ABSTRACT

Students and teachers in the world of education after No Child Left Behind (2001) have felt the pressure of increased expectations, while many states have felt the frustration of decreased funding. Increased class sizes have forced teachers to look at alternative ways of teaching. While retention of knowledge is hopefully at the forefront of the teacher’s goals, motivation of students should also be a goal. The purpose of this paper is to examine the motivations of teachers and students, retention effectiveness of various teaching methods, and a variety of methods that support an inquiry-based classroom. Students and teachers deserve to coexist in an environment that fosters collaboration, while also still creating an environment that motivates students to learn.
Chapter One: Introduction

Years of mathematics exploration and emphasis has led the educational arena to spend additional time focusing on curriculum to prepare today’s student for their post-secondary education and working world. Problems have arisen with this increased emphasis to teach to high-stakes testing, which has inevitably prepared our students to recall short-term facts to score well on the tests, but not recall the concepts that the curriculum was set out to teach them. The focus of this paper will be to explore research based studies emphasizing a different method of teaching, called inquiry-based, rather than traditional direct instruction.

Background

Finding ways to aid in the development and enhance the learning process of middle and high school students has been a focus since No Child Left Behind made its debut in 2001. Following curriculum standards and preparing students to perform well on state mandated tests as well as high school completion has made the jobs of secondary mathematics teachers complex. While the Michigan Department of Education has raised the requirements of students, difficulty in achieving the requirements has become a daunting task for some students. Something must be done to improve attitudes and enhance problem-solving skills to avoid frustration in the mathematics classroom (Michigan Department of Education).
Statement of the Problem

Mathematics is a difficult subject for most students. State requirements are adding pressure to today’s classrooms. Teachers, administrators, parents, and students are searching for answers to make the path to a successful completion of high school and college mathematics courses a possibility.

In a system where schools are working harder to keep staff members and options for students, many times students are crammed into rooms with less space in courses that are difficult to teach and learn. Budgetary constraints have forced the hands of schools to lay off teachers and teacher aides as well, making learning for the special needs student even more difficult. Workshops and conferences have become less available for teachers and staff to enhance their curriculum. Teachers and students need help!

A 2003 study of PISA, Program for International Student Assessment, found that United States students aged 15 came in 24th place out of 29 possible countries in math literacy and problem-solving. Furthermore, only 69% of our nations’ eighth graders could perform at or above the basic level. That leaves 31% of our youth that have not made the minimum requirements of math mastery (White, 2008). What could be causing this disconnect in our nation’s mathematics classrooms? The focus of teaching used to center around the typical teacher-centered, “sage on the stage” approach to learning, which may be how today’s teachers learned and therefore teach. This approach has been suggested not as effective as the constructivist approach to learning (White-Clark, DiCarlo, & Gilchriest, 2008). Constructivism helps to guide instructional practices that build and guide students’ thought process and helps scaffold and elicit long-term memorization of concepts. The constructivist approach may strike
the traditional teacher as an uncomfortable step as the suggested approach requires manipulatives, exploration, and allowing students to use their graphing calculators to explore problems (White-Clark, DiCarlo, & Gilchriest, 2008).

Why focus at the secondary level? Interest in mathematics at the secondary level has been declining and student’s progress through mathematics is well behind their peers internationally (White, 2008). Students in Michigan can expect to take high stakes tests such as the MEAP, MME, WorkKeys, and ACT before graduation as well as complete a rigorous schedule of mathematics. English and mathematics courses are amongst the most strict for graduation requirements with 4 credits each. The mathematics curriculum in Michigan requires students to complete Algebra I, Geometry, Algebra II, as well as a math course in their final year of high school to be eligible for graduation (Michigan Department of Education). Michigan students are bound by the state on the courses in which they have to take. Teachers, in return, need to take the curriculum set forth by the state and deliver it in a meaningful and interesting way so students will take that knowledge and become better problem-solvers as adults. It is the goal of this paper to research and cite specific methods that will enhance the usage of inquiry-based instruction in the mathematics classroom.

Theoretical Framework/Model

The constructivist approach allows students to struggle with learning. This creates a sense of self-exploration and pride in learning, constructivist theory suggests. Constructivist approaches build upon Piaget and Vygotsky’s ideas of using higher-order thinking and questioning techniques, but turns the focus of learning back on the student. A teacher acts as a
facilitator in the process, guiding students to construct their own knowledge to solve the problems that are prompting them.

**4E x 2 Inquiry Model.** Following the inquiry approaches of educational past, the 4E x 2 Model embraces a melting pot of Piaget and Vygotsky’s ideas within the framework. The model takes the constructivist theory one step further in order to embrace ideas that help to incorporate student misconceptions as well as scaffolding using proximal development. Proximal development can be achieved by helping students figure out what tasks they can do on their own and which tasks need guidance from the teacher. Constructivism is an educational approach to learning that requires students to “construct” their own knowledge of a concept through the use of personal and meaningful learning opportunities. The 4E x 2 method seeks to help the teachers in developing deeper inquiry learning experiences in order to help student’s build conceptual understanding. The goal is to help teachers learn to facilitate learning by building conceptual understanding in the learning experiences (Marshall, Horton, & Smart, 2008; Allal & Ducrey, 2000).

Focusing on three major constructs of learning, the 4E x 2 Model incorporates the following: metacognitive reflection, inquiry instructional models, and formative assessment, which will be discussed at length. Metacognitive reflection infuses understanding and control of one’s cognitive processes and a focused reflection on the concepts being investigated (Marshall,
Horton, & Smart, 2008). Inquiry instructional models are defined as curricula and instructional practices that promote and facilitate engaging students in scientific inquiry (Marshall, Horton, & Smart, 2008). Lastly, metacognitive reflection research goes beyond teacher reflection of the concept that has been learned to the deeper reflection on the students’ learning process. Once a student feels confident in understanding the concepts, each individual student can then recognize how he or she knows each concept and base that understanding to critically examine their own knowledge (Marshall, Horton, & Smart, 2008).

Support for inquiry-based approaches comes from the assumption that regardless of test scores, students may not be learning beyond receiving the right answer on the high-stakes test. Is education teaching students to play the game to receive the good grade? Learning beyond the test has not been the focus and that is a problem the 4E x 2 Model hopes to change. Figure A below is a pictorial representation of the 4E x 2 Method. The figure below outlines each phase of the model and illustrates the processes in which a teacher should create when implementing such a model.

The first step in the process is to engage the students through their prior knowledge, alternative conceptions, motivating and interest inducing stimuli, and developing scientific questioning (Marshall, Horton, & Smart, 2008). The 4E x 2 Model provides a model to aid the teacher’s development in the learning process. A helpful checklist prompts the teacher at each phase and provides helpful techniques such as: “‘What do you know about….?’ ‘What have you seen like this?’ ‘What have you heard about…that you are not sure is true?’ ‘What would you like to investigate regarding…?’” (Marshall, Horton, & Smart, 2008, p. 507) Also in this
component, a teacher could include notebooks, drawings, brainstorming, warm-up exercises. (Marshall, Horton, & Smart, 2008, p. 8)

The second step is the explore phase. Metacognition is critical in this phase as well. Students can be prompted during this phase using questions such as: “What if…?” ‘How can you best study this problem?’ ‘What happens when…?’ ‘What data/information do you need to collect?’ ‘Why did you choose your method to study the problem?’ (Marshall, Horton, & Smart, 2008, p. 508)

Explaining is the third phase of the 4E x 2 Model and allows students to make sense of the curriculum in which he or she knows and some alternatives in their thinking. Unlike direct instruction, the explain phase comes after exploration. Direct instruction forces students into a passive state of learning. Students are expected to just accept the facts and then explore problems and situations that require him or her to use those explained skills. In this model, students are prompted with questions that lead him or her to explore situations using multiple representations and deepen their learning. Explaining their thoughts puts content at the center of learning. Some questions to be asked during this phase include: “What pattern(s) did you notice?” ‘What evidence do you have for your claims?’ ‘How can you best explain/show our findings?’ ‘What are some other explanations for your findings?’” (Marshall, Horton, & Smart, 2008, p. 510) A teacher can evaluate this phase through lab reports, presentations, and discussions (Marshall, Horton, & Smart, 2008, p. 9-10).

