________________________
   ___________________________________________
   ___________________________________________
7. During the project-based unit, how would you rate your level of motivation to learn mathematics?

Highly Motivated    Motivated    Neutral    Unmotivated    Very Unmotivated

Please explain your answer to question 7 on the lines below:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Appendix B - Project Description, Grading Rubric, and Sample Lesson Plan
Project Description

Students will be completing an Architectural Design Project in their Geometry class. For this project, students will be arranged in small groups. Groups will consist of 3 or 4 students. In one class section, the teacher will arrange the group heterogeneously. In a different class section, the teacher will arrange the group homogeneously. In a third class section, the teacher will allow the students to arrange their own groups.

Students will be learning the concepts of measurement for 2-dimensional and 3-dimensional figures throughout the project-based instructional sequence. In addition to traditional, teacher led instruction the students will be participating in group learning sessions while completing different components of their project.

The main components of the projects are to design a site plan for their School of the Future, create a floor plan for the layout of the building(s) in their site plan, build a 3D scale model of a classroom in their school, and perform the calculations necessary to determine a relatively accurate cost estimate. In addition, students will be presenting their School of the Future on the final days of the instructional unit. Students will be graded on a rubric, which is included after the timeline.

Timeline for Project-Based Unit

Day 1 - Introduction of Groups and Description of Project

Day 2 – Scaffolding Lesson on Calculating Area of Simple Figures

Day 3 – Scaffolding Lesson on Calculating Area of Composite Figures

Day 4 – Applied Lesson on Calculating Building Costs using Simple/Composite Figures

Day 5 - Project Work Session with Groups

Day 6 – Discussion of Properties of 3-Dimensional Solids and Apply to Buildings

Day 7 – Project Work Session with Groups

Day 8 – Calculating Surface Area of 3-Dimensional Solids

Day 9 – Applied Surface Area of 3-Dimensional Solids

Day 10 – Project Work Session with Groups

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Day 11 - Calculating Volume of 3-Dimensional Solids

Day 12 - Applied Volume of 3-Dimensional Solids

Day 13 - Project Work Session with Groups

Day 14 - Project Work Session with Groups

Day 15 - Project Work Session with Groups

Day 16 and 17 - Project Presentations

Day 18 – Review Properties and Calculations Associated with 3-Dimensional Solids

Day 19 – Formal Unit Assessment
<table>
<thead>
<tr>
<th>Quality and Accuracy</th>
<th>Proposal</th>
<th>Cost Estimate</th>
<th>Scale Model</th>
<th>Site Plan</th>
<th>Floor Plan</th>
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<tbody>
<tr>
<td>The educational program—the vision for learning—is clearly explained</td>
<td>Cost per square foot are correctly applied</td>
<td>All required elements are included—tables, storage, windows, doors, etc.</td>
<td>All required elements are included—buildings, parking lots, athletic fields, roads, etc.</td>
<td>All buildings on site plan are represented</td>
<td>All buildings on site plan are represented</td>
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<tr>
<td>The reasons for design decisions are clearly spelled out—how the shape and layout of rooms and buildings and rooms support what they are intended to accomplish</td>
<td>Dimensions used match those used in the floor plan</td>
<td>Elements are made to correct scale</td>
<td>Elements are drawn to correct scale</td>
<td>All required interior elements are included—walls, windows, etc.</td>
<td>Everything is drawn to the correct scale</td>
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<th>Site Plan</th>
<th>Floor Plan</th>
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<tr>
<td>The information in logically sequenced and includes helpful organizers</td>
<td>All totals are clearly labeled and easily verifiable—supporting calculations are well-organized, derived from stated formulas, and indicate all dimensions and units used</td>
<td>The scale model is carefully cut and assembled</td>
<td>The site plan is carefully rendered</td>
<td>The floor plans are carefully rendered</td>
<td>The floor plans are carefully rendered</td>
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<tr>
<td>The layout is professional looking: graphics enhance the clarity and complement the content. A cover page with team logo is included</td>
<td>A paper doll person is included to represent the relative size of the space</td>
<td>Every building and developed area is labeled</td>
<td>The scale used is clearly indicated</td>
<td>Building &quot;footprints&quot; required elements are included—tables, storage, windows, doors, etc.</td>
<td>All buildings and interior spaces are labeled</td>
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<tr>
<td>10 points</td>
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<tr>
<td>The proposal demonstrates an understanding that both the company and the design concept must be sold</td>
<td>The cost estimate is realistic and takes into effect the concept of inflation</td>
<td>The room shape and interior layout support a futuristic vision of education and provide for technology and varying needs of learners</td>
<td>The plan reflects thoughtful use of the site and takes advantage of the natural features, while preserving at least 50% of the wetlands</td>
<td>The arrangement of spaces reflects a thoughtful approach to use light and making circulation (vertical and horizontal) efficient</td>
<td>15 points</td>
</tr>
<tr>
<td>Tone is business-like</td>
<td>Consideration is given towards funding for the project (government, taxes, etc.)</td>
<td>10 points</td>
<td>15 points</td>
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<tr>
<td>5 points</td>
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Reeder (2001).
Sample Lesson Plan

