THE EFFECTS OF TEACHING MATHEMATICS WITH PROJECT BASED LEARNING IN CAREER AND TECHNICAL EDUCATION COURSES

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# Mathematics in CTE 2

## Table of Contents

Abstract.................................................................................................................. 4

Chapters

I. Introduction........................................................................................................... 5
   Statement of Problem......................................................................................... 6
   Research Questions.......................................................................................... 7
   Definition of Terms......................................................................................... 8

II. Review of Related Literature............................................................... 13
   Career and Technical Education (CTE)...................................................... 13
      Learner Participation............................................................................... 13
      Mathematics within CTE....................................................................... 16
      Workplace Learning............................................................................... 19
   Teaching for Learning Mathematics......................................................... 20
      Group Work.............................................................................................. 20
      Inquiry Learning....................................................................................... 22
      Hands-on Manipulation......................................................................... 24
   Project Based Learning (PBL)................................................................ 26
      Active Learning......................................................................................... 26
      Student Discovery..................................................................................... 28
      Student as Center..................................................................................... 31
   Teaching with PBL in CTE................................................................. 33
      Implementation......................................................................................... 33
Mathematics in CTE 3

Professional Development........................................... 36
Content Standards...................................................... 37

III. Results and Analysis.................................................. 41
Career and Technical Education (CTE)................................. 41
Teaching for Learning Mathematics..................................... 43
Project Based Learning (PBL).......................................... 44
Teaching with PBL in CTE ............................................. 46

IV. Recommendation and Conclusions............................... 48
Recommendation.......................................................... 48
Areas for Further Research............................................. 50
Summary and Conclusion............................................... 53

References......................................................................... 57
Abstract

The aim of this research report is to examine the effects of teaching mathematics in a Career and Technical Education (CTE) classroom using Project Based Learning (PBL). This researcher holds a participatory worldview with intentions of this exploration to provide data for future high school reform. Career and technical education and PBL provide students with autonomy and the learning of relevant content in an interactive, applied setting. In light of the new Michigan Merit Curriculum, mathematics learning strategies are critical in restructuring the curriculum to promote student success. Teaching mathematics within a CTE course using PBL should help eliminate negative attitudes towards mathematics, and provide a medium for applying mathematical theory which should increase student performance in mathematics.
Chapter I: Introduction

Introduction

On April 20, 2006, the Governor of Michigan, Jennifer Granholm passed the Michigan Merit Curriculum (MMC), which is one of the most rigorous high school curriculums in the country (Michigan Department of Education, 2007). The MMC defined common minimum standards and credits for high schools throughout the State of Michigan. The pressure placed on schools to conform to the MMC is influencing academic reform to meet the needs of the students by offering choices for the diverse learning population (Michigan Department of Education, 2009).

All schools in Michigan must abide by the standards set by the MMC. School districts may choose to require students to have more credits to graduate from high school than the State mandates, but no school may have fewer. Several people and agencies were responsible for creating the MMC, including Governor Granholm, the State Board of Education, and the State Superintendent of Public Instruction. Several alleged purposes of the MMC are to better prepare Michigan students for colleges, future employers, and vocational schools by establishing mastery of reading, writing, and math (Michigan Department of Education, 2007). According to the U.S. Secretary of Education Arne Duncan, mathematics scores for grade four have not increased from 2007-2009, and Grade 8 only increased slightly by two-points from 2007-2009. Mr. Duncan issued the following statement on The Nation’s Report Card: Mathematics 2009, National Assessment of Educational Progress (NAEP) at Grades four and eight: “Today’s results are evidence that we must better equip our schools to improve the knowledge and skills of America’s students in mathematics” (U.S. Department of Education, 2009). Career and technical
education laboratories are less utilized due to students having to fulfill higher credit requirements. The increased credit requirements required by the State of Michigan eliminate the opportunities for students to take CTE courses. The low enrollment in CTE courses opens CTE laboratories. The open CTE laboratories provide the tools and space necessary to teach mathematics using CTE laboratories with the PBL learning model. This study will provide insight on the effects of teaching mathematics within CTE using PBL.

Statement of Problem

Career and Technical Education (CTE) reform efforts are under researched and few scholarly attempts have been made to link CTE to research on academic components of U.S. schooling (Castellano, 2003). Alfeld, Pearson, and Stone (2008) suggested that students who receive mathematics concepts through CTE will perform better statistically than students who do not receive mathematics concepts through CTE courses. The MMC requires that all students successfully complete Algebra two prior to graduation. Currently there is proposed legislation that will allow students to bypass the algebra two requirement by successfully completing a State approved CTE course. The State approved CTE course must have the minimum math requirement which is set by the State for each approved CTE program (Michigan Department of Education, 2009). With all students having the option of opting out of the algebra two requirement by taking a State approved CTE course, researchers must study the effects CTE courses will have on students’ performance on mathematics sections of State tests.

To help achieve the rigors of the MMC, educators need to understand the effects of teaching mathematics using Career and Technical Education (CTE) and Project Based Learning
(PBL) as delivery methods. This research report will include four constructs to analyze the teaching of mathematics through CTE and PBL with the following subtopics.

<table>
<thead>
<tr>
<th>Constructs and Subtopics of the Literature Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Career and Technical Education (CTE)</td>
</tr>
<tr>
<td>Teaching for Learning Mathematics</td>
</tr>
<tr>
<td>Project-Based Learning (PBL)</td>
</tr>
<tr>
<td>Teaching with PBL in CTE</td>
</tr>
</tbody>
</table>

The review of literature will involve using the ERIC database and the National Center for Education Statistics, the U.S. Department of Education, and the Michigan Department of Education web sites.

**Research Question**

With the increase in State mathematics standards and the need for better equipped math instruction, what effects will teaching mathematics with project-based learning in career and technical education classes have on student performance in mathematics?

**Definition of terms**

_Career and technical education._
The amount of workers employed in manufacturing between the years 1979 through 1993 in the U.S. fell from 41 percent to 16 percent which meant students couldn’t automatically find jobs where his or her father worked (Castelano, 2003). The effect of the manufacturing decline caused vocational course enrollments to decline in areas such as: business, agriculture, and the trades (Castelano, 2003). Vocational programs were forced to change their focus to highly technical education which changed the name vocational education to Career and Technical Education CTE and concentrated on areas such as: computerized diagnostic repair, computer numerical control machines, and modern medical equipment (Castelano, 2003).

Gentry, Mann, and Peters (2007) suggest that both gifted and general students perceive CTE as providing autonomy, effective and caring teachers, connections to other students with similar interests, and relevant content in an applied setting. The themes that emerged from Gentry, Mann, and Peters (2007) suggest that the CTE structure helps in preventing students from dropping out of high school. Participation in CTE coursework reduces dropout rates and effectively prepares students for postsecondary education (Castelano, 2003).

Career and Technical Education provides a model for project-based learning (Burke, 2009). Students in CTE programs are often assigned projects in the start of a semester and are able work on them in any order the students choose (Gentry, 2007). Many projects allow for the student interest to drive the concentration of a project (Gentry, 2007). Many teachers understand the importance of cooperative learning but still teach all students traditionally to avoid the planning necessary to have students work in groups (Steward, 2004). Hands-on learners have difficulties with traditional learning because the formal seating, lack of mobility, and lack of hands-on manipulation tends to make learning boring and the brain exhausted (Strother, 2007). In a study by Gentry, Mann, and Peters (2007), 35 general and 19 gifted students simultaneously
attended a traditional high school along with a career and technical education (CTE) school. Through self-reported interviews both the gifted and the general students preferred the CTE school based on experimentation with careers, self-paced curriculum, students choosing the order of assignments, connection of a profession, hands-on learning, relevant content in applied setting, and high expectations of instructors.