The last phase in this cycle is the extend phase. This phase requires students to apply the knowledge learned to new situations. In doing this, extending helps to solidify their findings and create a deeper understanding of the concepts. Teacher prompts during this phase can include:
“‘How do you think…applies to…?’ ‘What would happen if…?’ ‘Where can a concept like this be used in the real world?’ ‘What consequences/benefits/risks accompany certain decisions?’” (Marshall, Horton & Smart, 2008, p. 511)

The 4E x 2 Model is not a quick fix, nor was the model intended to be used strictly either. Research and further explanation of the model explains variations of the approach and suggests alternatives for teachers to use. The template below may offer some help in creating a lesson using the 4E x 2 approach.
Key Focus or Essential Questions:
- Standards Addressed:
- Objective(s):
- Materials:
- Safety:

Sources/References/Auxiliary Materials:

### Central Framework

<table>
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<tr>
<th>Reflect (R)</th>
<th>Engage</th>
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<tbody>
<tr>
<td>R1: (Select One)</td>
<td>Check all that apply: Practice, Experience, Motivation, Interest, Develop spontaneous question</td>
</tr>
<tr>
<td>R2: (Select One)</td>
<td>Check Representative Questions: What do you think about? What do you like about? What is confusing? What questions do you have about? What would you like to investigate?</td>
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### Assess (A)

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<td>Process-centered</td>
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<td>Skill-centered</td>
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<td>Individual</td>
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<td>Small Group</td>
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<td></td>
<td>Class Performance</td>
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</tbody>
</table>

Anticipated time needed to complete engage:
- Description of Engage:

### Explore (E)

<table>
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<tbody>
<tr>
<td>E1: (Select One)</td>
<td>Check all that apply: Practice, Design, Time, Collect, Reason</td>
</tr>
<tr>
<td>E2: (Select One)</td>
<td>Check Representative Questions: What if...? What would you expect to happen? Why? How can you test this problem? What would you need to collect?</td>
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</tbody>
</table>

### Explore Assessment Context:

- Knowledge-centered
- Process-centered
- Skill-centered
- Individual
- Small Group
- Class Performance

Anticipated time needed to complete explore:
- Description of Explore:

### Explain (X)

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<td>Check all that apply: Interpret, Evidence, Communicate, All explanations, Verify, Justify, Analyze</td>
</tr>
<tr>
<td>X2: (Select One)</td>
<td>Check Representative Questions: What have you learned? How do you explain this? What is your idea different from...? What do you mean when you say...? What do you think happened? What happened?</td>
</tr>
</tbody>
</table>

### Explain Assessment Context:

- Knowledge-centered
- Process-centered
- Skill-centered
- Individual
- Small Group
- Class Performance

Anticipated time needed to complete explain:
- Description of Explain:

### Extend (D)

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<tbody>
<tr>
<td>D1: (Select One)</td>
<td>Check all that apply: Apply, Elaborate, Transfer, Generalize</td>
</tr>
<tr>
<td>D2: (Select One)</td>
<td>Check Representative Questions: What would happen if...? How do you think... applies to...? What questions/problems are still unresolved? What decisions need to be made?</td>
</tr>
</tbody>
</table>

### Extend Assessment Context:

- Knowledge-centered
- Process-centered
- Skill-centered
- Individual
- Small Group
- Class Performance

Anticipated time needed to complete extend:
- Description of Extend:

Teacher reflection/comments:
Research Questions

Research on inquiry-based, hands-on activities, as well as other mathematical research questions will be explored. The following questions are of concern and will be addressed.

1) What types of mathematics interventions increase motivation to learn for most students? For example, how will these interventions help to increase student interest in mathematics by improving test scores and succeeding in higher-level mathematics classes?

2) What type of evaluation will indicate frustration in the mathematics classroom?

Definition of Terms

The key to understanding constructivist theory lies in making connections with the terms that are critical to enacting and practicing its use. The following definitions will be used throughout this paper for the purpose of highlighting the major influences of constructivist theory.


Constructivism. “The philosophy, or belief, that learners create their own knowledge based on interactions with their environment including their interactions with other people” (Draper, 2002, p. 522).

Direct instruction. “Alternative to constructivism. Typically referred to as teacher-centered and would include lectures, textbook usage, choral responses, and the completion of worksheets” (White-Clark, DiCarlo, & Gilchriest, 2008, p. 41).

Cooperative learning. “Students working together to reach a common goal” (Haas, 2005, p. 27).

Problem-based learning. “Teaching through problem solving where students apply a general rule or draw new conclusions or rules based on information presented in the problem” (Haas, 2005, p. 28).

Manipulatives, models, and multiple representations. “Teaching students techniques for generating or manipulating representations of algebraic content or processes, whether concrete, symbolic, or abstract” (Haas, 2005, p. 28).

Zone of proximal development. “The distance between the actual development level as determined by independent problem solving and the level of potential development as determined under adult guidance or in collaboration with more capable peers” (Allal & Ducrey, 2000, p. 138).

Autonomy-supportive teachers. “Identify and support students’ interests and build around those personal interests to motivate content acquisition” (Manouchehri, 2004, p. 474).

Summary

While inquiry-based approaches have been discussed at length over the years and have become mainstays in teacher educational programs, the practice of inquiry lessons in school
systems has been lacking. The need for student-based approaches to learning is significant, but many teachers are unaware of what methods to use. Inquiry-based approaches could be the answer to that dilemma. Some models will help to guide a teacher in implementing this process, such as the 4E x 2 Model. For the teacher instructing out in the secondary setting who has been contemplating inquiry approaches to learning, models have been explored and researched to help guide the educator in implementing an effective and meaningful lesson strategy. In today’s world, helping students become centered in their learning process is key to their development in all of their educational endeavors beyond the safe haven of the K-12 school system.
Chapter Two: Literature Review

The focus of this paper examines the use of inquiry-based instruction in mathematics classrooms, but other areas of research were also used to try to structure the classroom to foster an environment of inquiry. Strategies that aid in effective usage of inquiry practice are explained. Successful implementation of inquiry practice and the prevalence of it in the classroom to increase student learning has been questioned. Further research and findings will also be examined.

Attitude and Motivations to Promote Inquiry in the Classroom

Embracing learning styles in the classroom needs to include both ability and attitude. Failing to link those two ideas may lead to an unsuccessful implementation of inquiry. Several surveys and questionnaires conducted asked about motivating factors of teachers as well as students. Finding the factors that motivate learning for both parties is essential in providing the successful implementation of inquiry learning.

