A MIXED METHODS PROBLEM-BASED APPROACH TO MATHEMATICS
VERSUS DIRECT INSTRUCTION

By

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ABSTRACT

Problem based learning was the foundation for this action research study. One class received direct instruction during the duration of the study while the other class received a mixed method approach of problem based instruction as well as direct instruction. The results from this study support the hypothesis that students will learn and have a better understanding of mathematical concepts if taught using a problem-based approach.

Background for the research, literature to support the study, methodology, findings, discussion and implications for results are discussed within the contents of this study.
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Chapter One

Introduction

Predictable activities can actually ‘dumb you down,’ whereas participation in unfamiliar structures that demand adaptation –this is, places where learning is required and literally can make you smarter.

-Davis, Sumara & Luce-Kaplar, 2000, p.76

A new era of teaching mathematics is upon us. For some time now, a huge reform movement has been occurring in the United States. In the 1980’s, the math community began to set standards for what students should know and be able to understand and do. The National Council of Teachers of Mathematics (NCTM), developed standards that placed an emphasis on the need for students to understand what they are learning. This also made it important for teachers to understand what they are teaching and assessing and the best practices in helping students develop that understanding of mathematics (Hiebert, 1997). Teachers have been asked to be more accountable since the “No Child Left Behind” act was set into place. Students are scoring low on international tests compared to other countries (Rich, 2012), and losing confidence and interest in their mathematics education. Dewey, an early psychologist cautioned that if teachers taught students without understanding, then this would damage a students’ ability to reflect and to make sense of what they were learning. Information should be shared as long as it does not solve the problem or take away the need for the
student to reflect and develop solution methods that they understand (Dewey, 1933). Many curricula today, teach without understanding. As individual and social constructivism suggests, understanding comes from engaging students in challenging and meaningful activities. To challenge our students is to make them effective critical thinkers.

For all the given reasons, it is a necessity to promote critical thinking in our students. There has to be a shift in the way teachers think and the way they teach. For decades, math has been viewed as nothing more than rules and procedures that students should memorize and apply. The movement taking place now, since the new Common Core State Standards (CCSS) have been adopted, is that these rules and procedures should become tools in a purposeful activity that students should be engaged in order to become critical thinkers of mathematics (Heaton, 2000). Constructivists view learning as a process of active individual construction and the CCSS are leading teachers and students toward this goal. Standards have gone from a very long list of expectations, to a shorter, broader list of what a student should be able to do and know. In order to implement the CCSS to their fullest extent, which means incorporating the Standards for Mathematical Practice, teachers must take a more problem-based learning approach that allows students to become active participants in their own education.

**Statement of the Problem**

The purpose of this study was to determine, what differences will exist in student performance within a classroom, when students are taught with the use of two different instructional approaches. These approaches are the traditional approach of teacher-led
instruction using the current curriculum versus a combination of teacher led instruction and problem based learning. Most teachers today teach students in a way in which they are expected to memorize formulas, procedures and facts with little understanding as to why or how they came to the answers. Expectations of students have been changing and have finally become clear with the new national standards. The state of Ohio has moved from the Ohio Academic Content Standards, which was a very extensive list of expectations in each subject that the students were required to learn and accomplish, in order to continue through their education and graduate to the adoption of the Common Core State Standards under the name, the New Ohio Learning Standards. The previously required state test, the Ohio Academic Assessment (OAA) has also been replaced with a newly adopted test for the new standards.

The OAA consisted of many multiple choice questions and a few problem solving questions that used a rubric to score them. Students had to give an explanation for how they formulated their responses, but, when looking at the sample test scoring sheet only a few responses would be accepted. The test basically scored rote memorization of mathematics. The new CCCS-M, gives attention to not only the particular rote content, but to the mathematical processes as well. The new state test, Partnership for Assessment of Readiness for College and Careers (PARCC), requires students to think more deeply and explain the processes used to find their response or answer. The aim of the CCCS-M was “not to dismiss rules and procedures, but to use them as tools rather than static bits of knowledge in order for students to construct powerful and reasonable understanding of why particular solutions and problem-solving
methods make sense” (Heaton, 2000, pg. 5). The task now is for districts to find a curriculum that provides opportunities for students to problem solve, model their responses, and communicate their thinking or reasoning. The textbooks have to provide an opportunity for the students to use the problem-based approach and need to include the three key components.

Given the new standards, teachers are expected to be able to provide students with a curriculum enriched with problems or tasks that promote deep understanding of the content. This would require most teachers to change their way of teaching. What I am wondering is, if I would teach mathematics using a mixed method of teacher led instruction and problem based learning, could I promote a level of learning using our current curriculum materials, a very teacher centered curriculum, and in the process, change some of the ways students felt about mathematics?

Review of Literature

Learning Theory. The mathematics reform movement that began in 1989 with the publication of the *Curriculum and Evaluation Standards* (NCTM, 1989) suggested changes in curriculum and instruction because current practices were developed around a view of learning as a behavior process rather than a cognitive learning process. Through a behaviorist lens, a teacher would input knowledge and a student would output it. Students would mimic teachers. If we take the constructivist approach to learning, students will be able to construct their own knowledge and meaning and apply it to future problems, thus gaining an understanding of the content in the process. When a student is taught with minimal guidance from the teacher, he/she learns to solve authentic problems
and acquire a more complex knowledge in an information rich setting. Students learn to construct their own solutions, which leads to a more effective learning experience (Herrera, T., Kanold, T.D., Koss, R.K., & Speer, W.R. (2007). The learners will learn to draw on their own unique learning experiences to scaffold their knowledge and solve the problems they are presented with. Students learn by making meaning of mathematical ideas, and they do this through experiences. Through the experiences, knowledge is created. When a student is just provided with given information, ideas or concepts are not easily connected to that information to allow the student to build upon his/her prior knowledge. A student has to develop an understanding of mathematics on his/her own (Van de Walle, Lovin, 2006). This is why problem-based learning is of great importance. Not only do the students understand the concepts, but they enjoy math more when taking the constructivist approach.

Fennema and Romberg (1999), state that there are five forms of mental activity in which mathematics understanding emerges. They are: 1) constructing relationships; 2) extending and applying mathematical knowledge; 3) reflecting about experiences; 4) articulating what one knows; 5) making mathematical knowledge one’s own (pg. 20). Of these five activities, reflection is one of the most important keys that builds on the constructivist theory. Learning doesn’t occur just by adding new concepts and skills to a students’ previous knowledge base. It comes about through the reorganization of what a student already knows (Fennema, Romberg, 1999). This reorganization occurs when one reflects on what he/she already know.

Conceptual and procedural knowledge are two types of knowledge that are
associated with long-term memory and short-term memory. Both types contribute to the reorganization of knowledge. When determining the methodology to use when teaching mathematics and desiring to use a problem based approach, conceptual and procedural knowledge are to be considered in the process. (Procedural knowledge is commonly associated with teacher led instruction and conceptual knowledge is commonly associated with problem based instruction.) But, procedural knowledge alone, does not allow our students to obtain the level of understanding and knowledge they need to be successful confident mathematicians.

Curriculum materials. Since the reform began in 1989, national and state standards have been moving toward a more constructivist problem based approach to mathematics education. Teaching needs to change in order to meet the needs of society and as content is addressed in the new standards. The standards have moved to a broader base and, therefore teachers need to have more knowledge and understanding of the concepts they are teaching and that students need to learn. Since No Child Left Behind (NCLB), teachers have been held more accountable for the education of their students. The instructional focus needs to change from only information processing, to developing an understanding of mathematical concepts. For understanding to develop for all students, problem based tasks must be developed and used to engage students for the sole purpose of fostering understanding, not just simply the purpose of completing the task (Fennema, Romberg, 1999). In order to help teachers implement the change, curriculum needs to take a more problem-based approach. This would mean that materials will need to change as well, from a teacher led instruction to a more student directed instruction.
Some districts have turned to professional development for teachers that is focused on the implementation of problem-based learning (PBL) instructional strategies. A second alternative is the adoption of a new curriculum series. However this is often a difficult task, due to the lack of direction, specific student population that the district serves, the lack of understanding of the needs of teachers and curriculum by the persons responsible for selecting curriculum materials, or the “deals” and “promises” of the publisher’s sales personnel. The curriculum chosen by the district in this study, is good for student mobility, but it promotes very little student understanding in mathematics. It is very teacher centered with rote memorization required of students. However, the published curriculum claims to be a PBL curriculum (McGraw Hill, 2013).

In the 1990’s, the National Science Foundation (NSF) funded several curriculum development projects on math curriculum, at the elementary, middle and high school levels. The University of Chicago, University of Michigan, and TERC are examples of institutions and research agencies that received the NSF grants for curriculum development. *Investigations in Number, Data, and Space* and *Connected Mathematics* are two of the curricula series that were developed explicitly to use situated problem-based lessons to engage students in learning mathematics. Heaton (2000) discusses the value added to her teaching by changing the method in which she presented her lessons to meet the national mathematics reform. If teachers want to make a change in their students’ math education and a lasting change, they will need to make a change to the delivery of the content. Content is more easily and uniformly changed via purchased materials. However, these are only helpful if they approach learning from a problem-
based perspective. Students need to be engaged in high level, cognitively complex tasks to develop the capacity to think, reason and problem solve (Smith, Stein, 1998).

“Learning mathematics requires construction, not passive reception and to know mathematics requires constructive work with mathematical objects in a mathematical community (NCTM, 1990, pg. 2).” Teachers need to ensure that they are establishing a mathematical environment that promotes this type of learning.

**Teaching.** A teacher’s main role is to construct and facilitate the learning experience for his/her students. The most productive way to accomplish this is to provide the students with opportunities to use the knowledge they already have acquired and build upon those experiences using the constructivist approach. Many teachers still rely on guided instruction and modeling, followed by practice worksheets. This approach often leaves many students in the position of memorizing procedures they do not understand and often forget.

The problem is that we are not educating our students to be critical thinkers, and test results are not improving much. The new standards require our students to be able to think critically and reason about mathematics. In order to teacher our students effectively, we are going to have to change our way of teaching. Teachers are going to have to reorganize and understand mathematics (Heaton, 2000.) We need to change our delivery and learn how children make sense of ideas and build upon that. A teacher’s role is to provide tasks and facilitate understanding. When using questions that engage a student and giving the student an opportunity to build upon their previous knowledge in order to build an understanding of the new concept, he/she will display a positive attitude.
and a genuine willingness to learn. These types of engaging questions, or tasks, used by a facilitator, are proven to help students explain their way of thinking or the strategy they used (Capraro, Capraro, Carter, & Harbaugh, 2010). Problem based questions probe for understanding and allow the student to scaffold his/her learning through previous knowledge and experiences. Hiebert, (1997) provides us with ways to change our teaching methodology in order to provide the students with ways to learn mathematics with understanding.

Change will have to occur from within. One of the best tools to help promote this change will be teacher reflection and conversation with our colleagues (Hiebert, 1997). Teacher communities share certain goals and ways to work together to accomplish those goals. Communicating and interacting develops understanding of these goals. A teacher needs to be aware that rote memorization can lead to a form of learning that allows a student to pass a test, but gain no ability to use this knowledge in the development of a more sophisticated understanding of the content, or apply what they have learned within realistic situations (Davis, 2008). Learners must be actively involved in what the teacher is presenting to them. Teachers must teach not only the procedural knowledge, but the conceptual knowledge as well. There is further research needed in finding the ways to make sure both conceptual and procedural needs are met for each student and changing our curriculum to take a more problem based approach.

**Purpose of the Study**

The purpose of the study was to examine and describe the changes in students’ attitudes and understanding of the mathematic content if the current curriculum is
manipulated to be a more problem based learning approach. The study sought to investigate the differences, if any, in scores, knowledge and attitudes of the students when using the PBL approach.

**Theoretical Framework**

This research is grounded in two types of learning theories that are very similar in their emphasis in the importance of constructing your own knowledge. The two types of theories are the Vygotskian social constructivism theory and Piagets’ individual constructivism theory (Steffe, Nesher, Cobb, Goldin & Greer, 1996). Knowing and working with Vygotsky’s Zone of Proximal Development (ZPD) is an essential component of the learning process (Vygotsky, 1978). The three zones are: 1) what I can do; 2) what I can’t do; and 3) What I can do with help.