*Workplace learning.*

Tan and Venables (2009) suggested that workplace learning should be embedded into the curriculum of higher education. Tan and Venables recognized the need for authentic workplace experience in the IT undergraduate program and started the curriculum reform process. Tan and Venables worked towards implementing a capstone project and a learn *in* and *through* process rather than a learning *about* and *for* process. To start the process of reform the researcher started tracking software developers at Microsoft using observation as the data collection process. The researchers suggested that soft skills were a major component of Microsoft jobs. The findings were in contrast with Victoria University’s expectations, thus impacted what the IT program will expect from students in the future. The University implemented a capstone project that imbedded students within the workplace to have actual workplace problems to solve (Tan & Venables, 2009).

Career and technical education has been viewed as benefiting industry at the expense of self-development needs of students (Grier, 2005). Grier’s suggestion that students’ self-development needs are not being address should be a concern for career and technical educators. Self-development is the first stage of being a lifelong learner (Grier, 2005).
Project-based learning.

Project-based learning is generally divided into three phases. First the teacher must select a topic based on State standards and help students create a problem or question, second the students must collaborate with peers to create subtopics they want to explore, and finally the physical project work is created by using technology or physical manipulation (Foulger, 2008). Much like CTE, PBL allows the student to tap into the students’ interests by allowing them to create projects that are meaningful (Bezon, 2007). State standards are requiring all students to be high achieving which is stimulating schools to reform (Corcoran, 2009). The use of PBL requires a continual professional development model to support the use of PBL in the classroom. The professional development increases the teachers’ knowledge of PBL and provides teachers with solutions to problems they may be experiencing in the classroom using PBL. (Eylon, 2008).

Rone (2008) suggested that effective teaching and learning is fostered by active learning through field experiences, experiences that promote interaction between teachers and learners, and diverse instruction that meets the needs of multiple learning styles. Both CTE and PBL accomplish Rone’s (2008) three criterion for effective teaching (Burke, 2009; Faris, 2007). Burke conducted a study which involved mathematics teacher and a CTE teacher that use house construction for the delivery of geometry. The participants included two years of students enrolled in a controlled group, and an experimental group. The control group included 30 students enrolled in general geometry and the experimental group included 32 students enrolled in the geometry in construction course. Both groups of participants were enrolled in the courses during the 2006-2009 school years.

The data for the study included the Colorado State standardized test. The results of the current test results were compared to the test results prior to the start of the geometry in
construction course. The initial Colorado State standardized tests annual comparisons suggest that high proficient students are staying highly proficient in geometry and 70 percent more non-proficient students are moving up an entire category (Burke, 2009). The geometry in construction class outperforms all other geometry classes within the district. Burke used CTE as a PBL model to teach academic courses to general and CTE students. Project Based Learning is more effective when a real problem is presented to students and research suggests that higher motivational levels exist when students are taught using PBL (Chia, 2009; Hakkarainen, 2009; Sungur, 2006). Increasing student motivation does not guarantee that students will perform better in the subject they are learning. The use of PBL must provide students with the motivation to learn, along with providing the student with the content. This study will examine the feasibility of increasing student performance in mathematics by teaching mathematics in CTE courses using PBL.

The MMC increased the credit requirements for Michigan secondary schools which is increasing the need for higher level instruction. There is limited research on the use of CTE as a delivery method for academic courses, and strong research in support of the use of PBL. The relationship between the research that highly supports PBL and the limited application of PBL in schools will be examined in this study.
Career and Technical Education

Career and Technical Education provides a model for project-based learning (Burke, 2009). Students in CTE programs are often assigned projects in the start of a semester and are able to work on them in any order the students choose (Gentry, 2007). Many projects allow for the student interest to drive the concentration of a project (Gentry, 2007). Many teachers understand the importance of cooperative learning but still teach all students traditionally to avoid the planning necessary to have students work in groups (Steward, 2004). Hands-on learners have difficulties with traditional learning because the formal seating, lack of mobility, and lack of hands-on manipulation tends to make learning boring and the brain exhausted (Strother, 2007).

Learner participation.

A study on the differences between general and talented students’ perception of their CTE experiences compared to their tradition high school experiences included six students from nine different programs. Each of the nine CTE program managers used the same instrument for selecting the participants of the study. The instrument involved a four-point scale ($4=to a great extent; 1=not at all$) on seven of the following areas: (1) shows outstanding talent in this domain or career pathway when compared to age peers; (2) performs or shows potential for performing at remarkably high levels of accomplishment when compared to others similar in age, experience, or environment; (3) has a desire to work with advanced concepts and materials in this area; (4) is willing to explore new concepts; (5) seeks alternative ideas; (6) actively considers others’ values; and (7) often thinks “out of the box.” Two of the six students selected
from each program were selected by having the highest scores and were referred to as talented students. All other students labeled talented were eliminated from the student to ensure a balance of general and talented students. The remaining four general students were randomly selected from the remaining students for each of the nine programs. A total of 51 students participated in the study due to three students being absent for their interviews. Sixteen students were identified talented and 35 students were identified as general. The age ranges of the participants were 14 to 19 years, and 57% were males. The participants were attending the CTE center from 13 different schools located near the CTE center. All schools had participant representation for the study, although students were not selected due to the school they attended.

Gentry, Mann, and Peters used a qualitative research design. The students were interviewed using a format that allowed for follow-up questions if needed. The interviews lasted between 30 and 60 minutes and were collected over a five-month time period by each of the two researchers. The researchers recorded extensive field notes on each of the nine programs prior to conducting the interviews. The interviews were recorded and transcribed, and field notes, logs and school documents were compiled to create a data triangle. The data were axial coded, organized and analyzed to understand the differences between the two settings between talented and general students attending the CTE center.

All of the talented students, and 33 of 35 general students observed differences between the CTE center and their traditional high schools. The themes that emerged from the study were autonomy, effective and caring teachers, other students with similar interests, and learning relevant content in an interactive, applied setting. Neither group spoke negatively about the CTE center; however, both the talented and general students commented negatively concerning their traditional high schools. The talented students made eight positive comments about their
traditional high school, where the general students only made three positive comments. The general students believed that their traditional high school teachers lacked depth, quality, and caring.

Students whom are given the opportunity to solve problems within groups will be more engage than students whom are taught using traditional education. The CTE center provided students with challenging problems that allowed students to choose the path in which they will solve the problems while interacting with their peers. Due to the nature of the self reporting research design, further research should follow this study to determine whether the outcomes of this study has an effect on student performance compared to traditional education (Gentry, 2007).

Students enrolled in CTE courses tend to have a higher engagement in their education than traditional courses (Burke, 2009). A study on student engagement and its relationship with high school dropouts involved 11,827 seventh to ninth grade students from 69 high schools. Consent forms of the participants were collected by the researchers prior to the study. Of the participants 44.6 percent were males and the average age of all participants was 13.1 years. The data collection instrument used in the quantitative study was a self reporting survey including six constructs. The constructs were school attendance and discipline, liking school, interest in academic work, and willingness to learn language arts and mathematics. Each construct question used a seven-point Likert scales ranging from strongly agree to strongly disagree. The purpose of the survey was to analyze if students with low engagement are a predictor for high school dropouts. The researchers of the study expected negative behavior to be a predictor of low engagement, which would then lead to students dropping out. The researchers generated descriptive statistics and correlations for the construct variables. The eighteen engagement items
within the constructs were tested using Explanatory Factor Analysis (EFAs) with Promax rotation in Mplus. Mplus is data analysis software used for estimating regression, path analysis, and EFA. The results of the data analysis suggested that students with low engagement are at higher risk for dropping out of high school than students who are engaged.

CTE courses that involve students in the learning will help fulfill the goals set by the MMC. In order for students to be successful in high level academics, teachers must provide lessons that are engaging to the learner. If all students are to be successful, teachers must provide innovative, active, and practical problems for students to solve. CTE provides the model all courses must follow to ensure student engagement (Archambault, 2008).

*Math within career and technical education.*

A mixed methods study on high school students’ math skills through career and technical education included 137 CTE teachers, 59 of which were teaching the experimental group and 78 were teaching the control group. The number of students between both the experimental and control group totaled 595. The teachers were recruited by the researchers and the students were selected based on successful return of permission forms that the parents or guardians signed.