Interventions focusing on real-world applications. Interventions were practiced with 128 seventh-grade students to see if significant gains would be made from a constructivist approach. Problems known as EAI, Enhanced Anchored Instruction, provided students with the ability to solve a problem using multi-media and then solve the problem using a hands-on approach to a problem that was more of a real-world example. For instance, students were prompted to measure and build a skateboard ramp or other interesting real-world activities. Findings were significant for LD students as well as regular students in that even after a length of time, 14 weeks in this study, students were still able to recall and apply concepts because of the constructivist approach (Bottge, Rueda, Serlin, Hung, & Kwon, 2007).
Attitude can be the difference in creating a personal investment in mathematics. Urban schools have studied the effect of attitude towards mathematics. The study highlighted by Manouchehri stated that one aspect of a student’s motivation to learn is the teacher’s attitude and disposition to teaching mathematics. Are today’s teachers willing to put forth the energy and motivating techniques that inquiry takes to help students succeed? What type of environment fosters a love of learning? How can teachers create an environment where students are more interested? Popular belief may lead society to believe that all teachers, even with similar educational practices and backgrounds, have the same methodology in enticing student behaviors. How can that be? All teachers have different personalities and approaches toward learning and will inevitably lead students towards different motivational techniques. All too common in the mathematics classroom is the direct instruction approach. Mathematics teachers want students to have the capability to solve problems on their own. Why then are teachers not embracing and putting the inquiry-based system into effect in their rooms? Almost 100 classrooms were studied on the characteristics of a teacher’s support of autonomy and self-determined motivation. Those teachers who supported the students development helped the students also in increased achievement and motivation, despite their socioemotional needs (Manouchehri, 2004). A good conversationalist was also a characteristic that helped students to succeed. Less talking and more listening was an approach that worked (Manouchehri, 2004).

Teachers who fostered a comfortable environment also allowed students to face frustration without interfering in the students’ problem-solving abilities. Verbal praise was evident and making personal statements about learning helped develop autonomy. Good autonomy teaching, creating personal investment to the concept and reinforces students abilities,
supports students by using statements such as: “That was always hard for me- I would do the problem this way,” “I can see why you are stuck,” “I can feel that you are frustrated.” This type of conversation helped students to make choices and solve problems using their own agendas rather than a strictly controlled teacher-centered environment. (Manouchehri, 2004, p. 477)

Creating a sense of ownership and pride in learning, helping to validate student’s feelings toward frustration and success, and helping to promote interest in the tasks being accomplished helped foster a successful classroom environment in creating autonomy.

**Prevalence of inquiry in the classroom.** Although inquiry has been a hot-button topic in the educational arena in recent years, its prevalence in the classroom is at question. Research done by McKinney (2008) focused on a survey derived from the literature of Cathcart et al. (2006), NCTM (2000), and Van De Walle (2006). The intention was to survey traditional and alternative instructional practices of the participants. Purposeful sampling took place with 64 in-service teachers attending a NCTM conference. The teachers, with diverse ethnic backgrounds as well as work experience were asked to complete a survey. They were instructed to indicate the frequency each practice was done using a 5 point scale ranging from never (1) to very frequently (5). The practices were then categorized into pedagogical and instructional practices: The Equity Principle; the Curriculum Principle; the Teaching and Learning Principle; the Assessment Principle; and the Technology Principle (NCTM, 2000). NCTM assesses teaching and learning based on these principles. Equity findings show that teachers are using reinforcement techniques, but only sometimes are they employing high expectation feedback to their students. Curriculum findings indicate that half of teachers surveyed link standards to prior learning, but an even higher percentage stick very close to the curriculum rather than adding personal creativity to
lessons, some 79 percent of teachers in this study (McKinney, 2008). Only 7.8% used personal creativity to support learning in their classrooms (McKinney, 2008). Teaching and Learning data indicates some very positive findings in the areas of mathematical connections to prior learning and real-world situations, hands-on learning, and problem-based activities (McKinney, 2008). Assessment Principle findings include prevalent use of teacher-made tests or diagnostic tests. Very few teachers used assessment strategies that included student reflections, interviews, writing, portfolios, or self-assessments (McKinney, 2008).

Teambuilding as a motivating factor

Additional resources indicate motivating factors such as teambuilding can promote inquiry in the classroom. A study conducted by Sashittal, Jassawalla, and Markulis (2011) focused on teambuilding activities. This study used qualitative-data by intensely questioning 19 instructors who taught in 12 business schools in the United States. The participants were split between 9 male and 10 female instructors and their average years teaching was 14.

Sashittal and colleagues questioned participants about why they assign team projects, teambuilding views, and the actions they take to improve team building qualities. A matrix was formed that housed the instructor’s responses. Each question headed a column and a summarized response from the instructor was placed in the appropriate cell. Based on the answers to questions of the above nature, the researchers noticed themes that became relevant about motivations, attitudes, and actions. Scales were developed as well as a hypothesis to compare and contrast in the second phase of the study. (Sashittal, 2011, p. 95)

Key motivations for assigning teambuilding activities were identified (Sashittal, 2011, p. 95):
1. Primarily, instructors believe that students gained a deeper learning of the content for the course.

2. Instructors thought it helped student creativity.

3. Students could learn teamwork skills to function better in teams.

4. Time and energy of instructors was managed more efficiently.

5. Some instructors were required by their schools to align activities because of traditional customs.

Attitude among instructors identified some common themes as to why teambuilding was not prevalent in their classrooms. Among them was lack of time, allowing students to manage teamwork on their own, instructors did not feel qualified enough to conduct teamwork, and because they were not sure that teambuilding was an effective practice and the benefits were unclear.

Intense interviewing yielded a few common themes among instructors regarding teambuilding. The surveyors strived to find connections between attitude and practice. If an instructor believed that students should manage teambuilding on their own, they would also respond negatively to the areas of time, qualifications, and the benefits of teambuilding. It was hypothesized that they would also spend less time requiring students to perform teambuilding activities.

In a second phase, 87 professors were asked to complete the questionnaire to test the hypotheses about attitude and action. Findings validated that instructors assigned teambuilding activities to increase student learning and also increase their convenience. Other findings
validated a precept that if an instructor believes that students should manage their own teamwork were not consistent in requiring it in their classes.

A gap exists in the findings of the second phase of Sashittal’s study. Participants say that teambuilding assignments will empower students, but don’t require students to perform activities that build teamwork. Also found in the research was a gap relating instructors desire to increase student learning instead assigned teambuilding activities to increase their convenience.

Teacher motivation and the prevalence of team learning go hand in hand, as indicated by Sashittal and colleagues (2011). If a teacher either disagrees or does not have the confidence in their own ability to conduct inquiry in the classroom, students are less likely to have participated in a course that requires it. Student motivation of inquiry can also then be evaluated. Not only is the attitude and motivation of the teacher important, the audience, or students, needs to be addressed as well.

**Student Perceptions of Inquiry**

Student interpretations of project work (PW) was analyzed using the Questionnaire on Teacher Interaction (QTI) (Wubbels et al. 1991). Focusing on non-traditional questions based on how the theory of student-teacher interactions can affect student attitudes, rather than the traditional questions that merely focused on the teacher’s behavior affecting student learning. Researchers used a Questionnaire on Project Work-Related Attitudes (QOPWRA) to analyze student attitude responses based on teacher project work.

The methods for project work analysis was three-fold in this quantitative study: to validate the use of PW work in Singapore, examining teacher-student interactions in the PW classroom, and the student perception of the teachers’ behavior and PW work.
Quek et al. (2007) analyzed students in seven secondary schools in Singapore, which consisted of 270 students whose average age was 14 years old. Classroom subjects ranged from mathematics, science, humanities, and the arts. Chosen teachers had at least 5 years of teaching experience. The teacher’s role in the classroom, as trained in workshops and modeled by a group of 5 teacher-team lesson plan, was to facilitate learning. It was a requirement that students complete the project with students from another school.