In this approach, students develop a sense of understanding of concepts through engagement in interesting activities. In using the PBL approach, this would be the tasks that are presented to the student. Adults can foster a child’s cognitive development using an intentional and systematic array of challenges and meaningful activities that engage the student. The teacher acts as a facilitator and might ask questions, encourage the students to work together, and provide support as the student tackles a problem that is rooted in a real life situation (Maddux, Cleborne D., Johnson, D. LaMont, & Willis, W.Jerry., 1997). Full cognitive development requires social interaction. In combination with the social constructivist theory, this research has also been grounded in Piagets’ individual constructivist theory. Piaget points out that humans cannot just be given information and be expected to understand it. People form meaning and produce
knowledge based upon their experiences. Again, the teacher is always in open conversation with the student, helping to guide his/her needs as a facilitator. Students formulate answers on their own. When the teacher challenges, or encourages the student to explain their thinking, he/she learns to become an effective critical thinker.

**Research Question**

In researching constructivism and how to best teach students for understanding in mathematics, the study was guided by problem-based learning and the current curriculum series or materials used within our district. The following question guided this investigation:

What differences will exist in student performance when taught using a mixed method approach of teacher led instruction and problem based learning versus just the teacher led instruction?

**Significance of the Study**

The research sought to investigate the differences in the two different methods of instruction, problem-based learning and teacher led instruction using a pre-post assessment in an experimental, mixed methods research design. Additionally, it sought to identify any differences in teacher practices from one class to the other, as well as any differences in student attitudes towards mathematics and opinions about the problem-based learning instructional method. This is significant because it would demonstrate the differences in student learning between rote, procedural instruction and problem-based instruction in mathematics. The results would guide me toward choosing the most desirable teaching method for students and provide the data needed to encourage other
teachers and administrators to consider the most appropriate instructional approaches to enhance student learning. The results of this study would also add to the research on problem-based learning.

**Limitations and Assumptions**

The limitations of the study were the number of participants, length of the study, interruptions and distractions during the course of the study, and transient student participation. The study involved only two teachers and was only done over a four week period. This was a short period of time given the interruptions during the course of the study. There are currently only two 5th grade teachers in the building, so to increase the reliability and validity of the research, more teachers would need to be involved. The length of the study was also a limitation. During the period of time that the study took place, there were a three days when students had to do PARCC test preparation and take the PARCC assessment. If the study had taken place over a longer period of time, the results might have been very different, or we might have seen a more drastic change in scores and attitudes.

Another limitation, was the distraction that occurred during the lessons for eight of the students in the experimental class. The students that were pulled out twice a week, during the lesson, and students who consistently arrived at school late were also distractions for the class, as well as the learners who missed instruction. Three students left to go to special education classes during that time as well. The control class did not have as many disruptions as her tutoring students would leave during the independent portion of the math lesson. It was a challenge for the teacher-researcher to attend to the
different interruptions and make sure that the students, who were joining the lesson late or missed part of it, understood the expectations. This also limited time that they had to complete the task and engage in a group discussion.

The final limitation was the number of transient students that transferred in and out of the school during the study. Two students in the intervention class moved halfway through the study and two students arrived as new students during the study. The control class had two students move out of the school as well, and two students move into the district halfway through the research study as well. I feel this may have impacted the results as well. Although both classes had students move in and out during the study, this was viewed as a greater limitation for the intervention group, as new instructional strategies were being used, whereas the students in the control group would “know” what to do when they came in late or as a new student. This is only viewed as a limitation because of the short duration of the study.

**Definition of Terms**

The research used the following terms consistently throughout the study.

- **Mathematical understanding**: Ones knowledge of mathematical concepts, and the understanding of how to build upon that knowledge.
- **Educational reform**: Name given to the goal of changing public education.
- **Teacher Base Team**: Group of grade level teachers, curriculum coach, and Principal, who get together each week to discuss any concerns or progress being made, or to be made.
- **Problem based learning**: Design meant to engage the learner in a task that will
challenge him/her mentally. The teacher acts as a facilitator. (Savery, J., & Duffy, T., 2001)

- Teacher led instruction: Instructional approaches that are structured, sequenced and led by teachers.
- Constructivist approach: Experiences that lead to understanding. It is how we come to understand built upon past experiences.
- Task: Activity that presents a cognitive challenge. A problem with many solutions.
- Conceptual Knowledge: Insight or understanding developed through experiences that provide a learner with opportunities to develop new understandings (Schwartz, 2010).
- Procedural knowledge: The ability to follow procedures and rules to solve mathematical tasks, often used in teacher led instruction.
- NCLB: National reform put into place to close the achievement gap, insuring that No Child is Left Behind.

Summary

The following chapter will explore more deeply the research behind problem-based learning; the reform and movement towards this method of teaching and learning, what teachers will need to do to implement this in their classrooms and the reasons why it should be the primary way to teach mathematics. Chapter three will discuss the methodologies involved in the action research and procedures that were used to implement it. Chapter four will inform us of the results of the data. The final chapter,
Chapter Five will analyze the data and reveal the conclusions of the research and discuss the significance of the study and the importance of it.

Chapter Two

Literature Review

Often, the exclusively behavioral characterization of desirable learning outcomes leads educators to rely on the teaching of discrete, disconnected skills in mathematics, rather than on developing meaningful patterns, principles, and insights. - Golden, 1990, pg. 30

The primary purpose of this study was to determine what differences would exist in student performance within a given classroom, when students are taught using two different instructional approaches. The approaches investigated were teacher led instruction and a combination of teacher led instruction and problem based learning. Research indicates that allowing a student to learn through tasks with a teacher as a facilitator, allows a student to develop understanding (Hiebert, 1997). Several bodies of literature were examined in order to gain knowledge about the constructivist learning theory, the problem-based approach to teaching, needed curricula changes in order to be a more problem based learning community, task selection, and appropriate ways to facilitate instruction in order to enhance student learning.

The review of the literature will begin with a review of the reform movements in mathematics education and a historical look at mathematics instruction. Next, the review
will discuss various learning theories. The third section is a review of the literature related to instructional changes that need to occur in order to promote understanding of mathematics in the classroom on all levels. The final section will review the literature surrounding the new Common Core State Standards and how problem based learning will promote student success.

History of Reform and Curriculum in Mathematics

The research literature in mathematics education suggests that the educational curriculum in mathematics has been undergoing many changes. What was once thought to be the best way to instruct our students is now being looked at differently and it is under more scrutiny than ever before.

Historical Methods of Teaching. Historically, it has been thought that students learn best through the use of procedural knowledge. Heibert (1986), defines procedural knowledge as, “knowledge of symbols and knowledge of rules, algorithms and procedures used to solve mathematical tasks.” (pg. 6) These tasks, procedures and rules were then recorded and stored in textbooks to be presented to the students by the teachers, much like it is in the present day. The teacher presents the concepts as understood by him/her to the student. The student then mimics what the teacher has presented. Publications such as, The Practice of Teaching, describe this method as mimetic tradition (Jackson, 1986). The mimetic tradition is the transference of facts and procedural knowledge from one person to another through the act of imitation (p. 117).

Answers can be judged right or wrong, accurate or inaccurate, correct or incorrect on the basis of a comparison with the teacher’s own knowledge or with some other model
as found in a textbook or other instructional material. Not only do judgements of this sort yield a measure of the success of teaching within this tradition, they also are the chief criterion by which learning is measured. (Jackson, 1986, p. 118)

In the past this idea matched the thoughts of many researchers and educators. A student was considered to be a successful math student if he/she could compute numbers quickly and find the intended response or answer, with no explanation or knowledge of why the solution to the problem. Conceptual meaning was not of great importance.

**Early Standards.** For the past three decades, each state had adopted its own set of content standards that were expected to be mastered by the students. The United States was scoring much lower and performing at a much lower degree in mathematics when compared to other countries around the world. The research literature suggests that those standards would have difficulty in connecting, building on or refining the mathematical understandings, intuitions and resourcefulness that students bring to the classroom (National Research Council, 1999). The instruction that was used in order to address the standards did not support students’ reasoning processes and replaced them with a set of rules and procedures. In giving students rules and procedures to follow, as the old set of standards promoted, a disconnect between problem solving and making meaning of the problems they attempted to solve was created. Instead of organizing the skills and tools to do math competently, with meaning, around a set of rules and concepts, the rules and concepts seemed to become the whole focus of the instruction.

This allowed procedural knowledge to be the basis for educating students in mathematics. The metacognitive skills needed to make the connections to real life
problems and situations was not promoted or present in this method of teaching that was promoted by the state standards at that time. Students who have been taught in this manner have come to believe that understanding how they arrive at a solution is irrelevant. They do not understand the need for conceptual knowledge. Teacher led instruction also makes it difficult for students to understand why they answer certain problems incorrectly, when they think that they did the procedure exactly as they were told. Students do not think the need for an explanation of why a solution is wrong because they do not understand how to make sense of the problem in the first place.

Research has shown that students need to build upon their existing knowledge in order to make sense of mathematics. This allows students to feel confident in their choices and math skills. Furthermore, research suggests that preconceptions are fostered early in a student’s school years, and that a student who believes that math is not for them, will adamantly avoid the subject (National Research Council, 2005). The academic content standards and the procedural way of thinking have fostered this thought among many students. If they do not understand the material or cannot relate it to everyday life, it is difficult for them to have a positive outlook on the content. For all these reasons, movements toward educational reform began to occur.

**Reform Movements.** Reports have been released in the past stating that Americans were falling behind other countries in the subject of mathematics. Many suggestions for closing this gap have been made and sparked one reform after another, with each new reform cancelling out the previous one. According to the research literature, only six percent of 17-year olds could solve multi-step problems involving
simple algebra in the 1980s (Dossey, Mullis, Lindquist, & Chambers, 1988). These unsatisfactory results led to many ideas for solutions.

The question now that begs to be answered, is how to proceed with change in the mathematics education world. Some people suggest that change in the amount of time that is spent on math in school needs to be extended. Another suggestion has been that the school year should be longer, as well as the length of the school day. Some critics suggesting that it is just the amount of time spent in math that will increase our students’ conceptual understanding of math. However, this argument relied on more direct instruction from the teacher. Others suggest that math needed to be more of a natural, everyday fit into the lives of our students. Students need to be able to relate to the concepts being taught and see a need for them.

National reports suggested that the issue needed to be attacked at a deeper level. NCTM published *Curriculum and Evaluation Standards* in 1989, as a response to a growing concern for the need for reform in mathematics education. In the years of 1990-2000, NCTM published the *Addenda Series* at preK-12 levels of education. These publications addressed all content areas so that teachers would have models and examples of appropriate tasks that would develop and promote communication and reasoning skills. NCTM also published *Assessment Standards* (1995), *Professional Teaching Standards* (1991), along with many resources for teachers. Many educators believe that we need to do less testing. The *Assessment Standards* provide guidelines to ensure that the testing that does occur will evaluate real understanding of the concepts being taught. In the year 2000, NCTM published the *Principles and Standards for School Mathematics*, which
specifically addressed mathematics content in five areas (e.g., algebra, data, number) and introduced process standards as the ways in which we learn and use mathematical ideas. The five process standards are communication, connections, problem solving, representation, and reasoning. A combination of research literature, publications for teachers, and national and regional conferences led the reform movement in mathematics education. However, it was hard to make an impact when state testing still consisted primarily of procedural questions that scored only on whether the answer was correct or incorrect.

Questions in school and research communities needed to be centered on what it means to be a mathematician and what it means to engage in the mathematical thinking, and tasks and activities that are presented by the teacher and are problematic for the student (NCTM, 1990). In response to questions posed by communities interested in promoting conceptual understanding of mathematics, some states moved to three and four point problem solving questions. However, these questions were time consuming for students to answer and states to score, so this discouraged the addition of a large number of this type of question on state test achievement tests. Yet, this was found to be the area of the test that could and would lower a school’s overall test score.

In 2001, George W. Bush initiated a bill that was passed by the U.S. Congress that was known as No Child Left Behind (NCLB). NCLB began what is referred to as the era of testing. The legislation required all states to have sets of content standards and test students in grades 3-8 and in high school yearly on their achievement of the state standards. Negative consequences would occur for schools that did not show an
appropriate measure of growth for all students. While some states wrote easy standards, others made standards that would align to what a student should know based on different developmental ages and grades.