The CTE teachers who were teaching the experimental group attended extensive collaborative professional development sessions where CTE teachers were given time to teach math lessons using CTE to their peers. The math teachers facilitating the professional development were providing the CTE teachers with feedback concerning the math content within the CTE teachers’ lessons. The professional development sessions provided CTE teachers with the process to weave mathematics such as algebra, geometry, and trigonometry into the CTE curriculum. A pretest was given at the start of the school year to all experimental and control
groups to provide evidence of the two groups’ equivalence of mathematics knowledge. Between the times of pretest and posttest the researchers collected data using qualitative observations. Upon completion of the courses all students completed several examinations which included a posttest of students’ mathematics knowledge, and a comprehensive exam that tested students’ knowledge in both mathematics and the technical course in which the mathematics was embedded in. The purpose of the second quantitative exam was to test if students had sacrificed technical content for mathematics content.

The results of the study suggested the differences between the controlled and experimental group outcomes were not statistically significant. The students enjoyed math using CTE instruction over the controlled group; however, the students enjoying the class didn’t make a difference in performance. The students within the experimental course didn’t sacrifice technical knowledge for mathematics knowledge. The students in the experimental group were able compete mathematically with the control group, while at the same time, increasing technical knowledge.

Although the researchers didn’t provide evidence to support their hypothesis that students will have better mathematics outcomes if they learn mathematics through CTE courses, they did provide information for further research concerning using CTE courses as an alternative to teaching traditional mathematics courses. Students with CTE interests could have the opportunity to take mathematics in their area of interest and not lose technical skills that the course is intended to teach. This study provides evidence to support that it is possible for students to take mathematics courses using the CTE model and still perform equivalent to traditional mathematics courses (Alfeld, 2008).
A course in Loveland Colorado named Geometry in Construction allows students to fulfill the geometry requirement. The course provides students with the opportunity to solve actual geometry problems that occur while skilled workers build houses. The students were building and erecting walls from sets of prints provided by the architects. A quantitative study by Burke (2009) was conducted comparing the students in the Geometry in Construction course to the traditional geometry course. The participants included 32 students within the Geometry in Construction, and 30 traditional geometry course students that returned the mandatory participant permission forms that were signed by the parents or guardians. Forty-two percent of the Geometry in Construction participants were female.

The study used the State standardized mathematics exam to compare the two groups of students. Prior year’s tests of the participants were tracked to analyze changes within student performance from prior years. The results of the test suggested that the high achieving students remained high, and 70 percent of the non-proficient students moved up an entire category. The geometry in construction improves lower performing students’ academic performance. The study indicates that the high performers stay high and improves low performers. The use of CTE in mathematics could be a step in the right direction for administrators. Improving low performance students should be the goal of schools struggling with the changes set by the MMC.

The use of mathematics in CTE will allow students to approach a problem often found in construction and use mathematics to solve the problem. Often in math, educators teach how to solve a problem without being given an actual scenario where a student must solve a problem. Frequently in education the relationship between solving a problem while building a house, and solving mathematic problems in the classroom are two separate subjects. According to this Burke (2009), students should be presented a problem while constructing, and be taught how to solve
the problem using mathematics. If students observe the benefit of mathematics they will more likely retain the knowledge they need to be successful with the subject later in the workplace (Burke, 2009).

Workplace learning.

A qualitative study on workplace learning in an undergraduate industrial technology (IT) program was conducted with 24 students at Victoria University in Victoria Australia. The 24 participants were selected by their amount of credits at Victoria University. All students starting their second year were given the opportunity to participate in the study.

Victoria University requires students to complete a capstone project for student graduating with an IT degree. Due to accreditation concerns they wanted to better prepare students for the capstone projects. The researchers developed a new initiative that would place students within industry for several classes over a three year period. The researchers used triangulated data collection through the use of field notes, interviews, and student projects. The researchers coded the data and developed themes that suggested students who learn through work tend to develop better communication skills, problem-solving skills, and are engaged in learning longer than students who are not learning through the workplace.

The suggested themes of the study are congruent with the ideas of many studies conducted on CTE courses. Learning through work presents opportunity for students to solve actual problems that industry workers must solve daily. Students in traditional education are often given synthetic problems that have little meaning, which is why it is necessary for teachers to provide learners with actual problems to be solved. The sense of meaning will help students
retain knowledge and demonstrate the need and importance of knowledge outside of school (Tan, 2009).

*Teaching for Learning Mathematics*

*Group work.*

Students often carry a negative attitude towards learning mathematics and science in a traditional classroom (Horton, 2007). A study conducted by Faris, (2008) on the impact of PBL on students’ attitudes towards science among ninths graders in Doha City, Qatar used a mixed methods research approach. The purpose of this study was to test if PBL would improve students’ attitudes towards learning science, and to identify strategies to improve teamwork skills. The quantitative data collection used a questionnaire after the students presented their final projects. The questionnaire included self reporting, Likert scale question ranging from one to four. One to three was considered “weak,” three to three and one half was considered “positive,” and three and one half to four was considered “strong positive.” Questions on the questionnaire included the topics of overall student attitude toward science, student attitude toward group work in PBL, student attitude toward problem solving in PBL, and overall attitude of student to PBL in science. The qualitative data collection methods included field observation and student interviews. The researcher assigned the participants with two semester projects as follows:

1. How can I reduce my carbon footprint?

2. Is obesity in our school correlated to bad dietary?

The participants included 25 ninth graders from Hamza Independent School. The researcher withheld the details on methods for participant selection. Hamza Independent School is well equipped with advanced furnishings such as smart boards.
The results of the study indicated that students’ overall attitudes towards science is positive, the attitudes toward group work in PBL is strong positive, the attitudes of students towards problem solving in PBL is strong positive, and the overall student attitude of PBL in science is strong positive. The quality of the student reports greatly improved when compared to the work of the student prior to this research project. The students constructively criticized each other’s work while positively accepting criticism. The students effectively divided the work between the group members and offered help to the students whom were overwhelmed with sections of the project. Students commented that they will be able to carry out their own investigations; the project taught them more than a textbook could, the assignments were fun; and not only were they learning science, they were doing science (Faris, 2008).

Students who want to learn place themselves one step further towards a successful education. When teachers use group work, it simulates how most students will work in their post-secondary careers. By allowing students to make inquiries with their peers allows them to create ideas to solve problems as a group. Faris’s (2008) findings should provide motivation for teachers to create innovative ways to present information and still cover the required information. Allowing students to work together using inquiry learning empowers students to become problem solvers instead of good listeners and note takers.

*Inquiry learning.*

Research indicates that the use of inquiry learning increases student motivation; however, the use of inquiry learning is dependent on the delivery of the teacher. If the teacher properly prepares the students for inquiry learning, it will increase student motivation (Faris, 2008). A quantitative study on K-12 science and mathematics teachers’ beliefs about and use of inquiry in
the classroom included 1,222 participants. Surveys were sent to 4,784 mathematics and science teachers. Of the 4,784 teachers, 1,222 complete responses were returned. Two hundred and thirty-six were science teachers, 283 were mathematics, and 703 teach both science and mathematics. The survey was a 58-item electronic survey over a 10 day administration period. The survey include Likert scale question on demographics; beliefs about inquiry instruction, content standards, and support structures; and strategies for inquiry learning, and frequency of instructional style. The Likert scale ranged from one through six, one meaning completely disagree, and six meaning completely agree.

The results of the study indicate that teachers do not use inquiry teaching style most of the time as 38.7% (SD=18.9%) of instruction time is spent on inquiry learning. Teachers report that 57.3% (SD=19.5%) of time should be spent on inquiry learning. The data for the remaining section were analyzed using ANOVA. The data suggested that elementary teachers report inquiry learning significantly higher than both middle and high school teachers, and science teachers use inquiry learning significantly higher that mathematics teachers. There is a correlation between grade level and inquiry learning support from administration. Younger grade level teachers report having more support for inquiry based instruction than higher grade level teachers. Teachers who have a higher self efficacy of inquiry instruction tend to spend more time on inquiry instruction than teachers who have less self efficacy. Female teachers use more inquiry instruction more than males, and there is no correlation between teaching experience and the amount of inquiry used in the classroom (Horton, 2007).