Unit: Measurement

Lesson Title: Area of 2-Dimensional Shapes

Lesson Objective: Students will be able to calculate the surface area of various 2-dimensional shapes by using an appropriate formula. Students will then be able to calculate a cost analysis based on the square footage of a particular building.

NYS Standards:

G.G.12: Know and apply that the volume of a prism is the product of the area of the base and the altitude

G.G.13: Apply the properties of a regular pyramid, including lateral edges are congruent, lateral faces are congruent isosceles triangles, volume of a pyramid equals one-third the product of the area of the base and the altitude

G.G.14: Apply the properties of a cylinder, including bases are congruent, volume equals the product of the area of the base and the altitude, lateral area of a right circular cylinder equals the product of an altitude and the circumference of the base

G.G.15: Apply the properties of a right circular cone, including lateral area equals one-half the product of the slant height and the circumference of its base, volume is one-third the product of the area of its base and its altitude,

Application to Project: Students will be drawing up designs for a floor plan of their school building(s). After coming up with an appropriate design, students will calculate the square footage of the building and use this figure to calculate the building costs.

Assessment: Students, within their groups, will complete a worksheet applying the new content. This will be collected and graded, so I can monitor their progress.

Closure: I will revisit how this concept is applied to the specific classroom project, as well as other “real-world” applications. Within their groups, students will discuss other applications of surface area and cost analysis.
Calculating Area

When calculating area, the first task is to determine which formula to use.

Below is a list of formulas that will come in handy:

<table>
<thead>
<tr>
<th>Shape</th>
<th>Area Formula</th>
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<tbody>
<tr>
<td>Rectangle, parallelogram, square</td>
<td>$A = bh$</td>
</tr>
<tr>
<td>Triangle</td>
<td>$A = \frac{1}{2} bh$</td>
</tr>
<tr>
<td>Trapezoid</td>
<td>$A = \frac{1}{2} (b_1 + b_2)h$</td>
</tr>
<tr>
<td>Circle</td>
<td>$A = \pi r^2$</td>
</tr>
</tbody>
</table>

Find the area of each of the following figures:

1. Rectangle: $110 \text{ ft} \times 35 \text{ ft}$
2. Triangle: $40 \text{ ft} \times 100 \text{ ft}$
3. Trapezoid: $28 \text{ ft} \times 18 \text{ ft}$
4. Circle: $50 \text{ ft}$
Application to Project:

If you consider the field of construction, you can probably imagine that these calculations are used on a regular basis. If a contractor wanted to give a cost estimate to a potential client, he/she would need to be able to calculate the dimensions of the building and then estimate the cost it would require to build.

For example, suppose the rectangle below represents the ground floor of a proposed building. The dimensions of the building are 200 ft. by 300 ft. The building contractor knows that the cost per square foot is approximately $200. What would be a good estimate for the projected cost of this building?

\[
\text{Area of rectangle} = bh = 200 \text{ ft} \times 300 \text{ ft}
\]

\[
\text{Area of floor} = 60,000 \text{ sq. ft.}
\]

\[
\text{Cost estimate} = 60,000 \text{ sq. ft.} \times $200 \text{ per/sq.ft.} = $12,000,000
\]

A good estimate for the building cost associated for this project would be $12 million.