In 2010, the National State Governors Association initiated a movement to have common state standards in English/Language Arts and Mathematics. This was to ensure that all states would be held accountable for the same educational goals, gains, and deficits. The products of this movement are the Common Core State Standards (CCSS) in English/Language Arts and Mathematics. The writing of the standards and the development of the assessments for the standards were partially funded by the Bill and Melinda Gates Foundation. The standards hold all students in the states that adopted the standards to the same set of educational expectations. This alignment of standards would place all adopting states on a common ground. Not only would this be a benefit for our mobile population, but one would be able to make reliable and valid comparisons of student achievement among states. The CCSS would improve the education of students and give colleges a chance to bring in students under the assumption that they were on level playing fields. The assessment of student achievement of the common core standards in mathematics would require students to be able to problem solve, reason, represent, and communicate in order to solve the problems correctly. A majority of the states, approximately 46, initially adopted the standards and that meant that teachers would need to change the way in which they taught, to teach for deeper conceptual understanding, in order for students to successfully master the mathematics content. The reasons and goals for instructional change throughout the decades has not changed. They
are as follows:

1. To get each student to view mathematics as a reasonable response to a reasonable challenge.
2. To get each student to see mathematics as worthwhile and rewarding.
3. To get each student to see mathematics as a subject where it is appropriate to think creatively about what you are doing, and to try to understand what you are doing.
4. To get each student to see mathematics as a subject where, it was possible to understand what you were doing. (There is abundant evidence that most U.S. students do not usually see mathematics in this light, nor is it taught in such a way that understanding is really possible).
5. To give students a wider notion of what sorts of things make up the subject of “mathematics”. There is overwhelming evidence that most students think that mathematics refers to meaningless rote arithmetic.
6. To let students see that mathematics is discovered by human beings, that their own classmates and they themselves can discover ways to solve problems if they take the trouble to think about the matter and if they work to understand it.
7. To give students a chance to learn the main ”big ideas” of mathematics, such as the concept of function and the use of graphs.
8. To have students see mathematics as a useful way of describing the real world. (It is quite different to see mathematics as a description of the real world, instead of seeing it as a process of following a set of meaningless rules, which, unfortunately, is how most students view mathematics) (NCTM, 1990, p. 95).
Critics of the reform are mostly challenging the change due to their lack of understanding of how to teach from a constructivist approach using the problem based learning method.

**Learning Theories**

The constructivist learning theory is foundational to the development of instructional practices in many content areas today. The first effort to modify mathematics in the school system occurred in the 1950’s. Some of the names of such projects were P.S.S.C., SCIS, E.S.S., and the Madison Project. Some of the individuals responsible for this effort were Jerrold Zacharias, Francis Friedman, Marion Walter, Frances and David Hawkins, David Page, Leonard Sealey and Robert Carplus (Davis, 1988). The mathematical efforts of these projects were lumped together in no sort of organizational method and were titled “The New Math”. Some methods used manipulative materials, others built up ideas gradually, while others attempted to just teach and get it right from the beginning. This form of teaching sounds very close to recent years, adding in teacher led practices to those methods.

In the late 1960’s, and early 1970’s, researchers began to change their focus on learning from a behaviorist to a cognitive perspective. Cognitive psychologists renewed their interest in the forming of concepts, problem solving and the connection between cognitive structures and behavioral structures. Then came the need for change in mathematics. As the movement towards mathematic reform began, mathematicians, researchers and educators started to look more towards the constructivist learning theory. In doing so, it has become the center of controversy in the subject of math.

Constructivism can be defined as knowledge that is constructed and the
instruments of construction are themselves products of developmental construction (Piaget, 1953). This idea suggests that a person will build upon what he/she already knows, continually constructing new knowledge. Von Glaserfeld states that knowledge is built upon experiences. Considering this thought, one can understand that knowledge, is a process that is ongoing and requires experience in order to actively build upon it, piece by piece. It is based on previously constructed knowledge. Teachers obtain their curriculum from their administration and are required to transfer that information to their students.

Many teachers do this in a teacher led instructional way. However, this does not allow the student to build upon his/her experiences or previous knowledge, as it is very process and retrieve oriented. Constructive learning requires that students be given experiences to learn from and build upon. Constructivism learning theory has been described as a philosophy that enhances students’ logical and conceptual growth. Two key concepts within the theory that serve to describe the construction of an individuals’ new knowledge are assimilation and accommodation. In assimilation an individual takes new experiences and incorporates them into the knowledge of old experiences, causing the individual to develop a new outlook and rethink misunderstandings. They then evaluate what was important which leads to an altered perception. Accommodation reframes the world and the new experiences into the mental capacity that is already present in the individual. Students who learn from teachers who use the constructivist learning theory to help frame their instructional strategies are challenged to become effective critical thinkers. These students develop the skills and confidence needed to
analyze the world around them, create solutions, justify their words and actions and encourage others to do the same while respecting their difference in opinions.

**Information Processing.** According to the research, information processing could be seen as a very weak form of constructivism. In the behaviorism theory, the mind acts as a computer, taking in information and actively processing data and then recalling whatever procedures, rules or routines that would accompany that data, then reorganizes, memorizes and retrieves any information needed to organize and process new information. Information processing also has similar attributes to this theory. It is sometimes referred back to the metaphor of “the mind being a computer”. Similar in some ways, information processing theory focuses on how human beings mentally manipulate the information they encounter. The two approaches direct the structure of a classroom environment in a certain way to promote effectiveness and efficiency of learning. But unlike behaviorism, information processing theory makes students aware of how they learn and how they can improve upon their classroom performance.

Behaviorism is commonly carried out in the form of direct instruction, or teacher-led instruction. The direct or teacher-led instruction model of instruction has several components in each lesson that are: 1) a very brief introductory; 2) a development portion in which the teacher tells the rules giving some examples; and 3) transition to the period of individual seatwork. Increasing amounts of evidence show that this form of instruction may not provide the adequate base for a students’ cognitive development of skills (Doyle, Sanford, & Emmer, 1983).

According to the research literature, information processing does not count as a
constructivist theory, but it is close to one. There are two principles that have been used to determine if the theory is a form of constructivism. They were designed by psychologist, von Glasersfeld. The first principle states that knowledge is not passively received but actively built up. If this is the case, it meets the first principle to some degree. It does however fall short of the second principle. Principle number two states that, “the function of cognition is adaptive and serves the organization of the experiential world, not the discovery of ontological reality” (von Glasersfeld, 1989, p. 182). As well as falling short to meeting von Glasersfeld’s principles, Mayer argues that cognitive processes must be recursive and built up in order to build and process new information. In looking at the information process theory metaphorically, the computer as the mind, is only processing objective knowledge at a basic level. This is where teachers expect student to memorize, recall and recite facts and rules, but no real learning is taking place. According to Mayer, information processing can be defined as nothing more than “the study of how humans process information, and includes the acquisition, storage and retrieval of knowledge” (Mayer, 1982, p. 3).

**Individual Constructivism.** Individual constructivism is a theory that proposes that knowledge is constructed by the individual on the basis of its cognitive processes interpreting the experiences he/she encounters (Steffe, Neshern Cobb, Goldin, & Greer, 1996). It comes from a biological or nature perspective. In believing that knowledge is actively built through a persons’ own experiences, having access to reality does not exist. All knowledge is constructed. Students must use their prior knowledge that was constructed through personal experiences, build upon it and create a new knowledge to
continue to build on and scaffold information. No two people have the exact same knowledge, as no one has had the same experiences in life as another person. This is why it is important to learn through experience, provide our students with opportunities to build their knowledge through experience and allow our students to use their prior knowledge to construct new knowledge.

Piaget tells us that learning is an active process. Students construct their own knowledge on an individual level acquiring it from exploration of new experiences and adding it to their existing knowledge base. Knowledge is not acquired from the teacher. Piaget believed that knowledge is categorized into schemes. A scheme is an organized group of similar actions that are or thoughts that are used repeatedly in response to the environment (Georgia State University, 2014). He believed that we learned as a result of assimilation and accommodation which both build upon schemes. Assimilation uses existing schemes to interpret new events while accommodation modifies the existing scheme. When children interpret new events with their existing schemes, it is called a state of equilibrium. Disequilibrium occurs when they encounter a situation that they cannot fit into their scheme or current knowledge base. For example, you see an animal that walks like a duck and sounds like a duck, but it has furry hair. This is not what you have come to associate with a duck’s characteristics.

Social Constructivism. Social constructivism differs from individual constructivism in that learning is structured around peer interaction (Ernest, 1994). Learning and understanding takes place through conversation and language. Research related to social constructivism purports that communication plays a key role in a
students’ cognitive building skills. It is essential that a teacher teach concepts as a form of communication and assist students in structuring and restructuring views. A child may view a concept much differently than what an adult may view it as. This is because they base it on the experiences they have had as a child. They will make sense of it within the limited framework they possess. Another important part of constructivism is the reflective process. Math is built on human activity, example, counting, sorting, ordering etc., we must teach students to reflect on these processes, create a language for it and carry out the processes creating construct to build upon.

Vygotsky believed that adults could foster the cognitive growth of a child through challenging and meaningful activities. These activities required social interaction in order for maximum cognitive growth to occur. There were stages to this development. He called these stages the Zone of Proximal Development (ZPD). In the center of the circle lies, what a child can do, then what a child can’t do. The outer circle signified what a child can do, with help. Again, reinforcing the need for social interaction to occur to promote maximum growth. This theory is now what is becoming the backbone for mathematic reform. The following Table 2.1 (Steffe, Nesher, Cobb, Godin, & Greer, 1996) shows the metaphors for the constructivism in an attempt to visually show you the differences.

Problem based learning (PBL) is deeply connected to the constructivist theory of learning. PBL is built on the construction of experiences and communication among students and teacher, and students are not just given a set of instructions and rules to remember and recite. Instead PBL encourages reflection but rather reflection of ones’
Problem based learning (PBL) is deeply connected to the constructivist theory of learning. PBL is built on the construction of experiences and communication among students and teacher, and students are not just given a set of instructions and rules to remember and recite. Instead PBL encourages reflection but rather reflection of one’s own experiences and prior knowledge, with the guidance of communication. It is an organization of “ill-structured” problems that help students to develop critical thinking skills, problem solving and collaborative skills. PBL enhances a student’s capacity for creative and responsible real world problem solving (Preetha, Ashwin, Sprague, 2005).

**Teaching**

**Math practices.** The Professional Standards for Teaching (NCTM, 1991) states the need for changes in teaching and learning mathematics as noted in Table 2.2. Research literature on mathematics teaching suggests that the teacher’s role should include certain characteristics of a problem-based learning classroom. The teacher should act as a coach rather than a deliverer of information; facilitate the learning, and be the person who “orchestrates the oral and written discourse in ways that contribute to students
Table 2.2

<table>
<thead>
<tr>
<th>Shifts in Teaching</th>
<th>Toward</th>
<th>Away from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towards classroom as a mathematical</td>
<td>• Toward classroom as a mathematical</td>
<td>• Away from classrooms as simply a collection of individuals</td>
</tr>
<tr>
<td>community</td>
<td>community</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Toward logic and mathematical</td>
<td>• Away from the teacher as the sole authority for the right answers</td>
</tr>
<tr>
<td></td>
<td>evidence as verification</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Toward mathematical reasoning</td>
<td>• Away from merely memorizing procedures</td>
</tr>
<tr>
<td></td>
<td>• Toward conjecturing, inventing, and</td>
<td>• Away from an emphasis on mechanistic answer-finding</td>
</tr>
<tr>
<td></td>
<td>problem solving</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Toward connecting mathematics, it’s</td>
<td>• Away from treating mathematics as a body of isolated concepts and</td>
</tr>
<tr>
<td></td>
<td>ideas, and its applications</td>
<td>procedures.</td>
</tr>
</tbody>
</table>

understanding of mathematics” (Heaton, 2000, pg. 7).