Teachers report that they would like to increase the use of inquiry in the classroom by 20%. The amount of support teachers receive for using inquiry teaching styles is significant in the amount of inquiry that takes place in the classroom. As scores decrease in science and
mathematics, administrators should look seriously at ways they can support or encourage teachers in using inquiry learning. The use of inquiry is a strategy that could help student who are struggling. If scores continue to stay stagnant or decline, administrators should research the problem with the use of inquiry, and modify based on the finding of the research. If teachers know they need to increase the amount of inquiry in the classroom, they know the importance of using inquiry in the classroom. The use of inquiry lends itself for students to solve problems by using science and mathematics. Mathematics and science are subjects that can be taught through laboratory experiences where students solve problems, and solving problems through activities keeps students motivated to learn (Burke, 2008).

*Hands-on manipulation.*

Advances of pedagogical theory have evolved throughout time to shape educators instructional methods to a more interactive model. A qualitative study on a computational tool to assist in learning primary school mathematical equations uses a constructivist approach. The objectives of the study were to develop a computational tool to replace the conventional balance for practical mathematics exercises, and checking how the replacement of the conventional balance with a computational tool for the solution of first degree equations affects aspects of the learning process such as motivation, cooperation, dialogue, discussion, reflection, reciprocity, negotiation and responsibility. The exploratory research uses non-participatory observations of 46 mathematics students whom were selected through convenience of two groups of 23 students in grade six in Brazil. The teacher was the same for both groups.

Students for this research study were presented with five first-degree polynomial equation problems. In the first group the equations were presented and solved in the
computational tool which consisted of a three dimensional computer software program created for this research study. The second group was presented the same equations; however, the presentation was in a classroom on a traditional blackboard with conventional balance procedures. Data were collected from each of the groups through observations and analyzed after the duration of the study.

The data suggest that students in the traditional math class were able to complete one complete balance equation during class. The teacher had to verify that all balanced equations were correct. Student within the computer based instruction were given the opportunity to work at their own speed. All students within the computer based instruction completed at least five balanced equations while others completed more than five. A portion of the reason students were able to complete more in the computer based instruction is because they didn’t have to wait for the teachers’ instruction. The computer gave every student instructions at the students pace. On the computer based instruction students were able to manipulate the on screen balancing functions to visually see how equations are balanced using three dimensional graphics. The students were able to experiment with the equations to see what works and why. The primary difference in observing both groups was the lack of interaction between students and the problem in the traditional math class compared to the computer based instruction. The lack of physical and social experience for the traditional math class made the learning tedious which negatively affected motivation, dialogue, and cooperation (Carrijo, 2009).

The use of computer based projects in allowed the students to see how equations are balanced and experiment with the graphics to see why certain methods don’t work, without wasting time (Carrijo, 2009). Students who are given the opportunity to manipulate problems using their hands may have higher motivation than students whom are only given information
through traditional instruction. Teaching mathematics is often taught using desks and a blackboard where teachers should be adopting new methods that researchers are suggesting such as PBL. Using new concepts requires teachers to spend more time to preparing; however, once the concepts are prepared, the teaching requires less work. Traditional teachers who choose not to use modern methods often don’t want to prepare new lessons when they already created traditional lessons.

*Project Based Learning*

*Active learning.*

A quantitative study to understand students’ motivation in project work was conducted using Secondary two (equivalent to Grade 7 in the United States) students from five government schools in Singapore. The students were selected using a cluster analytic approach and were comprised of 430 males, and 337 females. The mean age of the participants was 13.78 (SD=0.77). The participants were broken into three categories based on their academic record which were, most academically inclined, normal academically inclined, and least academically inclined. Informed consent was received on all participants.

The data collection for the study was a pre, and post self reporting survey and measured perceived locus of causality, basic psychological needs, emotions, metacognition, and perceived skills learned in project work. The pre-survey was given during week two of the study after students were broken into groups. The post-survey was given after 10 weeks of group project work.

The data from the survey were analyzed using Confirmatory Factor Analysis (CFA) and was conducted with EQS for Windows 6.1, and MANOVA. The results suggested that the
students gained no significant perceived skills over the duration of the study. All groups reported that the group experience decreased their enjoyment and value of learning. The researchers suggested that the students didn’t like the project work because the expectations of the projects were unrealistic (Ee, 2008).

The implication that project work decreases students’ enjoyment and value of learning is alarming. The important discovery of this study is the importance of the projects the students have to choose from. If the projects are overwhelming to the students after a given amount of time, teachers must be willing to manipulate the projects. Teachers whom use project-based learning must be prepared to alter assignments if needed to motivate learners and keep them on task.

Experiential education is an example of an active learning model which uses PBL (Rone, 2008). A study on experiential education included 35 students from Emory College. Of the 35 students there were 23 woman, and 12 men. The participants included all students enrolled in Language and Culture at Emory College during the semester the study was conducted. The course was to introduce students to linguistic anthropology. The purpose of the study was to determine if students learn course content through experiential learning. The experiential learning for the study was a field trip to St. Helena island in South Carolina to study Gullah Creole. The study was mixed methods. The qualitative data collection included participant observations, field notes, photography, student discussion, and assignments such as reflective essays. The quantitative data collection used several pre and post tests, one test at the beginning and end of the semester, and one test at the beginning and end of the field trip. The tests assessed student knowledge of the Gullah culture, perception of learning, prior learning experiences, and recommendations for future Gullah field trips.
The quantitative data suggested that the instruments were not valid due to all students successfully answering the knowledge questions on the pre-test. The open-ended questions provided insight on follow up research that could be conducted by the researchers. Themes emerged from the qualitative data that suggest the students better understood the Gullah culture. Most students reported that they were surprised by the amount of isolation of the Gullah people. The students commented that they would have been unable to know of the isolation if they didn’t participate in the field trip. All students reported having an increase of knowledge of the culture after the field trip. The field trip also gave the students the ability to communicate with the culture they were studying which helped revealed social characteristics of the Gullah culture (Rone, 2008). Active learning helps students become engrossed in the subject they are studying. The stimulation from social interactions allows the students to feel, touch and manipulate what they are trying to learn. Active learning allows students to explore what they are interested in by allowing the students the freedom of student discovery.

*Student discovery.*

When a student has the opportunity to investigate a problem and discover a solution, the student is receiving an important aspect to his/her education. Upon graduation, students’ will have to solve on their own without the help of teachers. If teachers fail to give the students the skills to discover solutions to problems, the students are not getting the education required for the post-secondary world. A study on inquiry teaching and learning examined students’ perceptions of their ideal or best math class both before being introduced to inquiry based learning, and after they are introduced to inquiry-based learning. The participants for the study included 29 students enrolled in a college level math class that hadn’t been exposed to inquiry based learning. One
student was non-traditional at an age of 38. All other students’ average age was 19.9 years. Most students were in their third year of college, and all completed a college level calculus class.

The data collection instruments were a pre-course essay and post-course essay. The students were given an essay to complete on the first day of class that was due the following day. Towards the end of the course the students were given the second essay along with their first completed essay. The students were told to note any changes concerning their perceptions on the best math class. The students received 10 points out of a total of 500 course points for completing both essays.

The data analysis of the pre and post essay used a qualitative approach. The themes that emerged from the essay were identified, coded, and re-analyzed to refine the themes. The pre-essay results suggest there were two major categories which were Watch-Learn-Practice (WLP) view (20 of 29 students), and Self as Initiator view (SI) (9 of 29 students). The WLP group seemed to have a high external locus of control where the SI group had a high internal locus of control. The WLP looked at the teacher as the primary source of knowledge where the student should practice what the teacher instructs. The SI group viewed the teacher as a guide to help student learn the information; however, the student provides the knowledge through research. The WLP group has the idea that the teacher provides information while the SI group solves problems through inquiry. The post-essay results for the WLP group reveal that 14 of the 20 students slightly changed their views of the best math class. Of the 14 students who changed their minds, all suggested that math be taught using a mixed methods approach. Traditional instruction followed by discovery through inquiry. The post-essay results of the SI group revealed that six of the nine students changed their views of the best math class. The changes from the SI group were not changing to the outlook of the WLP group. The SI group further
refined their original opinions on the best math class. The students were giving specific examples of strategies to incorporate discovery through inquiry into math lessons. The students mainly commented that students must put more effort into learning mathematics on their own, without specific instruction from a teacher. The main problems with this study were the lack of field observations, and relying strictly on student self reports. The students may have completed the survey to sway the teacher to instruct using the easier method (Stonewater, 2005).