A multiple regression analysis was completed using the results of the QTI. A significant correlation resulted for the Enjoyment of Project Work Lessons, suggesting that the association of a strong leader who is strict in performing student lessons and discipline leads to more enjoyment in Project Work Lessons.

Research questions surrounding student attitudes toward the interactions of their teachers and Project Work Lessons fared favorably when leadership was friendly, helpful, understanding, and students were given responsibility and freedom. Unfavorable results came from indicators such as Uncertain, Dissatisfied, Admonishing, and Strict perceptions. (Quek et al., 2007)

Further discussion indicated that skills performed by PW teachers in the classroom also helped by engaging students, building relationships with them, offering group work and teacher assistance. Quantitative results of the attitudes and perceptions of teacher interactions in PW classrooms was the goal for the second research question.

Introduction of reform-based mathematics

Achievement in mathematics is crucial. Along with achievement, motivation, attitude, and cooperative group skills also need to be identified and researched. Many of these controls have immeasurable affects on achievement. Although cooperative learning has been addressed in
numerous studies at the elementary level, few have focused on the learning of mathematics at the secondary level. Students in secondary school have many idiosyncrasies, one of them being their social skills, which are still in the developmental stages. Whicker et. al found that students participating in group work often learned tactful ways to resolve conflicts, also helping in the areas of self-esteem, attendance, enjoyment of school, and motivation to learn (Whicker et. al, 1997). With groups minimized to fewer students, teachers would also notice less dependency on them, while the grouping still allowed for individuals to feel achievement. Quality time on task is also an indicator of successful implementation of cooperative learning groups.

Of utmost importance to the implementation of cooperative learning and inquiry-based approaches is teacher motivation. How a teacher responds to his or her class and their students motivation to learn was questioned. The purpose of the study was done for two reasons: will a teacher’s motivation style affect mathematics teaching and will their motivation style influence their willingness to implement reform-based mathematics in their classroom?

Each teacher participant was a part of a three-year university-school partnership whose goal was to increase student performance in algebra and geometry. This study was conducted in the 3rd year of the partnership. Each of the selected 47 teachers were required to complete a rigorous schedule of professional development which included 2-day workshops, two 3-week summer institutes, and twelve 2-hour after-school sessions (Manouchehri, 2004). Each of the sessions focused on reform-based criteria that would include technology and manipulatives. Teachers were given time to use the investigations to plan open-ended tasks for their classroom lessons as well. Teachers received a stipend for their time as well as a computer station with a projection device.
The study consisted of 4 phases:

1. Teachers were required to complete a questionnaire that chronicled the types of issues that struggling mathematics students might encounter in their classroom and their appropriate response to that problem. Their responses were categorized using a scale from HC (highly controlling) to HA (highly autonomy-supportive). In the middle of the scale, MC (moderately controlling) and MA (moderately autonomy-supportive) was also used. The motivation style employed by each teacher was computed using the equation 2(HA) + MA - MC- 2 (HC). They could range in scores from -18 to 18. The negative scores indicate a highly controlled classroom, while the positive scores indicate an autonomy supported classroom environment. From the results of their questionnaire, two groups were formed. Forty-two teachers scored in a mean number of -10.9. One teacher scored -3, and the remaining 4 teachers scored a mean of 7.8. Observations were then done on the 12 lowest scoring teachers, 5 teachers with a score above -5. Participants were chosen because their motivational style claim matched the actual practice in their classroom. They were included in the final study.

2. Two classroom observations were done in 17 classrooms between the months of August and September. They were required to be observed in 2 different classrooms to ensure that their behavior was consistent based on student populations. The observations were scored on criteria using Objective measures (OM) and Subjective measures (SM). Objective measures followed Flink et al.’s (1990) guidelines and were measured based on the amount of time a teacher spent talking. They included verbalization of time spent listening to students, commands, rules students ought to follow, what students wanted to do, response to student-generated
questions, praise, teacher hints and solutions to students, and personal statements (Manouchehri, 2004).

Deci’s (1995) dimensions of autonomy-supportive style helped to guide the checklist for the SM component. Subjective measures could include initiative encouraging, opportunities to choose, attempting a student method, pursuing a student question, giving appropriate validation of students’ feelings, and supporting confidence and student questions.

Each teacher received a score of 1-7. Manouchehri also used 4 other measures including: teaching experience, background in mathematics, reform-based mathematics background, and plans for replacement. Based on their scores, 4 each from categories of autonomy-supported and controlling styles were used.

3. An interview was conducted to indicate the reasons behind a teacher’s motivation style. Does the teacher respond to a particular student based on their perceived motivation style, an administrator’s impact, performance scores outcomes, etc. The study also wanted to know if a teacher planned on implementing the particular reform in their classroom and how they planned on accomplishing that task.

4. A teacher was observed 10 times in 8 weeks during the months of October through December. The teachers were measured using General impressions (GI) indicators that included student engagement, mathematical context, supportive group discourse, interest in student thinking, making sense of student ideas, synthesize mathematical ideas, and the use of pedagogical tools and resources (Manouchehri, 2004).

Qualitative research was also employed in Phase 4 by the researcher, vying that a change in teacher behavior over the course of 3 separate class periods would be included in the GI list.
A group of raters would also conclude a change in teacher behavior through the use of sample videotapes from each participants’ classrooms.

Results indicate that teachers supporting autonomy style classrooms chose questionnaire options supporting areas such as: students are creative and original; student participation in the classroom routine will encourage them to respect it; and the need for student respect and problem-solving skills were areas that were in highest contrast to a controlling teacher environment. Where a controlling teacher used student background to indicate hindrances in student performance, an autonomy-supportive teacher would use the students’ background in a more positive fashion and use their experience to enhance classroom routine. Autonomy-supportive teachers allowed students to create more opportunities and choices than the controlling group. A controlling classroom teacher often corrected student behavior and had rules they were expected to follow, but oftentimes failed and excused the student to the principal’s office. In conjunction with this type of behavior, a controlling classroom teacher exhibited behaviors that did not enhance student performance. Examples include spending most class period having students complete a worksheet, requiring all students to work on the same activity, little encouragement to work in groups or on various problem-solving techniques, and referred to answers as “correct” rather than “best work”. On the contrary, an autonomy-supportive teacher would encourage his or her student to solve a problem in a way that made sense to them rather than having a quick or most effective way be the focus. They also focused classroom instruction time by having students voice answers to the previous day’s work for a minimum of 20 minutes in the beginning of each period. They would hold a discussion and have students find comparisons in various student answers. Referring back to the controlling classroom, oftentimes
disruptive student behaviors were called out publicly, with student retaliation and ultimate removal of the student, resulting in little mathematical work during that time.

Every classroom, whether an autonomy-supported classroom or controlling classroom, student behaviors consisted of showing up tardy, sleeping in class, disruptive behaviors, and without materials. Teacher reaction to those constraints offered different results. For a controlling teacher, the reaction was negative. They would oftentimes focus on a negative consequence such as failure of the course, confusion in the next math section, as well as referring to some students as using a lazy excuse to not learn the material. In contrast, an autonomy-supportive teacher would respond differently to those types of barriers by allowing the student to voice their opinion, but offering suggestions such as completing one task could lead to a more fun or interesting topic.