For the next example, the cost per square foot of the building will be $150 per square foot. Try this example on your own (remember, first calculate the area of the shape, then multiply the square footage by the cost given).

\[
\text{Area of rectangle} = bh
\]

\[
\text{Area of floor} = 60,000 \text{ sq. ft.}
\]

\[
\text{Cost estimate} = 60,000 \text{ sq. ft.} \times $150 \text{ per/sq.ft.} = $9,000,000
\]
What happens if the shape of the building is irregular... like some of the compound shapes that we studied last week...

What we need to do is calculate each individual shape independently and then total the area of the entire figure. Then, we simply multiply by the indicated cost.

For examples 1 and 2 below, the cost per square foot of the building will be $150. Let's try these examples together.

1)

2)

For examples 1 and 2 below, the cost per square foot of the building will be $120. Try these examples within your group. (If you are unsure, try looking up your notes from Thursday!)

1)

2)
Appendix C – Formal Unit Assessment
3-Dimensional Solids Test

Multiple-Choice Section: Choose the best answer for questions 1-10.

1. How many bases does a triangular prism have?
   (1) 0 (2) 1 (3) 2 (4) 3

2. How many bases does a pyramid have?
   (1) 0 (2) 1 (3) 2 (4) 3

3. Which 2-dimensional shape is the base of a cone?
   (1) Square (2) Cylinder (3) Triangle (4) Circle

4. In a prism, the bases are ________________:
   (1) Parallel (2) Congruent (3) Parallel & congruent (4) Not enough info.

5. In a prism, which shapes can represent the lateral faces?
   (1) Circle (2) Rectangle (3) Triangle (4) Octagon

6. Which of the following figures would be classified as polyhedra? (circle all that apply)
   (1) Sphere (2) Pyramid (3) Cylinder (4) Cone (5) Prism

7. What is the name for a 2-dimensional figure that can be folded into a 3-dimensional solid?
   (1) Floor plan (2) Scale model (3) Net (4) Map

8. What is the name for the largest circle that can be drawn on a sphere?
   (1) Equator (2) Great Circle (3) Hemisphere (4) Cylinder

9. What 2-dimensional shape can be a lateral surface of a pyramid?
   (1) Triangle (2) Circle (3) Rectangle (4) Prism

10. What can be said about the lateral edges of a prism?
    (1) Parallel (2) Congruent (3) Parallel & congruent (4) Not enough info.
For problems 11 – 16, calculate the surface area and volume of the given figure. If your answer is not an integer, round to the nearest tenth. Be sure to SHOW ALL WORK!

11.

12.

13. Square Base Pyramid

\[ h = 8 \text{ in} \]
\[ s = 10 \text{ in} \]
14. Right Circular Cylinder

\[ h = 20 \text{ in} \]

15. Right Circular Cone

\[ r = 6 \text{ in} \]

16. Right Circular Cylinder

\[ 10 \text{ in} \]

\[ 6 \text{ in} \]
EXTRA CREDIT QUESTION:

Calculate the surface area and volume of the hexagonal prism below:
Appendix D – Exemplar Student Work
Student Exemplar – 3D Scale Model of Classroom
Finally wind turbines and solar panels have been included to produce power for the school and to help the students learn about alternative energy sources.

Cost Estimate

The New Horizons High School will consist of 16 story floors totaling 74,300 sq. feet. At $175 per square foot the total cost will be $13,102,500. The four wind turbines will cost about $1,500,000 dollars each and $14,000,000 total. There will only be a few solar panels at a cost of a $1,000,000 or less. Also the hills will be leveled at a cost of $10,000. That leaves $21,907,500 for the construction of the sports complexes, parking lots and walkways. A bus garage will not be built and a busing service similar to First Student will be used. Any remaining money not used after that will be put in a scholarship fund to be given to students or into a maintenance fund to be used to repair to the school and keep it in working order.

Scale Model and Perspective drawings

Both a scale model and a perspective drawing have been included in this proposal. The scale model is just of one room, while the perspective drawings will show both the inside and outside of the New Horizons High School.

Site Plan

A detailed site plan has been included to show the layout of the New Horizons campus. Everything has been drawn in to scale and in the appropriate locations.

Timeline of construction

Construction will begin in 2018 and will open in late August of 2050 in time for the new school year. Once completed the school should last forever, barring of course a hurricane, earthquake, tsunami, or nuclear war.