Although the research has flaws the information suggests that the majority of the students from the study preferred traditional style education along with discovery through inquiry. The research article was chosen to contrast most articles that are in favor of PBL and inquiry. Teachers that choose to use PBL and student discovery must place importance on promoting lifelong learning. The only method in teaching lifelong learning is to keep the student in the center of the learning by not always giving the information they need. The student must know how to research on their own.

*Student as center.*

A study on the effects of problem-based learning and traditional instruction on self-regulated students included 61 tenth grade students from middle- to upper-class families. Of the 61 tenth grade students, 39 are boys and 22 are girls. Two class sections of biology students were selected for the study, and each class was taught by the same biology teacher. The mean ages of the two groups were 16.6 years of age. One class made up the control group (n=30) and the other the experimental group (n=31). The experimental group was randomly assigned. The teacher of the two classes volunteered to teach the classes. The students all completed self-reporting surveys.
The researchers used a quantitative, quasi-experimental research design. The study used a MSLQ, which is a student self-reporting tool to assess motivation and use of learning strategies and consists of two sections, motivation and learning strategies. The motivation section of the MSLQ has six subscales that assess students’ goals and value beliefs, beliefs about their ability to succeed, and anxiety about tests. The learning strategies section of the MSLQ has nine subscales that assess students’ ability to use various cognitive and metacognitive strategies and management of different resources. Two multivariate analyses of variances (MANOVAs) were used to determine the effect of various methods on students’ self-reported motivation and self-reported use of learning strategies.

Both the controlled group and the experimental group were taught four, 45 minute sessions per week for one semester. The groups were each given syllabi with identical content. At the end of the semester the students were given the MSLQ. The researchers analyzed the mean scores and standard deviations of both the self-reporting pretest, and the self-reporting posttest.

The pretest scores suggested there were no preexisting differences between the experimental and controlled group. With respect to self reported motivation, it was statistically significant that problem-based learning (PBL) had a positive effect. The experimental group experienced a 31% increase in self-efficacy for learning and performance, intrinsic goal orientation, extrinsic goal orientation, task value, and control of learning beliefs. Sixty one percent of the control group and 86% of the experimental group agreed reported the course material was useful to learn. Seventy percent of the experimental group and 38.7% in the control group indicated that they agree that they applied ideas from the course readings in other classes. Eighty six percent of the experimental group and 61.3% of the control group agreed that, “I try to think
through a topic and decide what I am supposed to learn from it rather than just reading it over when studying”. Students in the experimental group were able to apply previous knowledge to current situations to solve problems, reach decisions or make critical evaluations more than the control group. Students in the experimental group tended to control their attention when distracted more than the control group. The control group students didn’t communicate class information outside of classes with classmates as much the experimental group did (Sungur, 2006).

Project-based learning students are often able to solve problems, reach decisions, and integrate and connect new information better than traditional groups. Project-based learning can enhance student motivation, group working skills, and supports higher level thinking. The challenges with project-based learning are the increased anxiety before tests, and teacher prep time. Although the anxiety before test was not significantly significant, the student centered methods of project-based learning creates anxiety when traditional assessment tools are used. High school teachers use project-based learning to improve academic performance beyond content. Project-based learning teaches students how to learn rather than learning from a textbook.

Teaching with PBL in CTE

Implementation.

A study using PBL in a mainstream middle school included 35 teachers from Dakota Meadows Middle School in Mankato (DMMS), Minnesota. The study was initiated by the school principal to help the school integrate project-based learning. The teachers were required to participate in the study as part of a professional development day by taking the initial survey
and by participating in a daylong professional development on project-based learning. The teachers were not required to use project-based learning in the classroom. The teachers who participated in the research project were interested in using project based learning.

The researchers used a qualitative research design with instruments that included surveys, interviews, and staff training sessions. The data were collected during the 2005-2006 school year. The first survey was conducted to develop the teacher’s baseline knowledge of project-based learning. The first survey consisted of four questions.

1. What is your definition of project-based learning?
2. Have you used project-based learning in your classroom? Provide an example.
3. What are the challenges of using project-based learning?
4. What are the benefits of using project-based learning?

The first survey was followed by an extensive workshop on how to implement project-based learning. DMMS was divided into four trails. Each trail consisted of six to eight different teachers. After one semester a second survey was conducted.

Seven individuals were selected for interviews to gather more information on teacher acceptance and student engagement. The seven teachers were selected based on their interest in project-based learning. The interviewees were given seven questions.

1. How did project-based learning affect the problem-solving skills of your students in your class?
2. How often did you engage your students in the problem-solving process?
3. How often did your students apply problem-solving skills while involved in a project?
4. What are the strengths of using project-based learning?
5. What are the challenges of using project-based learning?
6. What components of the problem-solving process (Problem, Plan, Test, and Reflect) were a) most often used by your students, b) least often used by your students? Why?

7. Will you continue to use project-based learning in your classroom?

8. To analyze the data the researchers extensively reviewed all responses to the research tools.

Initially the teachers had a weak understanding of the authors’ definition of project-based learning. Eleven of the teachers had hands-on-learning in their definitions of project-based learning. The results of question one revealed that only two of the 36 teachers mentioned problem solving as the key aspect of project-based learning. The initial survey suggested that teachers had misunderstood what project-based learning contains.

Twenty six of 34 teachers completed the second survey. All 26 teachers responded “yes” to using project-based learning. The majority of teachers that reported they are using project-based learning observed an increase in the four components in the problem solving process.

Of the seven teachers interviewed, six reported that they were engaging their students in problem solving process twice a week. Four of the seven interviewed teachers reported using the problem solving process 90% or more during the year. Comments from the seven teachers interviewed concerning project-based learning included, enhances student ownership, increases higher order thinking and life skills, and promotes group cohesiveness. The challenges associated with project-based learning were time, fairness, and control. Four of the seven teachers reported that it takes more time to plan. Two teachers reported some students do more work than others. Four of the teachers interviewed reported it was hard to control the classroom. When the interviewed teachers were asked question six, they reported that they would absolutely continue to use project-based learning.
The researchers suggested that Project-based learning is highly accepted by teachers; however, the project-based learning method presents problems with time for teacher preparation, and releasing control within the classroom. Students who are taught using project-based learning develop skills through the problem solving process. The problem solving process encourages students to work through a problem. Often a student will make mistakes and the teacher must watch the students. Watching students fail is often difficult for teachers. Teachers must let students work independently and make mistakes (Bezon, 2007).

Meaningful projects are necessary for students to learn. The time required for teachers to create meaningful projects is quite demanding. The demand for time is often a problem in schools that use traditional methods. Teacher preparation time is crucial for project-based learning to be implemented properly.

*Professional development.*

Continuous professional development is recommended for teachers using PBL (Eylon, 2008). A study on the effects of a professional development model for motivating teachers to enact PBL in science and technology included three groups from middle school teachers using PBL. Group one included 20 participants whom studied transport systems, group two included 24 participants whom studied materials, and group three included 21 participants whom studied senses and sensors. The professional development model focused on the process of design and development instead of conducting scientific research. The purpose of the study was to evaluate their knowledge of PBL skills before and after the professional development, and what the perceived benefits are of PBL for students, teachers, and the school.
The quantitative study included a pre-questionnaire and a post-questionnaire. Both the pre and post-questionnaires required close-ended and open-ended responses. The closed-ended portion of the questionnaire tested the perceived level of knowledge in the following areas of question asking, choosing a driving question, formulating a research question, writing a proposal, peer evaluation, developing evaluation criteria, research and development methods, data collection and analysis, and drawing conclusions. The open-ended portion of the questionnaire included questions on the perceived benefits and challenges associated with PBL.