In conclusion, autonomy-supportive teachers often will give more opportunities to their students, they also listen and respond positively to struggles and solutions, and motivated students by requiring participation and asking questions. Although autonomy-supportive teachers were seemingly more open to reform practices, they were only partially successful in their implementation. These teachers would often lose mathematical authority in the classroom and fall back on the controlling style of teaching.

The controlling teacher, having been instructed in the same 3 year study through the university as the autonomy-supportive teacher, saw the importance of reform, but did not see the need to implement it in their classroom or found it impractical.
Methods of Inquiry

Graphic Organizers

The use of manipulatives and graphic organizers are fairly prevalent in the elementary classroom, but are lacking in the upper-level secondary classrooms. Ives (2007) found in this study, done in an algebra setting, that using graphic organizers to solve procedural issues worked as well as they have to help students with reading difficulty.

Memorizing basic facts in mathematics proved to be an issue with some students who had struggled with language and reading skills as well. Ives (2007) used schema diagrams in which students were taught to distinguish which type of schema was the most effective in solving a particular type of math problem. Although it would be helpful to think that a graphic organizer could be the key to problem-solving issues in advanced mathematics classrooms, concrete models seldom are able to aide. Graphic organizers can be expanded from the typical use of word, phrase, and sentence structure to include arrows and boxes to help with mathematical concepts.

Two studies were conducted with the use of graphic organizers in an algebra setting where systems of linear equations was being taught. The studies consisted of an experimental design with students with language-related disabilities.

The graphic organizer used in this study consisted of 6 boxes arranged in 2 rows and 3 columns. In this design, a student was trained to work from top left and move in a clockwise fashion, eliminating variables along the way. The figure below shows the process of eliminating variables using a graphic organizer approach:
The top row of the graphic organizer are meant to eliminate a variable one at a time. The bottom row makes space for solving for the remaining variables.

Before the study could be done in this classroom, students had to have a few prerequisite skills. (Ives, 2007)

1. Solving linear equations with one variable

2. Substitution of one variable to solve for the other variable in a system of linear equations with 2 variables.

3. Combining linear equations with 2 variables.

4. Finding common multiples for 2 positive integers.

The teachers in this study used a combination of strategy and direct instruction, both of which rely heavily on language ability. Students completed a pre-test and post-test after a 2-3
week cycle that included the instructional phase of the experiment. Participants consisted of 6-12th grade students with learning and attention disabilities. It was performed in a private school in Georgia where most class sizes are 10 or less. The GO (graphic organizer) group consisted of 10 males and 4 females. The CO (control group) consisted of 11 males, 5 females. Each group had been diagnosed with language-related disabilities. Mean ages for the GO and CO group were 15.9 years and 15.8 years respectively. English was the first language of all participants.

An ANOVA was used to compare the first 2 questions of Study 1, which were:

- “Will secondary students with learning disabilities or attention disorders who have been taught to solve systems of two linear equations in two variables with graphic organizers perform better on related skill and concept measures than students instructed on the same material without graphic organizers?” (Ives, 2007)

- “Will the difference in performance cited in the first research question be maintained for 2-3 weeks after instruction and immediate posttesting are completed?” (Ives, 2007)

Results were compared using 2 teacher-generated tests with similar content including systems of two linear equations with single digit coefficients and two variables. All solutions consisted of integers. The results were compared because the difficulty level was considered to be equivalent.

In this study, two groups of similar skills sets were compared. Teachers were also trained using language strategies provided by a transcript. The results of the test for the Graphic Organizer group were significantly higher on the teacher-generated tests than the Control Group.
Posttest results ($F = 0.19$, $p = .664$, $n^2 = .007$) were compared with the maintenance test ($F = 0.00$, $p = 1.000$, $n^2 = .000$).

*Interactive Software*

Geometry, as cited by the NCTM, is meant for students to “learn about geometric shapes and structures and how to analyze their characteristics and relationships” (National Council of Teachers of Mathematics, 2000, p.41). Geometry has been an area of mathematics that teachers have been able to use manipulatives to teach, with the use of the compass, straightedge, and numerous other three-dimensional objects. Technology has allowed us to branch out even further and dynamically change the way that students “see” relationships. No longer do students have to construct objects using a compass and straightedge, instead they can use software such as Geometer’s Sketchpad to create the same objects with less time and more interaction.

To determine if interactive software can in fact enhance the learning of students further than traditional paper and pencil methods, Erbas and Yenmez (2011) took 134 sixth grade students from Ankara, Turkey to test. Two groups were taken into a computer lab and taught geometry concepts through Geometer’s Sketchpad software, while another 2 groups were taught in the classroom, learning the same concepts, but with traditional methods. Results indicated similar differences among students in both experimental and control groups between pre- and post-tests and delayed post-tests. Gender did not influence performance. Motivating factors and participation in class discussion had significant differences. During observation periods, while the experiment was being conducted, students were asked daily to help generalize information that was covered in the previous day. Researchers determined motivation and attitude differences between classes. The experimental group, using interactive software, were able to give more
responses to review procedures, but also gave multiple situations where the concept could be analyzed and interpreted. Control group responses were fewer in frequency, and often resulted in less interaction with the teacher and class in general. Often, students forgot the necessary materials to conduct daily procedures and instead waited for other classmates to report the answers. Control group students often seemed bored with the discussion and lacked confidence in their answers.

Setting aside the fact that students in both the control and experimental group were statistically similar, educators cannot ignore the fact that discussions afterwards proved to indicate that motivation and attitude was significantly different with students who had the opportunity to use interactive software. This indication alone could prove to support the need for schools to support the use of interactive means to educate their students, not only in mathematics, but across the board. Students were ready and able to answer discussion questions and could back their understanding with multiple answers. The experimental group can not be described as passive recipients of information.

Team Learning

Sashittal and colleagues (2011) refer to evidence that Rassuli and Manzer (2005) found. Rassuli and Manzer grouped students in two ways; positive attitudes towards team-learning and negative attitudes towards team-learning. After coursework where team-learning was in focus, the first group, the indicators that team-learning was positive, reported that team-learning helped to improve their attitude towards the instructor, communication with their peers, as well as a better understanding of concepts in the course. Not surprisingly, the second group (initially
negative towards team-learning) did not report to have had a change in their attitude towards this learning method, instead stating that they would rather lecture.

**Teaching Style Match-ups: Inquiry vs. “Others”**

*Inquiry vs. Cognitive Load Theory*

Cognitive load theory (CLT) and Constructivism went to battle—literally. These two theories were matched up head to head to determine which approach would yield better, more efficient thinkers in a simulated battle-type environment for military purposes. Hotly debated is the issues surrounding working memory and the ability of each approach to decipher information and respond appropriately. Constructivists have maintained the argument that deep learning comes from the processing of new information actively and integrating it with prior knowledge to store. By personally attaining knowledge, constructivist supporters say that deeper knowledge can be obtained.

Problem-based learning (PBL) is a Constructivist approach that was used to focus on learning in this study. PBL can be obtained by two different methods: direct instruction or scaffolding. The issues surrounding PBL is that by allowing the learner to construct their own knowledge about a concept, that working memory (WM) may be overloaded and the learner may not be able to decipher between important and unimportant information.