In order to implement the change needed to move towards a more constructivist approach, the demands on the teacher are going to have to change as seen in Table 2.3. Learning to change for teachers may be difficult. For students to be intellectual learners, it is going to require more of the teachers’ time, commitment, and willingness to change or alter their instructional approach and methods. Not only is the instruction going to have to change within the classroom, the assessment will have to change as well. The line between instruction and assessment should be a blurred line. It should happen each
<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Increased Attention</th>
<th>Decreased Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>K - 4</td>
<td>• Use of manipulative materials</td>
<td>• Rote practice</td>
</tr>
<tr>
<td></td>
<td>• Discussion of mathematics</td>
<td>• Rote memorization of rules</td>
</tr>
<tr>
<td></td>
<td>• Questioning</td>
<td>• One answer, one method</td>
</tr>
<tr>
<td></td>
<td>• Justified thinking</td>
<td>• Use of worksheets</td>
</tr>
<tr>
<td></td>
<td>• Writing about mathematics</td>
<td>• Teaching as telling</td>
</tr>
<tr>
<td></td>
<td>• Problem solving approach to instruction</td>
<td>• Drilling on paper and pencil algorithms</td>
</tr>
<tr>
<td></td>
<td>• Content Integration</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Use of calculators and computers</td>
<td></td>
</tr>
<tr>
<td>5 – 8</td>
<td>• Actively involve students individually and in groups in exploring, conjecturing,</td>
<td>• Drilling on paper and pencil algorithms</td>
</tr>
<tr>
<td></td>
<td>analyzing, and applying math in both real and world contexts</td>
<td>• Teaching topics in isolation, stressing memorization</td>
</tr>
<tr>
<td></td>
<td>• Using appropriate technology and computation for exploration</td>
<td>• Being the dispenser of knowledge</td>
</tr>
<tr>
<td></td>
<td>• Using concrete materials</td>
<td>• Testing for the sole purpose of assigning grades</td>
</tr>
<tr>
<td></td>
<td>• Using concrete materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Being a facilitator of learning, assessing learning as an integral part of instruction</td>
<td></td>
</tr>
</tbody>
</table>

and every day and be an integral part of informing the instruction as you teach (Van de Walle, Lovin, 2006). Good assessment should allow each student in the class, no matter what instructional level, to demonstrate his or her understanding of the concept through the task at hand.

The literature suggests that tasks should not be designed to find out what the student does not know, rather, what they do know. This will allow teachers to guide the instruction in the right direction. Teachers will have to change the way they practice and abandon traditional roles. Teachers will need to be able to share doubts and thoughts with colleagues, reflect on the lesson, and experiment and accept uncertainty. This will take time, but will greatly benefit our students as well as our own view of teaching if we learn to teach in a student centered learning manner. These types of assessments should increase students’ awareness of how knowledgeable they are becoming on the topic or content. They will learn to assess themselves as well as self-monitoring skills.

The use of questioning, problem based instruction and manipulatives need to have an increased attention to them in the elementary grades. In the middle school grades, group exploration, technology and use of concrete materials needs to be present in order for implementation of the math reform to occur. A decrease in memorization, testing for the sole purpose of assigning grades, rote practice and one answer responses needs to occur.

Summary

The history of mathematics, its reasons for the need for reform, and the learning theories that are being supported in this movement have been the basis for the research by many. Vygotsky suggests that teachers need to be able to teach in a manner that supports
social interaction and critical thinking within our students. The constructivist approach is being widely adopted among curricula, but the full understanding of what that looks like in a classroom is still in the process. If teachers can transition from teacher led instruction to problem based learning, research suggests that a great change in how our students not only view mathematics, but how well they learn to apply it to the classroom and their lives will occur.

The following chapter begins with a description of the research question and what the research question seeks to answer. This will be followed by the research design and rational, including the data collection methods, instruments and tools, and procedures.
Chapter Three

Methodology

The purpose of this study was to investigate and analyze the differences in student learning when two different instructional practices are used in mathematics. One practice will use the problem based learning method and the style of the other practice will be teacher lecture followed by rote practice. Research has shown that students, who are taught using the problem-based learning method, understand and can apply that knowledge to other areas of life as well as mathematics, in a more meaningful way than that of rote memorization techniques. Problem-based Learning has a strong positive effect on a student’s skills. Deep conceptual understanding involves actively adapting and testing thoughts, ideas, concepts, and processes used within new math contexts. Research shows that long term change occurs when people are involved in shaping their learning experiences (Davis, Sumara & Luce-Kaplar, 2000, 2008).

This chapter will begin with a description of the participants and the setting in which the study took place. To ensure confidentiality for the participants, the researcher will provide a pseudonym or number that will be used for all names of participants and subsequent locations. The pseudonyms will be given in the participant section of this chapter. The section following that will include a description of the research design, methods, lessons, and tools used for the data collection, and analysis of the data in response to the following research question presented: What differences will exist in
student performance when taught using a mixed method approach of teacher led instruction and problem based learning versus just the teacher led instruction?

Setting

The study was conducted at Smith Elementary School, a Kindergarten-6th grade building, in the Rosewood School District. The district is located in an urban mid-western city with a population of about 60,000 people and surrounded by county schools on all sides. The district consists of one preschool, ten elementary schools, three middle schools and one high school. It has 100% highly qualified teachers as defined by the percentage of teachers meeting all state requirements for their teaching positions.

To my knowledge, there has been no other teacher in the district that has participated in a study investigating problem-based learning. The current math curriculum states that it is a problem based learning series, but shows little signs of that being the case. However, as of the end of the current school year, June 4, 2015, it was noticed that a drive from the administration of the building to promote this method of teaching had begun. For this study, two fifth grade classrooms were used. They are side by side in the building allowing for the sharing of information to be easily attained. The number of students in each of the fifth grade classrooms during the study ranged from 24-26 students. For the majority of the time, the average class size of both classrooms was 25 students. The study took place over a four-week period and consisted of 8 lessons.

One room was room number 25. It is on the second floor of the building towards the end of the hall. The desks are grouped into 5 groups of 5. From their desks, all students can very easily see the SmartBoard, as well as, the white board. The mathematic
manipulatives sit on a shelf along the back wall in two bins. The bulletin boards consist of interactive math activities relating to the math standards for fifth grade. These activities include geometry, measurement, factoring and conversions. The student workbooks that are part of the district adopted curriculum materials are stored on a desk in front of the factoring board.

The second classroom, room 27, is directly to the right as you exit room 25. The teacher has an area where the students can easily access math games and fact games. This area is located on a table close to the door. The student desks are set up in four rows facing the SmartBoard on the farthest wall from the door. The SmartBoard is an integral part of the publisher’s textbook lessons, and this teacher uses the SmartBoard to access the interactive lessons through the company’s website. The math lessons for both classes were implemented from about 11:00am to 12:30pm.

Participants

Two fifth grade teachers, one being the researcher, both acted as a full participants, and voluntarily participated in this study. The teacher participants ranged in experience from five years to eight years of teaching. The years that the teachers have been teaching in this district ranged from three years to seven years. The teacher participants have worked together in the 5th grade the past three years. This year was the first year that they did not teach in a self-contained setting. Participant descriptions, including teaching experience, degrees, and knowledge of problem based mathematics background can be viewed in Table 3.1. The pseudonyms, Pam, will be used for the non-researcher participant, and Ana will be used for the teacher-researcher participant. Both
Table 3.1

**Participant Descriptions Table**

<table>
<thead>
<tr>
<th>Teacher</th>
<th>Teaching Experience</th>
<th>Problem Based Learning Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pam</td>
<td>• 5 yrs. K-5</td>
<td>• My Math curriculum training</td>
</tr>
<tr>
<td></td>
<td>• BA in Early Childhood Educ.</td>
<td>• Participated in a study to gain insight into the best practices suited for teaching the Common Core State Standards.</td>
</tr>
<tr>
<td></td>
<td>• Generalist 4-5 endorsement</td>
<td></td>
</tr>
<tr>
<td>Ana</td>
<td>• 8 yr. experience teaching – K-5 incl. k-1 readiness and after school program - Eagle and Dove for 2nd gr.</td>
<td>• Participated in lesson studies at the University and thesis on Problem Based Learning.</td>
</tr>
<tr>
<td></td>
<td>• AA degree in Early Childhood Education</td>
<td>• My Math curriculum training</td>
</tr>
<tr>
<td></td>
<td>• BA in Elementary Education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Generalist 4-5 endorsement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Master’s degree in progress</td>
<td></td>
</tr>
</tbody>
</table>

The researcher and the participant teacher have had training on the district adopted publisher curriculum series that proclaims to be problem based. However, this training was more of an introduction to the series and its components than more a training over problem-based learning.
At the start of the study, there were 48 fifth grade students who participated in the research. Four students not included in that number, did not return permission slips. During the duration of the study, Pam had one girl out of the district and one boy move into it. Ana also had one boy move out of the district and one girl move into it. The students that participated in the study for the complete length of time was forty-eight and are represented in the data presented in Chapter Four. Pam’s class consisted of 12 boys and 12 girls at the completion of the study and Ana’s class had 15 boys and nine girls at the completion of the study. Eight of the students are on an IEP and one of the students is an English Second Language student. There were four female students on IEP’s in Pam’s class and three students in Ana’s class. Of those three students, two were boys. One hundred percent of the participants are on a free and reduced lunch in our building. Of the participating students, 16 of them are female and 34 of them are male students.

**Role of participating teacher and teacher-researcher**

In order to analyze the teachers’ thoughts and get an overview regarding how the students felt about math, the teacher-participant would write down notes during the week related to student comments and her thoughts about the lessons being taught. The teacher-researcher would meet with participating teacher during teacher based team (TBT) time and discuss any thoughts she had or any student thoughts that she overheard while teaching the lessons. Sample lessons for both the teacher participant and the teacher researcher can be found in appendix A. The participating teacher’s role was to take notes and meet with the researcher weekly to discuss those notes. She was to administer the survey and pre-/post-tests, as well as teach the math content in the manner
that was ordinary and usual for her. The researcher’s role in the study was to participate
in all participant activities, and facilitate activities within the class. The researcher would
facilitate TBT meetings and design all tools to be used during the study.

**Intervention**

The typical structure of a problem based learning lesson had only a few
components. Lessons were only taught using this format in the researcher’s classroom as
the second teacher, Pam, taught the control class. Students were given a small task at the
beginning of the lesson, and were asked to work on it in their table groups. The task
would relate to the same concepts that could be found in the adopted textbook lesson that
was to be taught that day according to the district pacing guide. For example, if the
lesson focused on adding two factions with common denominators, then the task would
relate to the addition of fractions with common denominators. The teacher-researcher
would act as a facilitator who could be described as one who leads the class discussion or
small groups in an inquiry based discussion when necessary. The teacher-researcher
would also walk around the room from group to group and encourage discussion as the
students talked about different ways to explore the task. The facilitator would
occasionally remind the students of their prior knowledge constructed in previous lessons
if they seemed to be at a standstill. These tasks would be realistic offering the possibility
of multiple solution methods. An example of a problem would be:

Tim added $\frac{3}{6}$ and $\frac{1}{2}$ and wrote an answer of $\frac{4}{12}$. Is Tim’s solution correct?

Explain why or why not using pictures, numbers or words.

Lessons of this type are considered student centered when students are left to their own
devices to find a solution strategy. After allowing the students to work on the problem for approximately 30 minutes or whenever most groups appeared to have a solution, each group would present the details of their strategy and their solution. After all solution strategies were discussed and conversations were held among the class as a whole, the students would solve the problems in the publisher’s workbook related to the lesson. At the end of the page, there was one question that claimed to be a problem based question, it was called a “HOT TOPIC”, and the students were required to solve this question.

Control group instruction.

In the control class, the lesson was taught strictly using the publisher’s curriculum and directions for instruction. The teacher would present the how to use a procedure and the students would follow along in their practice books. For example, if the lesson’s goal was to add fractions with common denominators, the teacher would model the procedures for completing the addition of two fractions with like denominators, while telling the steps required to complete the addition problem. Then the teacher would do a guided lesson problem with the students, and after she saw that they were finished with that, she would allow them to work on the “independent practice” pages. She would then collect the independent practice pages and grade them. The students were not required however to do the “Hot Topic” question/s. If they attempted them and got the problem right, they were given extra credit for the correct answer. The method students used to solve the problem was not important, as it was assumed that they would apply the rote method that they had just learned in the lesson, as the method they would use to find the answer.