The teachers attended a professional development workshop on PBL that allowed the teachers to ask questions on concerns they are having in the classroom. The PBL professional development sessions were to better prepare teachers for teaching using PBL.

The data from the pre and post questionnaires were compiled and entered into a histogram for visual analyzing. Descriptive statistics were also created. The data results suggest that teachers acquired a significant increase in PBL skills from all three groups. The three group had different pre-questionnaire mean scores; however, the post-questionnaire mean scores were nearly the same (Eylon, 2008).

The findings of the research gave insight to the importance of professional development when using PBL. Teachers whom have different skill levels entering a professional development session will have similar skills upon completion of professional development. Teachers should be provided with PBL professional development if schools want successful student learning; however, teachers must be cognizant of State content standard mandates when preparing to use PBL.

*Content standards.*
A concern of this researcher is teaching mathematics in CTE courses using PBL and meeting the math content standards expectations set by the State of Michigan. A quantitative comparison of CTE participants and non-CTE participants on a state mandated proficiency test was conducted by Majerous, 2008 to investigate two research questions as follows:

1. Is there a statistically significant difference between CTE students’ performance on State mandated eleventh grade math and reading proficiency tests and a comparison group of non-CTE students with similar math proficiency scores in the eighth grade?

2. Is student performance on an eleventh grade state mandated proficiency test associated with math course taking patterns prior to enrollment in CTE?

The participants for the study included four groups over two academic years. The first year participants included 18 CTE students and 43 non-CTE students. The second year participants included 24 CTE students and 29 non-CTE students. All participants were identified by having eighth grade math and reading scores in the range of the mean plus or minus one standard deviation and then randomly selected. The participants for the CTE group must have been enrolled in three or more credits in occupational courses in CTE. State standardized tests from eighth and eleventh grade will be the data analyzed for the study.

A t-test was conducted to determine if the math and reading performance of CTE and non-CTE students in 11\textsuperscript{th} grade were statistically significant. The data were analyzed using SPSS statistical software. The results indicate that CTE students reading scores are significantly lower than non-CTE students from both years the study was conducted. There was no significant difference between CTE students and non-CTE students’ 11\textsuperscript{th} grade math performance. The actual T-test scores were not reported in the article. The sample size of both cohort groups was low for a quantitative study. The information in the article presents a platform for further
research. The findings of the study indicate that CTE courses decrease student performance in reading, while not affecting student performance in mathematics (Bae, 2007).

Career and technical education teachers must provide students with research assignments that require more reading as CTE doesn’t lend itself to extensive projects that require reading. CTE courses provide a foundation for teaching mathematics through PBL on actual physical problems which is the reason CTE student math performance is not statistically lower than non-CTE students.

Teaching mathematics through CTE must provide students with the content of the CTE course while still providing the mathematics content required by the State. Missing content from both the mathematics and CTE curriculum will raise concern of both parents and administrators and could cause problems with implementation of teaching mathematics within a CTE course using PBL. A study conducted on incorporating statistics in the physiology classroom involved physiology students whom were trained on an iWorx data acquisition unit. The qualitative study included 16 students from a university physiology course that were selected through convenience. The purpose of the study was to analyze the effectiveness of teaching statistics within a physiology class. The students’ knowledge of the iWorx unit provided the students with the skills to collect data on heart rate, blood pressure, lung volume, height, and temperature. The students gave the information to a statistics class for statistical analysis. The statistics class did not share the results of the statistical analysis with the physiology students. The physiology students began their semester projects which included a website, large group discussions, and final project presentations using the data they collected with the iWorx data acquisition unit. Data collected included a pre and post questionnaire, observations of student performance on semester projects, and a pre and post statistics quiz.
The results of the study indicate that student projects were improved from projects in years past which indicated that the physiology content was not compromised with the introduction of statistics in the course. Thirty-three percent of the students within the physiology class reported being comfortable with their understanding of statistics in the pre-questionnaire compared to 83 percent on the post-questionnaire. Students reported that their knowledge of statistics increased their knowledge of physiology. Student attitudes were higher on the post-questionnaire than the pre-questionnaire. The post-quiz results revealed that students were better at applying and understanding statistics after the completion of the semester projects (Majerous, 2008).

Students in the physiology class were able to better learn physiology while learning statistics. The important factor to introducing mathematics into CTE courses is the how the mathematics will help teach CTE courses. Statistics when studying physiology as trigonometry and geometry are important when learning carpentry or CNC machining. Finding the link between course content is the important factor to consider when teaching a subject within a subject.
Chapter III: Results and Analysis Relative to the Problem

Career and technical education and PBL use similar models to deliver information to students. Most of the literature reviewed in chapter two suggests that the use of PBL in CTE should increase student motivation. The review of literature also provides a warning for teachers that using PBL requires an extreme time commitment, which is often the reason teachers do not teach using PBL.

Career and Technical Education

Career and technical education provides autonomy, effective and caring teachers, other students with similar interests, and learning relevant content in an interactive, applied setting. Students generally do not speak negatively about CTE courses. In light of the new MMC, students’ perceptions concerning CTE are critical in structuring the curriculum to promote student success. Often students have a negative attitude concerning mathematics. Teaching mathematics within a CTE course could help eliminate negative attitudes towards mathematics which could increase student motivation for mathematics.

Students with low engagement are at higher risk for dropping out of high school than students who are engaged. CTE provides students with challenging problems that allows them to choose the path in which they solve the problems while interacting with their peers. Students who are given the opportunity to solve problems within groups are likely to be more engage than students whom are taught using traditional education. The engagement of students will help students from dropping out of high school.
Mathematics in CTE 39

Students enjoy math using CTE instruction over tradition instruction; however, the students enjoying the class doesn’t make a difference in performance. Technical educators are concerned that teaching mathematics in CTE courses will sacrifice the technical CTE curriculum for mathematics knowledge. Students’ who take CTE courses that includes a mathematics curriculum perform equivalent to students’ taking traditional mathematics courses while also attaining career and technical skills.

The use of mathematics in CTE will allow students to approach a problem often found in construction, and use mathematics to solve the problem. Often in math, educators teach how to solve a problem without being given an actual scenario where a problem must be solved. The relationship between solving a problem while building a house, and solving mathematic problems in the classroom are two separate subjects. Students should be presented a problem while constructing, and be taught how to solve the problem using mathematics. If students observe the benefit of mathematics they will more likely retain the knowledge they need to be successful with the subject later in their careers. Learning through work in a CTE course presents opportunity for students to solve actual problems that industry workers must solve daily. Students in traditional education are often given synthetic problems that have little meaning.

In order for students to be successful in high level academics, teachers must provide lessons that are engaging to the learner. If all students are to be successful, teachers must provide innovative, active, and practical problems for students to solve. CTE provides a model for academic courses to follow to ensure student engagement. The engagement of all students is critical in achieving the rigorous goals set by both the MMC and NCL

Teaching for Learning Mathematics
An overwhelming theme that emerged from the literature review is the suggestions for teachers to incorporate projects or physical problems into mathematics curriculum. Student attitudes toward group work in PBL, the attitudes of students towards problem solving, and the overall student attitude of PBL in academic courses is positive. Students greatly improve the quality of their work when given the opportunity to solve problems through projects. Students learn more through inquiry than they do from textbooks.

When teachers use group work, it helps students understand how they will work in their post-secondary careers. By allowing students to make inquiries with their peers, allows them to create ideas to solve problems as a group. Teachers should create innovative ways to present information and still cover the required information. Allowing students to work together using inquiry learning empowers students to become problem solvers rather than good listeners and note takers.