Working memory is limited, says CLT researchers, so any information that enters WM may run the risk of not being processed by long-term memory. Long-term memory (LTM) can, unlike WM, group information into chunks, or connected ideas. If learners can be trained to maximize their WM load during the acquisition of information, then they may alter LTM.
For a period of 7-11 days, outcomes of decision-making ability, integrated knowledge acquisition, and procedural, conceptual, and declarative understanding were measured for longevity (Vogel-Walcutt, 2010). Participants were 292 undergraduate psychology students. Neither racial nor ethnic backgrounds were shared as well as the mean age or academic history of the participants. Each participant was randomly assigned to a group that varied in the training conditions: CLT-C, CLT-U, or CON. As you may have figured, the first two methods stem from Cognitive Load theory and the third is a method of Constructivist theory, some groups were tested during exposure time and others were untimed.

SPSS 17.0 for Windows analyzed the data. No significant differences were found after conducting an ANOVA nor a post-hoc pairwise comparison, however after delayed assessment, CLT had significantly higher scores than CON. Test items for 2 particular types of questions, Conceptual Knowledge Test (CKT) and Integrated Knowledge Test (IKT), tested the participants ability to answer fact-based questions and free-response questions that demonstrate the participants ability to extend their deeper understanding to a specific task. Neither approach had significant differences in CKT or Decision-making (DM) ability. The only area where significant differences was in the area of IKT, where the CON group had higher scores.

In the areas of information acquisition as tested by this research; procedural, declarative, conceptual, and decision-making skills were all obtained effectively regardless of the type of instructional method. Better results were obtained, however, if participants were given extra time to complete integrated-knowledge tasks. PBL approaches is put in question for the use of application because of this study. Constructivist approach can be costly, both in the areas of
tangible costs as well as time. The researchers question its effectiveness on the learner if integrated knowledge isn’t placed into consideration.

*Inquiry vs. Direct Instruction*

Two different groups of researchers tested the abilities of direct-instruction and discovery learning. One advocate for direct instruction, Klahr and Nigam (2004), tested students in a very teacher-controlled environment and reported that students outperformed a group which had the freedom to design materials with no instructor help. The theory behind Krajcik and Varelas (2006) poses the question of time frame. Does a ‘long view’ approach yield better results for inquiry-based learners? Is the inquiry approach the best way to teach inquiry-based learning?

The study conducted consisted of a unique student population. The school was an urban district that was comprised of university-affiliated students- children of faculty and administration were mixed with students obtained from a largely low-income background who attended through a lottery process as well as substantial financial aid. Forty-four of these students, all in grade 4, showed no predetermined preference to either method. The design of the experiment had three groups of students, each in a classroom of 15. Groups were categorized into PR, DI, and DI/PR groups. The PR group consisted of a practice method, one where students had control over the variables and were free to develop their own interest. The DI group was taught using direct instruction for a single session. Lastly, the DI/PR group received a mix of the first two methods, allowing for free time to develop interest after direct instruction.

All students were given an introduction to ensure equity amongst the groups and to deliver the project goals to all students. Students were given a task to compare a group of
catalogs and determine which changes would yield the most sales. The groups receiving direct instruction, DI and DI/PR, were shown 4 comparisons to symbolize some of the “do’s” and “don’ts” for this particular project. Students in the PR group were told that they would be given multiple class periods to investigate the project and would have to compare their findings with a partner to be sure that they were both in agreement. This group was the only one to receive practice sessions over a 10 week period. The other two groups received regular science instruction at this time. After the 10 week cycle, all groups participated in assessment and maintenance sessions, which chronicled familiar and unfamiliar content through posttests and transfer assessments.

Results over time indicate that overall the 2 groups with similarly significant results were the groups that allowed practice, whether it was paired with direct instruction or not. Direct instruction over time did not produce significant results. Discussion results indicate that the “time on task” is greater for the practice groups, but indicate their confusion on whether direct instruction for the one group made any significant gains at all. The researchers indicate that results may be taken lightly seeing as though the group studied sometimes showed “minimal to no indication of proficiency” (Krajcik & Varelas, 2006). Inquiry, they say, should be an ongoing process and that results will not appear overnight.

Constructivist vs. Traditionalist approach

Remembering basic multiplication facts and converting between symbolic and concrete connections in multiplication were the two goals that this study was determined to find an
appropriate and effective model. For each goal, constructivism and traditionalism, were compared and their effectiveness on student learning documented.

The quasi-experimental pretest-posttest study was performed using 71 third grade students, between the ages of 8 and 10 in the St. Louis area public school district. Both school districts were of middle-low socio-economic areas. This research design split the groups into 2 classrooms consisting of teachers from two methodology backgrounds; Constructivist and Traditionalist. Constructivist methodology was conducted methodology based on the Bruner (1966) method through action, visual pictures, and by using symbolic representations. Traditionalist teaching strictly used the school assigned mathematics textbook, Exploring Mathematics (Grade 3) which primarily used practice worksheets as the instructional tool.

In the resulting data for this experiment, no statistical significance was found using ANOVA. Although the statistical data showed no significant difference, it was noted that the mean scores of the Constructivist group were significantly improved from only 10 lessons. The researcher poses a question rooted in the idea that if improvement was made over a mere 10 lessons, the impact of a Constructivist approach over an entire year could be significant.

**Interventions to help achievement in the mathematics classroom**

Students experiencing problems with academic performance is an issue requiring schools to intervene in order to meet federal legislation in the form of No Child Left Behind. An experiment using non-concurrent multiple-baseline across teachers design was used for this study. Integrity was measured by using verbal training, faded 3-criteria classroom training, and response-dependent performance feedback (RDPF) (Gilbertson, 2007). Participants for this study
consisted of students referred to a group of graduate students. The first 5 certified teachers to refer a child having difficulties in math would have the opportunity to participate in the study. Three 1st grade teachers referred students Beth, Will, and Roger, who needed assistance adding and subtracting basic math facts. (Gilbertson, 2007) Two more students, Ann and Mike, 5th and 4th grade students respectively, were referred for interventions in adding, subtracting, and multiplication. Tutors were assigned to each student following the criteria of good attendance, responsibility, good peer relationships, B average in math, and parental consent. Three interventions were discussed and evaluated: verbal training, faded 3-criteria classroom training, and response-dependent performance feedback (RDPF). Each day a student would receive one intervention in the classroom. Verbal training consisted of a consultant-led explanation of specific steps of the verbal and written intervention summary. A summary of how each step should be performed followed by a rationale for the intervention was provided. A role-play of the intervention was then performed by the teacher and consultant.

Faded 3-criteria classroom training began once a teacher performed the intervention with 100% integrity for at least 3 classroom sessions. Once that was complete, the teacher could then perform the intervention independently in their classroom. In the first phase, a consultant would perform the intervention in the classroom setting and then communicate with the teacher using a VAAT communication device to give verbal prompts to the teacher during instruction. Secondly, the consultant would observe the intervention, but no longer offered cues to the teacher during instruction, but later provided positive feedback to the teacher. Discussion of accurate steps and analysis of missed steps was done after instruction. Lastly, a teacher performed the intervention without the presence of a consultant and results were verified using a permanent example from
class. Feedback was given the next school day after the intervention was complete. Once the teacher performed the intervention with 100% integrity for three separate classroom sessions, they were considered trained. (Gilbertson, 2007) In order to maintain integrity, a consultant would provide feedback to teachers who did not perform the intervention with 100% integrity before their next class session.

Average mean scores and trends increased slightly for math performance during the verbal phase of the program. Results for each of the five teacher participants varied based on the ability to implement the intervention to 100% integrity once a consultant was removed. Despite lower performance integrity, the use of faded classroom training and RDPF can increase student performance.