Research Rationale and Methods Design
The purpose of this study was to examine and study the differences in student learning when two different instructional practices were used in mathematics. The research used a mixed methods experimental design. This mixed methods study utilized both qualitative and quantitative analysis of the data. It was experimental because, one class was using the intervention of problem-based learning while the other continued to follow the structure and design of the published curriculum materials., the ordinary math was taught in the classroom. In order to examine the differences in the class’s scores, as well as the way students thought about mathematics and any correlation between the two areas several tools were used to collect the quantitative and qualitative data. “The combination of both types of data tends to provide a better understanding of a research problem than one type of data in isolation” (Mertler, 2012, p.13). Tashakkori & Eddie (2003) suggest that when using data from both quantitative and qualitative methods, it provides a much clearer look at the changes that took place during the study. The use of qualitative data provides rich descriptions of the instruction, student thinking, and student dispositions, while the quantitative will provide a statistical analysis for the comparison of the two different instructional styles.

Data Collection

A variety of instruments and tools were utilized to measure, analyze, and describe changes in students understanding of the content as well as attitudes towards the construction of new knowledge to be applied to future mathematics content. Data collection consisted of three primary sources: a pre-/post-test, a disposition survey, and teacher notes or journal. By using the mixed methods and multiple data sources, teacher-
researcher was able to provide a greater, more holistic way to examine any change in
disposition towards mathematics, as well as look for positive growth in understanding the
content, and notice any consistency as well as inconsistencies in the patterns that emerged.

**Pre-/Post-tests.** The pre-/post-testing instrument was used to record two types of questions. Each teacher gave the tests to classes A and B. They were given on the same day, both before the unit and after the unit. No assistance to the students was given during the testing period. The teacher-researcher scored both tests from both classes in order to eliminate the possibility of scoring differences, especially on the problem solving questions that were scored using a rubric. The test was comprised of two different types of questions. The first type of question was the systematic rote questions. These were the questions where the student could memorize a method, equation, or use factual information to answer the problem. This type of question relies on the process of recall. Teaching rote methods for quick recall has historically been the strategy used to teach mathematics. This type of question allows students to demonstrate their ability to memorize the rules and procedures, compute problems and check their answers with the teacher’s guide. In rote mathematics, there is no real rational reasoning in the communication of knowledge. It is simply a question of “can you do this”? An example of this type of problem would be to ask a student to multiple 2/3 times 3/4.

Research by Smith and Stein (1998), suggests that tasks are set up in ways that engage students in different cognitive levels of thinking. These tasks can range from lower levels to higher levels of cognition being demanded of the student in order to
complete the task. The nature of the tasks to which the students are exposed determines what the student learns (NCTM, 1991). Reproducing facts, rules and formulas as present in the above example, are considered lower level cognition demand tasks. There are 15 questions of this type on the pre-/post-test, and each question is worth one point when answered correctly. This part of the test was taken directly from the published mathematics curriculum materials that are currently being used within the school district (see Appendix B).

The second part of the pre-/post-test consisted of four multi-step problem-based questions to be solved by the students. Questions of this type foster thinking instead of memorization. Smith and Stein (1998) state that tasks of this design are cognitively demanding tasks. They have characteristics of higher-level cognition demands because they require students to explore and understand the concept and its processes, and to use reasoning, representation, and/or communication in the solving of the task. Research indicates that problem-based learning needs to be a constant interplay of teacher, student, and subject matter (Hawkins, 1974).

The multi-step problems were weighted using points. In determining the weighted value of these particular questions, the researcher turned to the way similar questions had been scored on previous editions of the state’s end of year mathematics tests, and a format similar to what was anticipated to be on the new state end of year test. The questions were written and/or selected from resources available to the researcher. The rubric that was followed in grading these questions was as follows: the first two questions were each worth 2 points (see Appendix B). The earned score consisted of one
point for showing student thinking and one point for the correct answer. The next task consisted of three parts: a, b, and c, which all were worth three points each. This totaled 9 points for the task. This question was used in an everyday situation format that a student could relate to and see the significance of the knowledge required to answer the question. For each part, a point was given for the diagram or picture provided, a correct equation showing understanding of the diagram or picture and a correct answer (see Appendix B). The final problem-based question was worth 2 points. The task required the student to find a correct answer and provide proof of their rational (see Appendix B). The same pre-test and post-test were given at the beginning and end of the study.

Disposition Survey. Martha Tapia (1996) designed a research study using a disposition survey that consisted of 40 questions (see Appendix C). The questions were randomly placed on the survey but each question related to one of four categories. The survey designed by Tapia (1996), was to be an instrument used to measure student’s attitudes towards mathematics. This survey has revealed sound results and proven to be a true method of measuring a student’s attitude towards the subject of math. The survey was given before and after the unit in order to look for changes in attitudes.

Tapia’s (1996) survey was originally separated into six variables/factors. They were value, anxiety, motivation, confidence, enjoyment and adults’ perspectives. The survey was constructed to use a Likert scale for the responses. There were five possible alternatives for the responses. They were strongly disagree, disagree, neutral/no opinion, agree and strongly agree. The responses were weighted giving strongly disagree a 1, and disagree a 2 and so forth. Out of the 49 items, 12 of them were reversed responses and
were given the appropriate weighted grade. After studying the validity of each question during pilot testing, the survey was shortened to 40 questions. The author also decided to change the scale used in the survey. Instead of having 5 categories ranging from strongly disagree to strongly agree, she decided to drop the category of neutral. In doing this, the categories were scored from one to four, giving one to strongly disagree. The six categories were also condensed into four categories. The two categories that were dropped pertained to adult perspectives and were not relevant to the structure of the survey.

For the purpose of this study, four categories were established. Table 3.2, Attitudes towards Mathematics Instrument (Tapia, p. 3, 1996), shows the categories analyzed: sense of security, value, motivation, and enjoyment. The survey was scored with the use of the Likert scale of one to four with four, designating strongly agree and one designating strongly disagree.

Individual student scores for each category were totaled. The mean of each category for each class was then determined. A comparison of means for boys to boys and girls to girls was completed and followed by comparison of the two classes.

The author only provided example questions that were categorically placed as seen in Table 3.2. The researcher used this as a guide to assign each statement/question to a category from the four named by Tapia (1996). A student’s sense of security measures the anxiety and confidence of a student when dealing with mathematics. Value measures how important a student considers math to be in the everyday life. Motivation refers to the students desire to go above and beyond when working with math. Studies
Table 3.2

<table>
<thead>
<tr>
<th>Category</th>
<th># of items</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense of Security</td>
<td>15</td>
<td>• Math makes me feel uncomfortable.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I have a lot of self-confidence when it comes to math.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Math is a worthwhile and necessary subject.</td>
</tr>
<tr>
<td>Value</td>
<td>8</td>
<td>• I believe studying math helps me.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I am willing to take more than the required amount of mathematics.</td>
</tr>
<tr>
<td>Motivation</td>
<td>9</td>
<td>• The challenge of math appeals to me.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• I get a great deal of satisfaction out of solving math problems.</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>8</td>
<td>• I like to solve new problems in mathematics.</td>
</tr>
</tbody>
</table>

have shown that math anxiety is directly linked to previous class experiences with the subject as well as past math performances (Hauge, 1991). The last category was enjoyment of mathematics. This category is based on the level of satisfaction a student encounters when working with mathematics. Positive attitudes in math have been found
to be adversely related to a student’s math anxiety and negative attitudes develop as students grow older (Terwilliger & Titus, 1995).

The purpose for the survey was to determine if any change occurred in the students’ attitude toward mathematics after the mixed method instructional strategy of problem based learning and rote memorization had been implemented.

Teacher Journal and Questionnaire Responses. Teachers from both classes, kept notes/journals about the lessons and their reflections on the lessons and student learning. Comments that were significant to the study were also included, such as ideas thoughts about specific lessons. The teacher from the control class was to document any deviation from the lesson that occurred. This was to help note any changes in the study that might occur if the control classroom teacher would not strictly teach from the published math curriculum lesson.

The questionnaire consisted of four questions about the subject of mathematics. The questions were a chance for randomly chosen students to elaborate on their thoughts towards the subject/question being posed in the interview. Students were chosen through a random drawing of student names. The questionnaire was given to the student and he/she completed it at their seats (see Appendix D). In doing this, a more honest opinion from the students was obtained. This was done at the end of the unit. The questions were as follows:

3. What could a teacher do to help you learn math more easily? Please explain the
teaching methods that help to make math easier for you to learn.


**Analysis**

The data collected from the four instruments was recorded and analyzed. Both teachers looked for common themes in the data and reported why those themes had occurred. They looked for any outliers and indicate why those students may have different thoughts than the others in the study. The teacher researcher examined the differences in scores as well as attitudes and looked for any changes that might be significant to the study and report as to why those changes may have occurred. Then the teacher researcher indicated the significance of these changes.

**Establishing Rigor and Trustworthiness**

The mixed methods design and use of multiple data sources provided the opportunity to document any changes in attitudes towards mathematics as well as changes in understanding in students’ conceptions of math. The use of the disposition survey, journals/interview, and pre-/posttests provided a deeper examination of the changes that occurred during and after the research lessons took place. The triangulation of the sources used in this study, provided reliability of the results. To ensure trustworthiness and rigor, the survey used in this study was adopted from a research-based study of attitudes and dispositions toward mathematics (Tapia, 1996). The pre-/post-test was developed by a published curriculum series, as well as the task based questions from published materials related to the Common Core State Standards (Illustrative Mathematics, 2014).
Summary

For this study, a mixed methods research design was presented and used to analyze and understand the changes in data that would take place among the participants in each class setting. Quantitative as well as qualitative measures were used in this research design. Examination of each instrument and the procedures used in the research were closely done. Triangulation of instruments as well as data would provide a better understanding of the changes that had occurred in the process. In Chapter 4, the analysis of the finding will be discussed. After reporting the findings of the pre-post-test, interview responses, survey responses, and teacher notes, comparisons of the groups will be discussed. Results would then be summarized with an overall discussion of any changes that might have occurred among the participants regarding mathematics.
Chapter Four

Results

This study investigated what differences would exist in student performance within a given classroom, when the students were taught using two different instructional approaches. The approaches consisted of teacher led instruction versus a combination of teacher led instruction and problem based learning. This study was implemented with the aide of three different instructional instruments. The participants were two different fifth grade classes, the teacher researcher and one other fifth grade teacher. The main focus of the study was to look for change in student performance using the problem-based learning approach.

Pre and post-tests were given to the students before and after the study in order to investigate any changes that occurred in performance. A disposition survey was given before the study to examine student attitudes related to mathematics in four different categories: value, motivation, sense of security, and enjoyment. Survey questions can be reviewed in the Appendix E. Pseudonyms were used for the teachers, as well as school and district, in order to maintain confidentiality of participants. Teacher notes in journals were used to guide the discussion between the teachers, as well as look for changes in student views about mathematics and the two different methods being used to teach the content. The quantitative as well as qualitative data were used to compare, analyze and identify any changes over the course of the study.
The sections that follow provide data results from the various instruments used in the study. First, the results of the pre- and post-test will be identified and compared. Second, the responses from the participants on the disposition survey will be averaged and documented. Third, the interview responses from random students will be presented. Last, any themes or differences that emerged from the teacher notes/journals will be documented.

**Pre-/Posttest Results**

There were two categories of questions on the pre-and post-tests to be analyzed. The same test was used for the pre-test as for the post-test. The test consisted of fifteen rote or formula based questions that constituted the first category, and three problem-based questions, each requiring multiple steps, which constituted category two. The first two problems, in the second category, required two steps while the last problem was had three parts. Each of those three parts had three steps. Thus, category one had 15 points possible and category two had 13 points possible for a total number possible of 28 points. Table 4.1 shows the results of Pam’s class on the pre- and post-test, displayed using the mean scores. The chart shows the comparison of girls to boys in Pam’s class, as well as how well the students performed as a class.