Teachers report not using enough inquiry in their classrooms (Horton, 2007). Early grade levels use more inquiry than higher grade levels. The support for the use of inquiry decreases as grade level increases. There is a correlation between grade level and inquiry learning support from administration (Horton, 2007). Younger grade level teachers report having more support for inquiry based instruction than higher grade level teachers. Teachers who have a higher self efficacy of inquiry instruction tend to spend more time on inquiry instruction than teachers who have less self efficacy. As scores decrease in science and mathematics, administrators should look seriously at ways they can support or encourage teachers in using inquiry learning. The use of inquiry lends itself for students to solve problems by using science and mathematics. Mathematics and science are subjects that can be taught through laboratory experiences where students solve problems, and solving problems through activities keeps students motivated to
learn. Science and Mathematics often use similar concepts to solve problems, yet mathematics is most often taught using strictly classroom instruction while science is often taught using laboratory exercises. Perhaps the two subjects could be taught together to help students understand the relationships between mathematics and science.

Students who are given the opportunity to manipulate problems using their hands will have higher motivation than students whom are only given information through traditional instruction. Teaching mathematics is often taught using desks and a blackboard where teachers should be adopting new methods such as PBL. Project based learning in mathematics increases the interaction between students. The lack of physical and social experience of traditional math classes makes the learning wearisome which negatively affects motivation, dialogue, and cooperation.

*Project-Based Learning*

Students often do not like project work when the expectations of the projects are unrealistic. If projects become overwhelming for students, teachers must be willing to manipulate the projects or spend extra time advising students. Teachers whom use project based learning must be prepared to alter assignments when needed to motivate learners and keep them on task. Some students dislike PBL because they are used to learning traditionally. Some students get distracted by the lack of structure, which makes PBL planning critical to ensure PBL success. Project based learning lends itself to promoting active learning. Active learning helps students become engrossed in the subject they are studying. The stimulation from social interactions allows the students to feel, touch, and manipulate what they are trying to learn.
Active learning allows students to explore what they are interested in by allowing the students the freedom of student discovery.

Project-based learning students are able to solve problems, reach decisions, and integrate and connect new information better than traditional groups. Project-based learning enhances student motivation, self-efficacy, group working skills, and supports higher level thinking. The challenges with project-based learning are the increased anxiety before tests, and teacher prep time. The student centered methods of project-based learning creates anxiety when traditional assessment tools are used. Teachers should use project-based learning to improve academic performance beyond content. Project-based learning teaches students how to learn rather than reading facts from a textbook. Student centered methods such as PBL requires the students to be the initiator of learning. Traditional education inherently assumes the teacher is the initiator of learning. Students whom have a high external locus of control often have a hard time understanding that using PBL requires the student to research solutions instead of getting the answers from the teacher. The use of PBL along with traditional education is suggested to accommodate multiple learning styles.

Teachers that choose to use PBL and student discovery must place importance on promoting lifelong learning. The only method in teaching lifelong learning is to keep the student in the center of the learning. Students must be taught how to research on their own.

*Teaching with PBL in CTE*

Many teachers believe problem solving is the key aspect of project-based learning. Teachers that use using project-based learning observe an increase in students’ ability to solve problems. The problem solving process of PBL encourages students to work through a problem.
Often students will make mistakes and the teacher must observe the students fail and then motivate the students to correct their mistakes. Watching students fail is often difficult for teachers (Bezon, 2007). Project based learning enhances student ownership, increases higher order thinking and life skills, and promotes group cohesiveness. The negative aspects of teaching PBL is the lack of teacher preparation time, some students do more than others, and it is difficult to control the classroom when first starting PBL. Once teachers are comfortable using PBL, teachers will use PBL for a larger percentage of their curriculum. The research from the literature review suggests that PBL is highly accepted by teachers and is beneficial to students; however, extremely time consuming to implement properly. Without the proper implementation of PBL, students may become overwhelmed and disconnected from the learning, which places an emphasis on teacher oversight of the projects. Due to the time consumption of PBL teachers opt not to use the PBL model.

Meaningful projects are necessary for students to learn. The time required for teachers to create meaningful projects is quite demanding. The demand for time is often a problem in schools that use traditional methods. Teacher preparation time is crucial for project-based learning to be implemented properly. Administrators should place a high importance of professional development when suggesting the use PBL. Teachers who have different skill levels entering a professional development session will have similar skills upon completion of professional development. Teachers must be provided with PBL professional development if schools want successful student learning; however, teachers must be cognizant of State content standard mandates.

Students in a CTE class are likely to learn CTE content better when learning using PBL. The important factor to introducing mathematics into CTE courses is the how the mathematics
will help teach CTE courses. Statistics can be studied in physiology as trigonometry and geometry can be studied while teaching carpentry or CNC machining. Finding the link between course content is the important factor to consider when teaching a subject within a subject. Career and technical Education is best taught using PBL, and mathematics is a theoretical foundation of many CTE subjects such as machining, carpentry, manufacturing, electrical, and many others. Teaching with PBL in CTE should be a priority for all CTE teachers.
Chapter IV: Recommendations and Conclusions

Career and technical education and PBL could increase student performance in mathematics. The concern is implementation of using PBL in a CTE course to teach mathematics. How are teachers going to attain the time and money required to implement a new program?

Recommendation

Many schools are facing difficulties finding a solution for helping students pass the mathematics requirements set by the State of Michigan’s MMC. Most schools are equipped with laboratories that can be used for learning mathematics through CTE courses using PBL. Administrators should consider recruiting mathematics and CTE teachers who want to teach using PBL and provide them with professional development for teaching academic courses using PBL. The PBL learning model could help students improve academics as long as teachers are given the time for preparation. Without sufficient preparation time, teachers might not have time to properly implement PBL which will turn teachers away from using PBL. Providing students with a laboratory based mathematics course would likely increase student performance in mathematics. A laboratory mathematics course should involve a CTE teacher and a mathematics teacher. The mathematics teacher could provide classroom theoretical instruction to half of the class in lecture form, as the CTE teacher has the other half of the class in the laboratory applying the theoretical knowledge through building, designing, programming, or destructing. The team teaching arrangement would not have an impact on the student/faculty ratio as the group will never be together at the same time which will not change the need for additional faculty, thus not increase the cost for instruction. When students are able to apply the information they learned,
the students will better retain the information compared to students who only listen to the information they are provided.

Not all students will opt to enroll in courses that use PBL. Project based learning should be an option for students who do not prefer learning traditionally. Teachers who don’t have an interest in using PBL shouldn’t be forced to teach using PBL, as PBL requires extensive planning time. Many teachers want to use alternative teaching strategies and will volunteer to teach mathematics using PBL in CTE courses. Once teachers are selected for newly offered courses such as mathematics in CTE, professional development should be arranged to prepare the teachers for using PBL in academics. Upon implementation of the mathematics in CTE mathematics program, constant support in the form of materials and professional development should be provided. As the course progresses the amount of time needed for professional development will decrease.

The cost for the mathematics in CTE program will most likely be from professional development and preparation time. The cost to operate the course should have no change from traditional operation. Both the mathematics and the CTE teacher will have approximately 25 students, which is close to the size of a traditional classroom. The cost of materials should not change. If the mathematics in CTE program was not offered, standard CTE courses would be offered. The material used in the CTE course would be equal to the material used in the mathematics in CTE course. Schools that don’t have CTE at their school may not have the means to operate a mathematics in CTE program. The schools that have the laboratory equipment and teachers who want to teach mathematics in CTE, I recommend teaching mathematics in a CTE course using PBL.
Areas for Further Research

The qualitative approach to understanding the effects of teaching mathematics with PBL in CTE courses at the high school level will use an interpretive strategy for inquiry. Creswell (2009) suggests that the participatory worldview is a strategy of inquiry that needs to be intertwined with politics and a political agenda. This research study holds a participatory worldview and the intentions of the exploration will provide data for future high school reform. The participatory worldview will shape interview questions to explore student’s perceptions of diverse delivery methods such as PBL within CTE and apply the themes to campaign for school reform to incorporate the teaching of mathematics using PBL within CTE.