After school programs to increase student learning

In order to receive Title 1 funds to meet federal mandates, schools must offer supplemental educational services (SES) for parents. Until this point, there has been no state to provide evidence that tutoring has helped to make gains in student performance in reading and math. A meta-analysis conducted by Ritter, Barnett, Denny, & Albin (2009) used investigative studies with students in grades K-8 with random field trials. Students from an ethnically diverse, urban school in New Jersey were used for this study. The Department of Education noted that it was classified as an Abbott district, meaning that the school met specific guidelines of low socioeconomic status, substantive failure with efficient education, large numbers of disadvantaged students who require atypical education, and excessive taxes for municipal services (Caskey, 2011). An eighth grade group was targeted for this study because they were
deemed “borderline” based on scores received from the New Jersey Assessment of Skills and Knowledge (NJASK). (Caskey, 2011) Of the 102 eighth grade students who qualified based on the NJASK, 43 agreed to be a part of the program. They were divided into 2 treatment groups, LA or MA, language or mathematics. For our purposes, we will focus on the 20 students who were borderline in mathematics. Ethnic diversity was a factor in the treatment group, which consisted of Caucasian, Latino, and African American students. Small group instruction, with a ratio of 4:1, was used with tutors who were hand-selected based on their effectiveness in the classroom. It was said that the tutoring program would simply feel like a continuation of the school day with tutors who rarely had disciplinary issues and higher test scores than other teachers with similar content area. The students would work in these small group tutoring sessions for 90 minutes each, twice a week. From October through March, the students would meet after school, for a total of 48 hours. Tutors used content from the Preparing for the New Jersey GEPA booklet (2001) in conjunction with a method called the Standard Solutions (2006), which aims at helping increase student test-taking strategies.

Once the program was complete, math scores on NJASK were compared to the control on the GEPA. An Analysis of Covariance (ANCOVA) was used to compare student performance on the NJASK at the end of the 7th grade year with performance on the GEPA, administered at the end of their 8th grade year.

Researchers concluded that students who received tutoring outperformed other students not receiving tutoring as shown in the math section of the GEPA; (F(1,54) = 4.55, p = .04). Borderline students receiving tutoring outperformed other borderline students not receiving
tutoring on standardized tests. Tutor relationships had a meaningfully significant factor on the effectiveness of the tutoring program.

**Groupwork**

Groupwork is at the heart of inquiry-based and collaborative learning. Creating the appropriate groups to enhance learning can be a struggle that many teachers are ill-equipped to handle. Forming groups with mixed abilities can help to solve that problem. Teachers have a calling to create groups in which diversity is maximized, thus not to alienate minority groups. When students are given the freedom to create their own groups, many times diversity is lacking. Students tend to group with other students of the same sex, academic background, similar interests, and similar status, thus creating a homogeneous groupwork environment. All of these things grouped together created an environment were the beauty of true collaboration was hindered. High-achieving students paired with other high-achieving students and students who struggled were paired with other low-achieving partners. Time on task was also a factor that hindered groupwork when students were given the ability to choose their own groups. (Mitchell et. al, 2004)

Students in grades 10 and 11 were chosen to participate, with ages ranging from 14-18 years. One hundred thirty-nine students in all from a high school in Montreal, Canada were used. Diversity and achievement levels varied and parental permission was necessary to participate.

A mixed method quantitative/qualitative study was used to create results. Three methods were used to analyze the data received. Each teacher would research his own actions and practice, pre-and post-tests were given to students, and focus group methodology was utilized to determine a deeper understanding of the questions on the tests.
Over a period of 6 weeks, students were divided into 2 science labs and assigned a specific group work situation, either teacher-chosen or student-chosen, depending on the students’ responses to an attitudinal survey given at the beginning of the program. The teacher-driven groups were assigned roles to uphold, but after a lab completion, were mixed again and assigned new groups. The student-chosen groups also had roles to uphold, but when the cycle was finished for them, it was required that at least one member join a different group. This enabled the students to decide who would stay and who would go.

Some benefits and drawbacks to both approaches were highlighted and discussed. For instance, teacher-monitored and teacher-driven groups often created a safe haven for low-achieving and alienated students. Student-driven groups were beneficial for academically-driven students, giving arguments that by allowing them to choose their own groups would ensure that another student wasn’t just riding on the coat tails of everyone else. Survey responses from individual students indicated that teacher-driven groups can be more beneficial because the time on task is greater with someone who you don’t personally know than with a friend. Many times friends working together in groups can distract each other and talk about issues outside of the particular project while other groups may not have commonalities and would choose to just get right to work. In another case deserving mentioning, with low-achieving students in the classroom, if the class is left to choose their own groups, typically these students are left to group with other low-achieving students in the class. This is called tracking and leads to a loss of collaborative learning, which is what groupwork was intended in creating.

After the study was said and done, many questions still remained. A shift in the opinions of some student differed and the teacher was left with some of the same questions he began with.
In this particular classroom choosing groups seemed to be at the teacher’s discretion. It was up to him to decide when teacher-generated groups or student-generated groups were more appropriate. Students indicated that regardless of their preference, it was ultimately the teacher’s decision when to employ either technique.
Chapter III: Results and Analysis Relative to the Problem

No Child Left Behind and an increasing demand for technical intelligence has forced legislation to affect the way that students learn. Gaining the skills that they will need to survive and thrive in this demanding workforce after college will no doubt make the jobs of teachers much more important. The delivery of content to aid students in their journeys through high school needs to be done using the best possible methods. Finding an appropriate method to help student retention of knowledge is at the heart of this research. Numerous questions and research studies have led scholars to this very task. After a review of literature, some common themes emerged: motivations of students; methods that encourage learning; and comparisons of traditional methods with constructivist approaches to learning. Which methods will produce the most knowledge? How will the results be measured? When methods and purposeful research focuses on the most effective methods to enhance student performance, students will benefit. Even with the best of intentions, how will the teaching staff respond to the results? What will be the best means to educate the teaching staff to buy in to this type of teaching style? Constructivist Theory has been discussed and researched in the last few decades, and many teaching methods, including inquiry-based approaches, have been influenced based on this view of knowledge, but the implementation of its use is unknown.

Motivation

Creating an environment of constructive learning can be a difficult task for some teachers. What types of strategies increase motivation for students? Motivating factors and the effects on student performance was what McKinney (2008) and Sutton and Krueger (2002) gathered data from questionnaires to focus on. Implications drawn from these studies indicate
that more work needs to be done to increase the prevalence of inquiry based approaches in the classroom and to diverse populations by way of research studies and professional development for teachers. Classroom practices are the most influential indicator of student achievement in mathematics (Sutton and Krueger, 2002). Teachers oftentimes may use a particular style of teaching because of their misunderstanding of inquiry, time, lack of confidence, or disbelief in the practice of inquiry. The research of Sashittal and colleagues (2011) indicated a connection between prevalence of constructivist approaches and teacher motivation. In the study, if an instructor had an attitude toward inquiry that was negative, meaning that they often required students to conduct teamwork on their own, they would also respond negatively toward the time required to conduct inquiry as well as their own discontent with their own qualifications. Motivating factors can make an effective difference in how an approach is implemented. Based on the findings of McKinney (2008), Sutton and Krueger (2002), and Sashittal et. al (2011), the prevalence of inquiry approaches are linked to instructor motivations. If inquiry-based instruction is to be used commonly in the mathematics classroom, more education and professional development supporting its use must be offered to mathematics teachers. Students may need to be motivated to learn not only by their will to do well in school, but by other factors, such as their teachers. A teacher has a tremendous influence on how a child will learn. Quek et al. (2007) found that student satisfaction toward a particular class centered on instructors who displayed a leadership style that was friendly, helpful, and understanding. Students were also given the freedom to work within groups where the instructor offered assistance as needed. Will an increase in professional development support the usage of this type of instruction? What
motivating factors need to be encouraged for educators to see that inquiry-based teaching can impact their classrooms positively?