Future development

The forest to the north of the school remain untouched and could be cleared in the future for the construction of additional facilities, like an airport, a space center or just a football field.

PROJECT PROPOSAL For the New Horizons High School

Prepared for: Mrs. Beres
Prepared by: [Signature]
Date: May 5th, 2011
Proposal #: 69

VISION FOR LEARNING

The New Horizons High School will provide students with 21st century technology to prepare them for the high-tech careers of tomorrow. Each room will come equipped with a “Smart Cabi” comprised of 4 smart boards located in the center of each room surrounded by a ring of desks. This will give every student a front row seat and ensure everyone can see and hear the lesson.

The building has been constructed with 2 acres to reduce wind resistance and provide a unique learning environment for the students. The second floor serves as a location for lockers and as a universal study hall area. The entire outside walls will be built of glass to let in natural light and give students a place to relax in between classes so they can clear their mind and take a break. Finally the third floor is entirely comprised of glass both the floors and the arched ceiling. It will serve as the school’s cafeteria and an auxiliary study area. It will provide sweeping view of the surrounding landscape and the glass floor will let students watch soccer games and track meets from above.

The New Horizons School also has research laboratories, technology shops and greenhouses have been included to let students apply what they learn in classrooms and get a chance to reach their full potential. A pier has been built in the pond to allow science classes to study the pond ecosystem and other things in it.
Our Vision:

At United Soviet States Educational Facilitation Company Incorporated, we hope to provide an optimal learning environment for students. We strongly believe that to do this, we must eliminate any distractions that may hinder the learning process of the students.

Accomplishing Our Goal:

The route to accomplishing our goal is clearly reflected in our building plans. Eliminating distractions to students, such as color and abnormal shapes, is key to providing the best learning conditions possible. Therefore, all of our facilities are rectangular and plain. The interiors of all buildings will be a dull gray color, and will look deceptively poorly built, though we assure you they are not. We believe that if there is nothing pleasant for the students to look at, they will be more focused on learning. The classrooms lack windows, ensuring that students are unable to be distracted by what goes on around the school.

We also provide patented state-of-the-art learning helmets for every student. One is pictured here:

These wireless helmets, created by a team of award-winning scientists from around the world, connect to the school databases and administer lessons in a fraction of the time a normal school does. It is possible to learn an entire day's worth of material in just under two hours with these helmets. These helmets also eliminate the need for teachers, allowing for school funds to be distributed elsewhere.
Cost Estimate

$35,358,750

Patented Learning Helmets: $10,000,000 for 500 students

320 ft x 160 ft Main Academic Building: $8,960,000
  320 ft * 160 ft = 51,200 ft²
  $1200 ft² * $175 = $8,960,000

400 ft x 80 ft Mess Hall: $5,600,000
  400 ft * 80 ft = 32,000 ft²
  32,000 ft² * $175 = $5,600,000

Five (5) 80 ft x 80 ft Dorms: $5,600,000
  80 ft * 80 ft = 6,400 ft²
  6,400 ft² * $175 = $1,120,000
  $1,120,000 * 5 = $5,600,000

120 ft x 120 ft Work Building: $2,520,000
  120 ft * 120 ft = 14,400 ft²
  14,400 ft² * $175 = $2,520,000

160 ft x 80 ft Disciplinary Building: $2,240,000
  160 ft * 80 ft = 12,800 ft²
  12,800 ft² * $175 = $2,240,000

Two (2) 35 ft x 35 ft Guard Towers: $428,750
  35 ft * 35 ft = 1,225 ft²
  1,225 ft² * $175 = $214,375
  $214,375 * 2 = $428,750

Cost to Level Hills: $10,000
Student Exemplar – Cost Analysis

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<th>Building</th>
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<tr>
<td>Library</td>
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<tr>
<td>Student Center</td>
<td></td>
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</tr>
<tr>
<td>Science Building</td>
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</table>

Cost Breakdown:

- Classroom Building: $X
- Library: $Y
- Student Center: $Z
- Science Building: $AA

Total Cost: $AB

Completion Dates:

- Classroom Building: Date 1
- Library: Date 2
- Student Center: Date 3
- Science Building: Date 4