The researcher should be involved in a sustained and intensive experience with CTE participants in an academic PBL setting (Creswell, 2009). I have a strong background using PBL in the CTE classroom and the CTE students enrolled in the researchers past courses preferred the use of PBL. The site at Marquette Senior High School (MSHS) will be chosen due to the researcher being a former CTE teacher at MSHS. I know the internal workings of the school system including the CTE department which will help understand student’s perceptions of learning mathematics using PBL in CTE. The researcher will be an observer within the CTE classroom using PBL. The researcher will help the teacher deliver the PBL learning model to the students. The researcher supporting the teacher will ensure that the researcher will be an active observer. The study will help administrator’s reform curriculum to support CTE students.

The participants in this research study will include all students who are enrolled in a yearlong (two semester) CTE course that teaches mathematics using PBL. The students who fit
the preceding criterion will be eligible to participate in the study upon the individual and their legal guardian signing an informed consent.

I will serve as the data collection instrument through the use of observations, interviews, and test grade averages. The use of observations, interviews, and documents creates a data triangle that is preferred in qualitative research (Creswell, 2009). The observation data collection method will use the participant as observer. The observer will serve as a teacher’s assistant and will help implement the PBL model. The interview will consist of a face-to-face in person interview, and the test grades of participants within the PBL academic classroom will be compared to test grades of the same participants within the traditional academic classrooms.

The observation data recording will include demographic information on the participants the time, place, and date of the field setting where the observation takes place, and descriptive notes which will include reconstruction of dialogue, a description of the physical setting, and accounts of particular events (Creswell, 2009). The interviews will be conducted by one researcher and will include 5 questions. A script will be developed to ensure the researcher asks the questions in a similar manner to all interviewee participants. The interviews will be recorded and transcribed. During the interviews the researcher will take detailed hand written notes and pair them with the transcribed interviews. The disciplinary referrals will be attained upon request of the administration.

Data analysis within this qualitative study will be conducted as the data is being collected. The researcher will reflect on observations and interviews through the use of memos. The data analysis strategies include both collecting open-ended data based general questions to develop an analysis based off the responses from participants and a linear approach (Creswell, 2009). The linear approach will begin with the raw data such as transcribed interviews,
observation notes, and test grades. The raw data will then be organized and prepared for the researcher to read the raw data. The researcher will then read through the organized raw data to get a general idea of what the data means. Reflection throughout the reading process will stimulate obtaining a meaning. Notes on the transcribed interviews will be used when reading data to make sure all of the researcher’s thoughts during the analysis process are recorded. After a meaning of the data is obtained the data will be coded. Every piece of raw data will be thoroughly read to answer the question, what is the data about? Once the researcher makes a determination of what the research is about, an abbreviation will be made for the category of the data. After all data is coded, the researcher will go through the coding process to finalize the abbreviation for each category. Once the abbreviations are finalized they will then be alphabetized. Themes will be developed based on the coded data that will then involve creating an interpretation of the meaning of the data. New questions on the research topic will be asked to inspire follow up research on the topic of understanding the effects of teaching mathematics with project-based learning in career and technical education courses at the high school level.

The tests will be gathered and organized. One group of documents will consist of test from a tradition classroom and another group of documents will consist of tests from a PBL classroom. The researcher will compare the responses to question in both groups and code the data based on the themes from each group. The researcher should pay close attention to the algorithms themselves and not just the final answers. The researcher will search for response differences between traditional and PBL environments.

The researcher will review transcripts to ensure there are no obvious mistakes made during the transcription process. Memos will be written during the coding process to ensure the proper definitions of codes were recorded. The researcher will be conducting this study solo
which will make it necessary for a data coding cross-check. The researcher will acquire help to ensure proper coding (Creswell, 2009).

The researcher will triangulate data through the use of observation notes, transcribed face-to-face interviews, and test themes. The triangulation of data will ensure theme validity. Member checking will be used to determine the accuracy of the finding. The researcher will interview selected participants to provide an opportunity for the participants to comment on the findings (Creswell, 2009). The researcher will use the person whom cross-checks as an external auditor. The external auditor will oversee the project as a whole to enhance validity.

Conclusion

Career and technical education provides students with autonomy, effective and caring teachers, and learning relevant content in an interactive, applied setting. In light of the new MMC, students’ perceptions concerning CTE are critical in restructuring the curriculum to promote student success. Often students have a negative attitude concerning mathematics. Teaching mathematics within a CTE course could help eliminate negative attitudes towards mathematics which could increase student motivation for mathematics.

Students enjoy math using CTE instruction over tradition instruction. Students taking a CTE course which includes a mathematics curriculum perform equivalent to, or better than students taking traditional mathematics courses, and are better equipped with mathematics skills which improve career and technical skills. The use of mathematics in CTE will allow students to approach a problem often found in construction, and use mathematics to solve the problem. Often in math, educators teach how to solve a problem without being given an actual scenario where a problem must be solved. Students should be presented a problem while constructing, and
be taught how to solve the problem using mathematics. If students observe the benefit of mathematics they will more likely retain the knowledge they need to be successful with the subject later in their careers.

Teachers should incorporate projects or physical problems into mathematics curriculum. Student attitudes toward group work in PBL, the attitudes of students towards problem solving, and the overall student attitude of PBL in academic courses is positive. Students greatly improve the quality of their work when given the opportunity to solve problems through projects. Students’ learn more through inquiry than they do from textbooks. Allowing students to work together using inquiry learning empowers students to become problem solvers rather than good listeners and note takers.

The support for the use of inquiry decreases as grade level increases. There is a correlation between grade level and inquiry learning support from administration. Younger grade level teachers report having more support for inquiry based instruction than higher grade level teachers. As scores decrease in science and mathematics, administrators should look seriously at ways they can support or encourage teachers in using inquiry learning. The use of inquiry lends itself for students to solve problems by using science and mathematics.

Students who are given the opportunity to manipulate problems using their hands will have higher motivation than students whom are only given information through traditional instruction. Teaching mathematics is often taught using desks and a blackboard where teachers should be adopting new methods such as PBL. Project-based learning in mathematics increases the interaction between students. The lack of physical and social experience of traditional math classes makes the learning wearisome which negatively affects motivation, dialogue, and cooperation.
Project based learning lends itself to promoting active learning. Active learning helps students become engrossed in the subject they are studying. The stimulation from social interactions allows the students to feel, touch, and manipulate what they are trying to learn. Active learning allows students to explore what they are interested in by allowing the students the freedom of student discovery.

Project-based learning students are able to solve problems, reach decisions, and integrate and connect new information better than traditional groups. Project-based learning enhances student motivation, self-efficacy, group working skills, and supports higher level thinking. The challenges with project-based learning are the increased anxiety before tests, and teacher prep time.

Teachers that use using project-based learning observe an increase in students’ ability to solve problems. The problem solving process of PBL encourages students to work through a problem. Project based learning enhances student ownership, increases higher order thinking and life skills, and promotes group cohesiveness. The negative aspects of teaching PBL is the lack of teacher preparation time, some students do more than others, and it is difficult to control the classroom when first starting PBL.

Teacher preparation time is crucial for project-based learning to be implemented properly. Administrators should place a high importance of professional development when suggesting the use PBL. Teachers whom have different skill levels entering a professional development session will have similar skills upon completion of professional development. With rising concerns about teacher accountability for content standards, support for PBL is at its peak. Teachers must be provided with PBL professional development if schools want successful student learning; however, teachers must be cognizant of State content standard mandates.
Students in a CTE class often will better learn CTE content when learning using PBL. The important factor to introducing mathematics into CTE courses is the how the mathematics will help teach CTE courses. Career and technical Education is best taught using PBL, and mathematics is a theoretical foundation of many CTE subjects such as machining, carpentry, manufacturing, electrical, and many others. Teaching with PBL in CTE should be a priority for all CTE teachers.

In order for students to be successful in high level academics, teachers must provide lessons that are engaging to the learner. If all students are to be successful, teachers should provide innovative, active, and practical problems for students to solve. CTE using PBL provides a model for academic courses to follow to ensure student engagement. The engagement of all students is critical in achieving the rigorous goals set by both the MMC and NCLB.
References