*Methods for Inquiry-based Teaching*

While understanding that inquiry-based approaches have been proven to motivate students, choosing the best method of implementation can be difficult. Teachers’ instructional styles differ; however, scholars such as Mitchell, Whicker, and colleagues (1997) have discussed ways to promote an inquiry-based classroom. Further discussion below highlights Mitchell and Whicker’s research.

*Promoting student bonding to increase the effects of inquiry-based teaching methods*

Allowing time for students to form bonds during group work could have significant affects on the implementation and overall effects of inquiry-based teaching. Over time, the cohesion of the group can create apparent differences in achievement. Students need time to create relationships with group members to increase the effectiveness of the whole group. Understanding each other’s strengths and weaknesses helps to create cohesion. When cooperative learning is practiced over time, Whicker et. al (1997) found that test scores in a precalculus group had significantly different results, results that favored cooperative groups. This relates to the research question about methods that promote a constructivist approach. Finding ways to promote methods that enhance *how* a student learns can help to gauge appropriate methods in the classroom. Working in cooperative groups can give students a sense of belonging and foster an environment of collaboration.

*Graphic organizers to aid comprehension.* Sometimes students with disabilities not only struggle in the mainstream classrooms of ELA, social studies, and science, but also in a
mathematics setting. Students who typically struggle with reading ability in other classes will also struggle in the mathematics classroom when expected to comprehend procedural problems. (Whicker, 1997) Graphic organizers were used to aid students who had difficulty memorizing basic facts and solving procedural math problems. Although not the answer to all problems associated with reading comprehension in the mathematics classroom, graphic organizers were shown to help students significantly than students expected to solve procedural problems without their use. Graphic organizers may help students who may typically show insignificant gains when testing academic achievement in an inquiry-based method.

*Approaches to grouping students*

Cooperative groups have been shown to increase student motivation and attitude. If kept small, cooperative groups can create a sense of teamwork while still offering individual satisfaction. A question still lingers when discussing groupwork. Should a teacher create groups based on ability or offer the freedom of creating the groups to the students? Mitchell and colleagues (2004) indicated that collaborative groups are difficult to manage for a few reasons. One reason for the difficulty is that creating groups, whether one is the teacher or student, can be a daunting task. Grouping high-achieving students with low-achieving students can prove to be frustrating for the high student because they may get the sense that other students are just depending on their knowledge to complete the task, while the low student may feel a sense of alienation because of their limited knowledge to complete the task. Attempting to track students based on this concern limits the effectiveness of collaboration and groupwork. Students have indicated that choosing groups was often not a responsibility that they were comfortable choosing, rather leaving the responsibility to the teacher. Students working in groups need to feel
that their contribution is meaningful to the outcome of the task. Constructing knowledge, therefore, must be created using groups that emphasize individuality while still offering open communication between students. Mitchell et. al hint that there is a relationship between cooperative groups and constructivist learning. When done with inquiry approaches in mind, students can cooperatively work together to create knowledge together and challenge each other.

*Constructivist Approach Compared to Traditional Methods*

Constructivist approaches to learning have been compared to traditional methods to test each method’s validity in the classroom. When compared to Cognitive Load Theory (Vogel-Walcutt, 2010), Direct Instruction (Krajcik & Varelas, 2006 ) and Traditionalist Approaches, inquiry-based instruction had similar results when conducting pre- and post-tests to determine if a method was academically effective. It bears mentioning that although the results yielded statistically minimal academic gains on the tests conducted by Krajcik and Varelas, the gains in achievement over time proved to be noteworthy. This relates to the research question of which instrument will gauge understanding the most appropriately. Many research studies relate constructivist learning and a one-year time span. When placed in question over a time block of more than a year, Le and colleagues found a relationship between retention and time using constructivist learning. Le et. al (2009) attempted to prove when they linked teacher and student data over a three-year period rather than the traditional one year block that most researchers conduct that there would be supportive evidence towards inquiry. This is important for educators to be aware of because if the goal is for students to retain knowledge, then the tests that are traditionally administered needs to be cognizant of a learners needs beyond the span of one year.

*Measures of success*
Another question that emerged from the literature is the measure with which mathematics achievement is conducted. Student achievement on multiple choice tests, for example, is lower when a student has been exposed to inquiry-based instruction rather than traditional methods. When the same group of students are asked to complete open-ended or discussion measures, their achievement scores improve significantly (Le et. al, 2009). Maybe the question of successful implementation of learning should be gauged using multiple measures. If a mandated test for funding supports traditionalist methods, then how is an educator supposed to argue with their traditionalist methods? If the goal of an educator is to create a successful learner over time, one who can retain knowledge past the point of a test, then constructivist learning seems to be the more successful method.

While educators in today’s system may not know which method is most appropriate, finding ways to incorporate constructivist themes into their teaching can be done using proposed research-based methods such as the ones mentioned previously in this chapter. Approaching education and student learning using different themes can no doubt benefit the learner.
Chapter Four: Summary and Conclusions

Our educational arena is changing, whether today’s educators want to face the facts or not. Our traditional classroom, although appropriate and successful in preparing students to score well on rote memorization to pass a test, that method is ineffective to meet the needs of today’s society and student base. A teacher, being cognizant of their student’s needs beyond high school, should look to approaches created with the constructivist theory base in order to help foster student ownership and pride in their learning.

Numerous studies and research has focused on the needs of the high and low-achieving student and has found that using inquiry-based and hands-on approaches to learning basic concepts is successful for students to both retain information and use inquiry approaches to solve mathematics problems outside of worksheets and book problems, both of which rarely entice students to look beyond the implication of the grade (Draper, 2002; Manouchehri, 2004).

Student achievement in mathematics has undergone critical skepticism since traditionalist means of education have been under question. It makes sense, then, when the typical means by which students have been taught (traditional methods) yield higher achievement results because it has been used and tested for a number of years. Now that researchers and educators from around the globe have brought other teaching methods into the educational arena, achievement measures must change. The question that remains is which method and measurement will prepare today’s student for the future?
INQUIRY-BASED APPROACHES IN THE SECONDARY MATHEMATICS CLASSROOM

What is the best way to appropriately incorporate constructivist learning into the classroom? When the educational system has for so long relied on state and federal testing that seems to favor direct instruction, how can a teacher, let alone a school system favor constructivism? In an educational arena where state and federal funding drives so much of evaluation, inquiry learning is difficult to justify because its results may not be noticed until years later. Teaching strategy should focus on teaching for student retention, rather than just teaching to a test on knowledge that can be quickly forgotten. When the testing process focuses on using the “just in time” knowledge that students learn from traditional methods of teaching, the results often support traditional, direct instructional means of teaching. This is especially the case because funding supports this testing process.

Teacher training in the Constructivist Theory needs to be incorporated into our secondary schools, especially in the mathematics classrooms. The time to act is now! Teachers should act as facilitators in the classroom and enact a reform that requires students to acquire their own knowledge to solve problems. Our nation is struggling to compete with the world in the mathematics schema. Our students in today’s school system need teachers to prepare the youth to compete in the mass market of strong-willed and competitive world we live in.
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