**Control class.** The pre-test data for Pam’s control class, (see Table 4.1) reveals that average number of rote questions that the boys answered correctly was 2.54 out of 15 questions. The average number of problem-based questions that the boys answered correctly out of 13 was 0.8, or less than one. For the post-test, there was a slight increase in both areas. The boys mean scores for the rote questions were 6.33 and 3.53 problem-
based questions out of 13.

Table 4.1

Pre-and Post-Test Data for Pam’s Class

<table>
<thead>
<tr>
<th></th>
<th>Rote - Mean</th>
<th>Problem based -Mean</th>
<th>Total - Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Boys</td>
<td>2.54</td>
<td>6.33</td>
<td>0.80</td>
</tr>
<tr>
<td>Girls</td>
<td>2.38</td>
<td>6.15</td>
<td>0.54</td>
</tr>
<tr>
<td>Total</td>
<td>2.46</td>
<td>6.24</td>
<td>0.67</td>
</tr>
</tbody>
</table>

The girls’ pre-test data showed that they had a mean number of correctly answered rote questions of 2.38 out of 15 and 0.54 out of 13 problem-based questions. The post-test data showed the girls scoring 6.15 out of 15 on the rote section and 2.31 on the problem-based section. These scores were slightly lower than the boys. The whole class comparison for the entire test showed that the mean score increased by 5.63 points. The average increase in the total number of points received out of 28 increased from 3.17 to 8.80. If the data is viewed in percentages, the class average test score for the boys rose from approximately 12% to 35%; and from 10% to 30% for the girls; and 11% to 31% for the entire class.

In looking at the difference of the mean scores between the rote and problem based for both genders, there is a slight drop in the scores when comparing pre-tests, although the data does show us that the scores had a slight increase from pre-to post-test in all areas.

**Experimental Class.** Table 4.2 provides the data recorded for Ana’s pre and
post-tests. Ana’s class was the experimental mixed methods approach classroom.

Table 4.2

*Pre- and Post-test Data for Ana’s Class*

<table>
<thead>
<tr>
<th></th>
<th>Rote – Mean</th>
<th>Problem-based – Mean</th>
<th>Total – Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Pre</td>
</tr>
<tr>
<td>Boys</td>
<td>3.93</td>
<td>8.37</td>
<td>0.27</td>
</tr>
<tr>
<td>Girls</td>
<td>4.37</td>
<td>9.37</td>
<td>0.74</td>
</tr>
<tr>
<td>Total</td>
<td>4.08</td>
<td>8.70</td>
<td>0.51</td>
</tr>
</tbody>
</table>

This table shows the differences in both female and male student preliminary scores as well as providing an overall percentage to the whole class. The pre-/test was given to fifteen boys and eight girls at the start of the study, and 15 boys and nine girls at the conclusion of the study.

For the rote questions of the pre-test, the boys had a mean score of 3.93. This means that each boy scored an average of 3.93 questions correctly out of 15. The pre-test mean score was 0.27 for the problem-based questions. This indicates that on average, the boys did not earn one point out of 13 possible points on the problem-based questions on the pre-test. For the post-test, there was an increase in the scores. The mean score for rote questions was 8.37 correctly answered questions out of 15 and 4.39 problem-based questions out of 13 correct.

The girls had a mean score of 4.37 correctly answered rote questions out of 15 on the pre-test. For the problem-based questions, they scored on average 0.74 out of 13 questions answered correctly. The data shows that there was an increase in mean scores.
between the pre- and post-test. The mean rote scores on the post-test was 9.37 correctly answered questions out of 15, and 5.87 out of 13 problem-based questions. The whole class comparison for the entire test showed that the mean score increased by 9.43 points. The average class score jumped from 4.59 to 13.94 correctly answered questions. This showed an average increase of 9.35 points and 3.72 points more than the student average increase in the control class.

If the data is viewed in percentages, the class average test score for the boys rose from approximately 15% to 46%; and from 18% to 54% for the girls; and 16% to 50% for the entire class. This data revealed a greater overall gain for girls when compared to the boys’ gain. The girls in the control group did not make a greater gain than the boys. When comparing total gains in the two groups using test score percentages, the increase in the control group was 20%, however the increase in the experimental group was 35%. Comparatively, this is a significant difference.

Administering an identical test as a pre-post-assessment was done to measure the exact learning that took place during the course of the study and to find an accurate measurement of how well the students built upon their previous knowledge. The data for both tests was recorded in the same way, and analyzed using the same statistical methods. Individual student responses were transferred to a spreadsheet to document the exact question each student missed and the number of points each question was worth. It gave an accurate representation of growth and areas for future improvement as presented in the above tables. The results show that both classes are similar in the gains made when viewing the rote type of problems, however, the difference lies in the gains student made
when viewing the problem-based questions and total test score gains.

The scores were calculated taking into account the students who moved in and out of the district. Those scores were included in the data. The classes were viewed as similar in the distribution of that student population. A factor that must be mentioned when using the same pre- and post-test, is that students have seen the question previously and that could skew the results. In this study, the students did take the same test, however, the students did not see the results of the pre-test or the post-test, and this might lessen the impact of repeated testing.

**Disposition Survey Results**

**Class Comparisons.** The survey (Tapia, 1996), was given to the students at the start of the study. It was organized into the four categories of security, value, motivation and enjoyment. Using a point scale, the data of each category was organized into the areas of strongly disagree, slightly disagree, slightly agree, and strongly agree. By finding the mean of each category, the data provide information about each. There were 15 statements in the area of sense of security. Sample statements in this area would be; 1) Math makes me feel uncomfortable. 2) I have low self-confidence when it comes to mathematics. The category of value had eight statements. Samples of those statements would be; 1) Math is a necessary and worthwhile subject. 2) I believe studying math helps me. Motivation had nine statements to be evaluated by the students. Samples of those statements would be; 1) The challenge of math appeals to me; 2) I am willing to take more than the required amount of mathematics. The last category of enjoyment had eight items on the survey. Samples of those items were; 1) I get a great deal of
satisfaction out of mathematics. 2) I like to solve new math problems. The ratings in the categories of value and motivation are almost equal for both classes while security and enjoyment tend to drop a small amount in the experimental class. The control class had very similar results but rated enjoyment slightly higher.

The post data for Ana’s class shows a few differences than that of Pam’s class. All statistics tend to remain the same, but Ana’s class had a higher score for security on the post survey than Pam’s did. The other difference was that of enjoyment. Ana’s class rated enjoyment higher while Pam’s class dropped from the previous survey (Table 4.3).

Table 4.3

<table>
<thead>
<tr>
<th>Categories</th>
<th>Pam Pre</th>
<th>Pam Post</th>
<th>Ana Pre</th>
<th>Ana Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment</td>
<td>69.74%</td>
<td>68.88%</td>
<td>59.38%</td>
<td>71.18%</td>
</tr>
<tr>
<td>Security</td>
<td>57.41%</td>
<td>57.91%</td>
<td>56.35%</td>
<td>64.22%</td>
</tr>
<tr>
<td>Motivation</td>
<td>72.46%</td>
<td>72.36%</td>
<td>69.57%</td>
<td>69.62%</td>
</tr>
<tr>
<td>Value</td>
<td>75.12%</td>
<td>76.84%</td>
<td>72.67%</td>
<td>79.17%</td>
</tr>
</tbody>
</table>

**Gender Comparisons.** A comparison was done by combining both genders of each class and doing a gender comparison as a whole. This was done to get an accurate view of how females feel about math versus how males perceive math concepts as a whole. Research shows that the two different genders have conflicting feelings about mathematics and that it affects the performance of students as well.

The data shows that the average of the girls’ survey scores places the highest score in the
area of value. The next highest falls to motivation in both classes.

The combined boys’ data reveals that value is placed as the highest score with enjoyment and motivation running a close second. Security in mathematics among the boys rates the lowest. In comparison to the girls, the boys scored all areas lower except the value of math. Although, even scoring those lower, the data shows that the girls score is close to the boys, only one tenth of a decimal away from their score.

**Questionnaire**

This tool was used after the chapter was completed. Students were randomly chosen to complete the questionnaire by selecting numbers out of a hat. The questions were designed to get an insight on the students’ feelings towards mathematics. These feelings were very much aligned to the survey in that they gauged the students value placed on math, motivation and feelings in general. The data collected gave an insight into the students’ enjoyment and security level. Four questions were asked to the students. From these four questions, common responses occurred. The responses that were given, related back to the disposition survey. The responses were also split in the answers based upon which setting the students belonged to for math (Appendix E).

**Feelings about mathematics.** The control class gave very general answers for number one, surrounding the theme of memorization. They responded with very basic responses such as, “I feel like math is easy because we learn to multiply fractions”. Where the experimental class gave a more in depth response such as, “math is important to me because it is an everyday part of life.”

**Feelings about procedures.** The control class responded with answers in regards
to how many days they go to school, helping them with mathematics to location of where they are taught to the asking the teacher to slow down. The experimental class gave very different responses. These responses ranged from the use of manipulatives, breaking down problems on their own, working in groups and being able to take their time.

**Feelings about instruction.** The control group felt that teachers could help them understand concepts of math more by explaining everything. They also felt that the teacher should take a slower pace, more math related activities they would use in real life, while others said that there is nothing a teacher can do to help. The experimental class had much different thoughts about the instruction in the classroom. They felt that they would learn best if teachers would always teach using a whole group approach. They also felt that they learn best when seeing the different ways to solve problems from others. In regards to explaining different ways of doing the math, some of the students said that they learn best by explaining how they arrived at certain answers.

**Excitement in mathematics.** The responses to this question were similar to the responses given about the feelings about instruction. The control group gave responses relating to basic math concepts and procedures such as, “Multiplication excites me”. In contrast to that, the other class responded with comments regarding the way in which they were taught. These were responses such as “being able to solve problems using more than one way”.

Four basic questions were asked and four very different responses were given to each question. The students responses were directly relate to the class setting and methodology in which they were taught.
Teacher Notes/Journal

Teacher notes were kept in a journal. The comments were important to comparing and analyzing how the students felt about the method in which they were taught mathematics. The teachers were able to find common themes that may have emerged either within the same setting or across the two different settings. These notes were discussed in the teacher-based team (TBT) meetings, or teacher plan time each week. Pam noticed that her class never really asked in depth questions about the problems. The questions were typically about the procedural process of finding an answer.

They also rarely tried the challenge question, which was typically the problem based question. They would ask if they had to attempt it and upon being told no, they would not do so. Many times they would ask to be shown steps to a problem over and over and would come back to the table for small group instruction which was very much teacher led. In Ana’s class, comments were somewhat different. Students showed signs of excitement about learning and couldn’t wait to see what the next challenge would be.

Some of the students who struggled with certain mathematic concepts, wanted to be given the problem through procedural methods, but most of the time, they enjoyed trying to solve on their own. At first students, had disagreements about solving them in different ways and felt that their way was the only correct method of doing this. After a few days, they very quickly saw that there were multiple methods to solve problems. They also began to become very eager to show me different ways to come up with answers to problems that they once felt was a one way only problem, such as six times.
six. What was once a rote problem, quickly became much more. The notes shared by both teachers were very simplistic as to be careful not to change the methods of teaching or influence them in any way. This was to keep the classroom instruction on target to the research.

**Summary**

Teachers entered the study wanting to know what differences would exist in the changes in performances of the students using the two different types of teaching methods. Analysis was conducted using four different types of tools. The disposition survey revealed the students attitudes towards the four different areas in regards to mathematics. The pre-/post tests were administered to monitor any change in understanding after the chapter. They were also used to look for growth during the study. The questionnaire was given to the students to look for insight into their thoughts about math and the methods used to teach them the materials. Last, the teacher notes were recorded and discussed in order to look for any changes in our instruction and revealed student thinking as the research continued. The triangulation of the different tools helped in the analysis of the study. Chapter five includes a discussion of the results, any changes that took place and the conclusions to be drawn from these results and changes. It will also include limitations that may have impacted the study, recommendations for future research and the significance of the study.
Chapter Five

Discussions and Conclusions

The primary purpose of this study was to investigate what differences would exist in student performance within a given classroom, when the students were taught using two different instructional approaches. The two approaches that were used were teacher led instruction and a mixed method with teacher led instruction and problem based learning. Research indicates that allowing a student to learn through tasks with a teacher who acts as a facilitator, provides the opportunity for a student to develop understanding (Hiebert, 1997). The research study was grounded in the constructivist theory of learning, which is heavily influenced by the work of Piaget and Vygotsky. Constructivism suggests that all knowledge is constructed and actively built upon through experiences and communication plays a key role in a students’ cognitive building process. The researcher-teacher worked to establish the validity and reliability of this study.

This study used four tools or instruments to collect the quantitative and qualitative data in order to examine the differences or changes that would occur throughout the research investigation. First, pre-/post-tests were used to obtain baseline data of the students’ prior knowledge and to look for any relevant changes that occurred by the end of the study. They were also used to compare the results of two classes using different
instructional methods. Data of the whole class, as well as data of students by gender were analyzed for comparative similarities and differences.

Second, data was analyzed from a survey that was used to determine the students’ perspectives and attitudes towards mathematics. This was analyzed by classes as well as doing a comparison of responses across genders. Third, qualitative data was recorded through the use of a questionnaire given to the students. This questionnaire was used to have students elaborate on their ideas surrounding the importance of mathematics and thoughts about the problem based method. It was also helpful in identifying any common themes between the responses given by the students who participated in the questionnaire.

Last, teacher notes/journal entries were used to identify teacher perspectives on the study and analyze student comments and changes in student behavior that occurred during the research. The following sections will discuss these changes and other valuable information gained from this research study that sought to answer the following research question:

What differences will exist in student performance within a given classroom, when the students were taught using two different instructional approaches?

Discussion of Pre-/Post Tests

Pre-test result analysis. Results from the pre-test analysis indicated several things. In a comparison of the total girls and the total boys, and it was recognized that the girls scored higher overall in the problem-based portion of the assessment. It is thought that this most likely occurred because girls tend to perform better than boys when
verbally expressing their thinking. Research has shown that males and females do equally well in basic math knowledge, but girls have better computational skills and can verbally express their understanding of logical relationships better than their male counterparts (Zembar, 2009). Overall, Ana’s class scored higher than Pam’s on the pre-test, however, the scores were very close. Research indicates that males and females do equally well in basic math knowledge and girls have better computational skills (Zembar, 2009).

The data collected concurs with this research. Rote scores were much higher than that of the problem-based questions and this could be because the students had not been exposed to many problem-based tasks or to the teaching strategy that used the mixed method approach in previous school years. The procedural questions did not require students to show connections with conceptual understanding of the mathematics, but only to follow specific steps or the manipulation of numbers to find the correct answer. The teacher did not ask for and thus, did not know whether the student understood why those steps were taken and how to apply them to other situations, such as the problem-based questions.

Post-/test result analysis. Many gains were seen within the control class and the experimental class, but big differences did arise when looking at the data. Overall, Pam’s class did very well, but did not show the gains that Ana’s class did.

Ana’s whole class scores showed a greater increase than that of Pam’s whole scores in the problem-based question part of the assessment. This portion of the assessment required students to use multiple skills such as reasoning, representations, and
communication. According to Smith and Stein (1998) these problems would be classified as higher order thinking skills that have a high cognitive demand. Ana’s class did better in this area because they practiced problem solving through the tasks that were presented to them during the lessons. They learned to show connections with the conceptual understanding of the mathematics. The same statistics hold true for gender comparisons between the classes. Ana’s class scored higher overall.

Where the rote questions pertained, data shows that both participating classrooms stayed about even in their comparison, showing growth by both classes. According to Smith and Stein, 1998), this data tells us that both classes were able to meet their lower level of cognitive demands. The procedural questions on the test would have a low cognitive demand that includes learning through memorization and constructing procedural knowledge without connections to the mathematics, just a rote series of steps to follow. The data suggests that this occurred because problem based learning and learning to be a critical thinker also increases procedural knowledge. Using the problem-based method, Ana’s class was able to increase their level of conceptual understanding in both rote and problem-based questions. The traditional method of direct instruction, as present in Pam’s class, did not connect the students to real world contexts that promote deep conceptual understandings (National Research Council, 2005). Again, the same held true for the comparison of genders from class to class. The data suggests that these results occurred because students learn to think more critically and build upon their prior knowledge successfully when taught using the mixed method approach rather than the teacher-led instruction. It also suggests that students only learn to solve problems
through solving them themselves in the classroom.

The research data provided in reference to the problem-based learning, that great gains were made in Ana’s class. Higher level of understanding of mathematical concepts was present. The tests presented us with multiple ways of solving the problems and required students to us prior knowledge to build upon their cognitive skills. Although students made similar gains in both classes on the procedural only questions, Ana’s class made more gains on the problem solving questions. Student learning is enhanced when a mixed method of instruction is used, specifically learning procedures through problem-based learning, followed by practicing using both problem-based questions and procedural only questions.

**Disposition Survey Data Analysis**

The research literature in mathematics education has shown that there is a direct correlation between attitudes in mathematics and performance (Tapia, 1996). The survey was given to the students to see if there was a relationship between student attitudes and the instructional strategies used by teachers today. It is the teachers’ responsibility to find the underlying reasons for poor dispositional attitudes in math among students and look for the ways to replace it with excitement and motivation. The job market and economy continue to grow in its need for people with a desire to work in the math field. The individuals who take jobs in this field need to display good attitudes towards math because attitudes influence the persistence of wanting to continue to work in that field of study. These attitudes begin with students in school and experiences they have with the subject of math. The survey was given to see if a change in teaching methods would also
change students’ attitudes about the value of mathematics, sense of security in mathematics, motivation in mathematics, and enjoyment of mathematics.

The data shows the responses that the students gave on the four overarching categories of security, value, motivation and enjoyment were very similar between the two classes. Security gives a sense of how comfortable a student is with performing math tasks or problems. Value represents how important mathematics is to the student. It is a representation of the importance of math in everyday life situations. Motivation represents how excited a student is or is not to do mathematics and to what extreme they would participate in math outside of regular classroom procedures. Enjoyment represents the level of joy a student gets out of participating in mathematics or activities related to math. Experiences also influence the students’ attitude toward mathematics. Attitudes towards mathematics, the enjoyment and confidence from it, and the recognition of usefulness, will influence persistence in that subject (Tapia, 1996).

The results of the surveys indicate that both classes have a low sense of security when it comes to mathematics. This is likely an indicator of their confidence levels that have not been supported in the past. This could be due to the method of instruction that was used in previous years as well as the current year. Direct instruction only allows for right and wrong responses. This tends to discourage a student from answering questions and does not promote a sense of security. Problem-based learning would be a start to changing this attitude. It would allow for students to present their method through discussion. In turn, eliminating the right or wrong response.

Although both classes placed value highest on the survey, Ana’s class as well as
Ana’s girls, placed it higher than Pam’s class. This is likely due to the mixed method of instruction that was used during the research. This method taught the students the importance of mathematics in the real world. It allowed them to solve real world problems constructively, sharing ideas as they built upon their prior knowledge. Experiences teachers provide are the single most important factor in moving a student up the developmental ladder (Van de Walle, 2006).

**Questionnaire Data Conclusions**

Students who were taught using the teacher led instruction show different insight into mathematics and the learning process than that of the mixed method students. By giving the questionnaire after the chapter was taught, an analysis of how the students think about the instructional methods and any perceptions about math that the students might have changed during the process, was able to be analyzed. Pam’s students gave responses that were very teacher centered. They included ways in which the teachers’ instruction might have helped them. For example, one student was working on multiplying fractions and asked “Do I cross multiply them?’ The comment was very reflective of simple math problems that required no critical thinking. Ana’s class however, gave responses that reflected more of what the student could do to improve upon their math experiences. They talked about ways to make multistep situations more beneficial to them.

The differences were very reflective of the two different instructional approaches. Ana’s class seemed to have a greater interest in the subject. In reviewing this data, the conclusion can be drawn that the students have been taught using the teacher led
instruction method and think procedurally. The questions formulated by the control class were very instructionally directed and did not show much insight into the use of prior knowledge. Students in Ana’s class asked few questions and would have discussions about the task or problem among each other. They showed signs of using prior knowledge to come to the conclusions that they would draw about the problem or task. Eventually, Ana did not have to respond to many questions at all. The students would ask each other questions such as, “How was the way you did it, similar to mine?” The students began to think conceptually and would build upon experiences as well as communication. This was due to the mixed method procedure used in Ana’s classroom.

**Teacher Notes/Journal Conclusions**

The teacher notes were kept and shared during meeting times and any free time that the teachers would find to discuss the study. Commonalities were looked for in the notes discussed and differences were as well.

One of the differences discussed by Pam and Ana was that of questions asked by the students during the duration of the study. In Pam’s class, questions were limited to lower level thinking questions. Students did not understand why they arrived at a wrong answer, as they did the procedure the exact way they had been taught. They were very often references to not understanding a formula or remembering something that they were to memorize such as a multiplication fact. The process or procedure as to how to add a fraction often came into question. The students did not understand why they had to go through a certain process and liked to question when they would even need this skill.

When discussing homework and independent work together, Pam and Ana
noticed that students in Pam’s class struggled with explaining their reasoning behind the response given, or even showing their work through pictures or diagrams. They often did not attempt the critical thinking question or task at the end of the lesson and would just write “I don’t know” on the paper. This was a true indication of how the students have been taught over their school career. It is very teacher led and the tasks have required limited cognitive demand of the students.

The conclusion to be drawn from this is that Ana’s class was taught using the mixed method approach as Pam’s class was not. This means that when a teacher uses a problem-based, conceptual knowledge is created. Using tasks that encourage communication among the students, as done in Ana’s class, develops a sense of understanding. Direct instruction only allows for procedural knowledge to be acquired. The delivery in which a lesson is presented to a student, can either promote understanding, such as the problem-based approach, or it can limit a students’ understanding, such as teacher-led instruction.

Research tells us that when a student begins to self-monitor and explore the nature of mathematical concepts, that higher cognitive learning skills are occurring (Smith, Stein, 1998). This was a big step into understanding mathematics. Self-monitoring was evident in Ana’s class as they explored different tasks

**Limitations**

Although the study positively impacted students’ attitudes, confidence and understanding of the importance placed upon constructive problem solving, some limitations existed. One limitation is that this is a very transient school district and a few
of the students moved in and out of the district during the study. This caused for less instructional time with those students using the mixed method approach. Another limitation was the varying cognitive levels of the student participants. A few of the students who struggle with certain mathematic concepts, had difficulty understanding what was being asked of them. They would tend to sit quietly and listen rather than participate in the activities.

The greatest limitation to this study was the amount of time or number of lessons that the researcher, Ana, had to execute the research plans. Students were pulled out of class for tutoring and band, as well as choir and other school assemblies. Lessons were also interrupted with fire drills and tornado drills. Yet, the biggest interruptions to the lessons was the time that was taken away during the study to do PARCC assessment review and testing. Star tests were also administered during the time the investigation was taking place. Final results might have been more noticeable if both classes had a more regular schedule with fewer delays and interruptions.

**Recommendations for Further Research**

The study used a mixed methods approach. This took some time to transition the students from the teacher led approach in which they were used to, from their math teacher. Next year the teacher-researcher will teach using only the mixed methods approach the entire year and would like to move to strictly using only the problem based approach in the upcoming years. The student’s attitudes changed during the duration of the study providing the teacher researcher with evidence that students enjoy problem-based learning. The students also showed growth in the assessments and classroom tasks,
which gave them more confidence in mathematic problem solving. The need for a
change is present in the district and the movement has started to occur in the
constructivist approach direction. Students can perform memorized tasks equally well,
but they can’t use them equally well to solve problems, and that is learned during the act
of problem solving.
Appendix A

Sample Lessons-
Teacher Led and Altered
Appendix A: Typical Teacher Led Lesson

Rounding Fractions:

Introduction-20 minutes

Math in My World. Introduce example 1. Watch it on the SmartBoard.

A poison dart frog is 2 inches long. This is equal to 2/12 foot. Is 2/12 closest to 0, ½, or 1?

Teacher graphs it on the number line for the students and they copy it into their practice books. Then they answer the question as a class.

Read the key concepts to the class. How to know when to round down, round to 1/2, or round up. Go over Example 2 with the class. Repeating steps from Example 1.

Body-45 minutes

Students work on Guided Practice Questions and show the teacher the answers when they complete the two questions. After they achieve a correct answer, they may then move to the independent practice page which consists of 18 questions. Example of questions 1-14 would be: round each fraction to the nearest 0, 1/2, or 1. 1) 1/8=?.

Questions 15-17 are story problem questions. An example of those would be: Corey has finished 3/ of her daily chores. Has she finished about half or almost all of them?

Question 18 is a “Hot Topic” problem. It states, circle the fraction that does not belong
with the other three and explain your reasoning. Then it provides four fractions to choose from. The students do NOT have to do the “hot topic” question. As the students work on this, the teacher sits at the back table to give assistance to any student who is struggling. Differentiation is provided through another workbook, provided by the publisher.

**Closing-5 minutes**

Students hand in their independent practice pages for a grade and tear out their homework.
Appendix A: Altered Lesson

Rounding Fractions:

Introduction-30 minutes

Teacher introduces the essential question on the white board. “How can equivalent fractions help add and subtract fractions?” Next place the task on the overhead projector and let the students work in groups to discuss and response to the task.

Task: Mrs. Smith has 12 students in her class that need to use a pencil for the test. She realizes that only 5/12 of her pencils are sharpened. Estimate about how many students that need a pencil, will be able to borrow one. Explain your response. Will the estimate of students who will not get a pencil be the same as the estimate of students who do get a pencil? Explain your response.

Teacher/facilitator walks around the room and provides questions that build upon the students’ prior knowledge to help them formulate a response if they need assistance. Students work together and discuss the task.

Body-30 minutes

Students take turns coming to the overhead or white board and sharing the method in which they found their answer. Other students can ask questions and discuss any interesting ideas. Teacher asks questions to the whole class that builds upon that students’ response.

Closing-30 minutes
Students take out the publishers practice book and the teacher assigns the first three problems in the corresponding lesson and also assigns the 3 story problems, as well as the “hot topic” question. They complete these as a group and go over them as a class. The teacher passes out one task for homework and asks the students to make up their own task for homework as well.
Appendix B

Pre- and Post-Test

and

Scoring Guide
Appendix B: Pre- and Post-Test and Scoring Guide

Part A

Tell whether each number is prime or composite.
1. 24
2. 17

Write the prime factorization of each number.
3. 28
4. 360

Find the GCF of each set of numbers.
5. 36, 64
6. 15, 45, 75
7. 18, 12, 3

Write each fraction in simplest form. If the fraction is already in simplest form, write simplified.
8. \( \frac{5}{25} \)
9. \( \frac{8}{9} \)

Find the LCM of each set of numbers.
10. 14, 7
11. 3, 6, 15

Write each fraction as a decimal.
12. \( \frac{3}{10} \)
13. \( \frac{1}{5} \)

Compare each fraction. Use the symbols <, >, or =.
14. \( \frac{3}{5} \) \( \frac{1}{2} \)
15. \( \frac{2}{3} \) \( \frac{5}{6} \)
Problem Solving Tasks: Part B

16. Tito and Luis are stuffed with pizza! Tito ate two-fourths of the cheese pizza and Luis ate one-fourth of the cheese pizza. Tito also ate one-fourth of the mushroom pizza, while Luis did two fourths of the mushroom pizza. Luis says they each ate the same amount of pizza while Tito says that he ate more. Who is correct? Show all your mathematical thinking.

17. Tim added 3/6 and 1/6 and wrote an answer of 4/12. Is Tim’s solution correct? Explain why or why not using pictures, numbers or words.

18. Banana Pudding Problem

<table>
<thead>
<tr>
<th>Carolina’s Banana Pudding Recipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 2 cups sour cream</td>
</tr>
<tr>
<td>• 5 cups whipped cream</td>
</tr>
<tr>
<td>• 3 cups vanilla pudding mix</td>
</tr>
<tr>
<td>• 4 cups milk</td>
</tr>
<tr>
<td>• 8 bananas</td>
</tr>
</tbody>
</table>

Carolina is making her special banana pudding recipe. She is looking for her cup measure, but can only find her quarter cup measure.

a. How many quarter cups does she need for the sour cream? Draw a picture to illustrate your solution, and write an equation that represents the situation.

b. How many quarter cups does she need for the milk? Draw a picture to illustrate your solution, and write an equation that represents the situation.

c. Carolina does not remember in what order she added the ingredients but the last ingredient added required 12 quarter cups. What was the last ingredient Carolina added to the pudding? Draw a picture to illustrate your solution, and write an equation that represents the situation.

Illustrative Mathematics, (NCTM, 2012)
Pre-Post-Test Scoring Guide

Questions # 1-15:

- Each correct solution – 1 point.

Questions # 16 and 17:

Each problem worth 2 points

- Show thinking in words and/or representations – 1 point
- Correct solution to the problem - 1 point

Question #18:

Problem worth 9 points total

- 3 sections (a, b, and c)
- Each section is worth 3 points.
  - 1 point - accurate response
  - 1 point - showing their thinking in words and representations
  - 1 point - writing an equation to match their thinking.
Appendix C

Attitudes/Dispositions Toward Mathematics Survey
Appendix C: Attitudes/Dispositions Toward Mathematics Survey

**Directions:** This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Enter the letter that most closely corresponds to how each statement best describes your feelings. Please answer every question.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mathematics is a very worthwhile and necessary subject.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>2. I want to develop my mathematical skills.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>3. I get a great deal of satisfaction out of solving a mathematics problem.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>4. Mathematics helps develop the mind and teaches a person to think.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>5. Mathematics is important in everyday life.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>6. Mathematics is one of the most important subjects for people to study.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>7. High school math courses would be very helpful no matter what I decide to study.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
<tr>
<td>8. I can think of many ways that I use math outside of school.</td>
<td>○ Strongly Disagree</td>
<td>○ Slightly Disagree</td>
<td>○ Slightly Agree</td>
<td>○ Strongly Agree</td>
</tr>
</tbody>
</table>

(survey page 1)
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>9. Mathematics is one of my most dreaded subjects.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. My mind goes blank and I am unable to think clearly when working with mathematics.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Studying mathematics makes me feel nervous.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Mathematics makes me feel uncomfortable.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. I am always under a terrible strain in a math class.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. When I hear the word mathematics, I have a feeling of dislike.</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>15. It makes me nervous to even think about having to do a mathematics problem.</td>
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</tr>
<tr>
<td>16. Mathematics does not scare me at all.</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>17. I have a lot of self-confidence when it comes to mathematics.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. I am able to solve mathematics problems without too much difficulty.</td>
<td></td>
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</tr>
</tbody>
</table>

(survey page 2)
19. I expect to do fairly well in any math class I take.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

20. I am always confused in my mathematics class.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

21. I feel a sense of insecurity when attempting mathematics.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

22. I learn mathematics easily.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

23. I am confident that I could learn advanced mathematics.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

24. I have usually enjoyed studying mathematics in school.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

25. Mathematics is dull and boring.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

26. I like to solve new problems in mathematics.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

27. I would prefer to do an assignment in math than to write an essay.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

28. I would like to avoid using mathematics in college.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Strongly Disagree</td>
<td>Slightly Disagree</td>
<td>Slightly Agree</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-------------------</td>
<td>-------------------</td>
<td>---------------</td>
<td>----------------</td>
</tr>
<tr>
<td>29. I really like mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>30. I am happier in a math class than in any other class.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>31. Mathematics is a very interesting subject.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>32. I am willing to take more than the required amount of mathematics.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>33. I plan to take as much mathematics as I can during my education.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>34. The challenge of math appeals to me.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>35. I think studying advanced mathematics is useful.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>36. I believe studying math helps me with problem solving in other areas.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>37. I am comfortable expressing my own ideas on how to look for solutions to a difficult problem in math.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>38. I am comfortable answering questions in math class.</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

(survey page 4)
<table>
<thead>
<tr>
<th>Survey Question</th>
<th>Strongly Disagree</th>
<th>Slightly Disagree</th>
<th>Slightly Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>39. A strong math background could help me in my professional life.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40. I believe I am good at solving math problems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from the *Attitudes Toward Mathematics Inventory (ATMI)*

by Assessment Tools in Informal Science
Appendix D:

Questionnaire and

Sample Responses
Appendix D: Questionnaire and sample Responses


   Control class responses:
   - I feel like math is easy because we learn to multiply fractions.
   - I feel that math could be needed when you are older, but most of it like shapes is useless.

   Experimental class responses:
   - I feel that math is good for your education because you need to know when to multiply in life.
   - Math is important to me because it is an everyday part of life.


   Control class responses:
   - I learn best by listening to directions.
   - I learn best by seeing the steps I have to do to solve the problem.

   Experimental class responses:
   - I learn best by talking to others in a group and using tools to find my answers.
   - I learn best by explaining what I do to solve the answer out loud.

3. What could a teacher do to help you learn math more easily? Please explain the teaching methods that help to make math easier for you to learn.

   Control class responses:
   - Explain how they do the work more slowly.
• Go over the steps more often, so I can remember them.

Experimental class responses:

• Use more math related activities that I would have to do in real life.

• A teacher could explain different ways to solve the problem.


Control class responses:

• Nothing. It is confusing.

• How you get to use numbers.

Experimental class responses:

• Being able to solve problems using more than one way.

• There are so many different kinds of math and ways to learn it.
Appendix E

Informed Consent Form
Appendix E: Informed Consent Form

April 7, 2015

Dear Parents,

My name is Kenya Andorfer, and I am a graduate student at Wittenberg University in Springfield, Ohio. I am inviting your student to participate in an action research study. Involvement in the study is voluntary, so you may choose to participate or not. The paragraph below will explain the study. Please feel free to contact me with any questions that you may have about the research; I will be happy to explain anything in greater detail.

I am going to use data from the two fifth grade classes for my action research study in mathematics. Your student will be asked to fill out a pre and post survey, which will be kept completely anonymous. A few random students will participate in an interview with myself. My objective is to study not only the attitudes towards mathematics, but to study the differences in student learning when two different instructional practices are used in math. Both classes will teach the same content and follow the same curriculum, so your child will not miss any content, they will just be taught using a different approach than the other class. My class will receive problem-based instruction following the math content and Ms. Ingle’s class will strictly follow the MY MATH curriculum. This will take approximately 4 weeks. All information will be confidential. Student numbers will be used to compare data, instead of student names. This means, I will assign a number to your student’s responses, and only I will have the key to indicate which number belongs to which participant. In any articles I write or any presentations that I make, I will use a made-up name for your student.

The benefit of this research is that you will be helping us to better understand a student’s attitude towards math and how to better help implement the content to improve understanding of math concepts. There are no risks to you or your student by participating in this study. If you do not wish to continue, you have the right to withdraw from the study, without penalty, at any time. If you wish to not participate in the study, your child will still be taught the same content, but will not be included in any pre or post test, interviews or data collection.

If you have any questions or would like a copy of the study when I am finished, feel free to contact me at (937) 505-4450 or kici9@icloud.com. You can also contact my professor, Dr. Regina Post at Wittenberg University. Her contact information is rpost@wittenberg.edu.

Please check one of the following statements:

☐ I choose, voluntarily, for my student to participate in this research project.

☐ I do not wish for my student to participate in the research project.

__________________________________________________________
Print name of participant Parent signature Date

__________________________________________________________
Print name of participant Parent signature Date

Thank you very much,
Kenya Andorfer
Appendix F

Institutional Review Board Approval
Appendix F: IRB Approval

Email communication.

April 6, 2015.

To:

Kenya A. Andorfer

From: Ralph Lenz <rlenz@wittenberg.edu>
Date: April 10, 2015 at 4:46:14 PM EDT
To: "'kici9@icloud.com'" <kici9@icloud.com>, "Nancy S. Woehrle" <woehrlen@wittenberg.edu>, "Regina A. Post" <rpost@wittenberg.edu>, "feltz@deltapsychologycenter.com" < feltz@deltapsychologycenter.com>, Ralph Lenz <rlenz@wittenberg.edu>
Cc: "June A. Viers" <jviers@wittenberg.edu>
Subject: irb andorfer

Hi Kenya,

I have looked over your materials, and on behalf of the Witt IRB I am communicating our approval of your petition.

Good luck with your research.

Ralph Lenz

Witt IRB chair
References


