# IMPLEMENTING MATHEMATICAL PRACTICES WITHIN MATHEMATICAL CONTENT

A Dissertation

Presented to

The Faculty of the Education Department

Carson-Newman University

In Partial Fulfilment

Of the

Requirements for the Degree

Doctor of Education

By

Jennifer M. Partin

March 15, 2017

CARSON-NEWMAN
UNIVERSITY

Dissertation Approval

Student Name/ CNU ID: Jennifer Partin/0273947

Dissertation Title:

A DISSERTATION PRINTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR

THE DEGREE DOCTOR IN ADMINISTRATIVE LEADERSHIP

This dissertation has been approved and accepted by the faculty of the Education Department, Carson-Newman University, in partial fulfillment of the requirements for the degree, Doctor of Education.

Dissertation Committee:

Signatures: (Print and Sign)

Dissertation Chair: Dr. Deborah Hayes

______________________________

Methodologist Member: Dr. Christopher Shon

______________________________

Content Member: Dr. David Dickerson

______________________________

Approved by the Dissertation Committee    Date: March 15, 2017

## Abstract

The 2009-2010 Tennessee Comprehensive Assessment Program (TCAP) test scores were completed before the Mathematical Practices were mandated by the state of Tennessee. These scores were compared to the 2011-2012 school year TCAP test which was the first school year that the state of Tennessee mandated the implementation of Mathematical Practices in grades kindergarten through 12th. The t-test indicated a statically significant outcome suggesting that students made more gains once the mathematical practices were implemented. The purpose of the qualitative piece was to understand the experience of the teachers and the ways mathematical practices were implemented in the classroom. The researcher compared the six teachers' personal interviews about implementing the eight mathematical practices. The interview questions enabled the researcher to understand recurrent themes. When teachers where asked how they implement the eight mathematical practices into the mathematical curriculum allowing extra time for more student based learning was reported. All six teachers indicated that the mathematical practices are important and helped students to gain a deeper understanding of mathematical concepts and help to build a stronger mathematical foundation. This analysis alone would not support the use of the mathematical practices to increase the TCAP mathematics scores. However, the data exhibited an increase in student growth from the 2009-2010 school year before the practices were implemented to the 2011-2012 school year once the mathematical practices were implemented.

Keywords: *mathematical practices, implementation, TCAP*

**Table of Contents**

## List of Tables and Figures

# CHAPTER 1

# INTRODUCTION

## Background of the Study

In 2010 Tennessee adopted new mathematical standards and practices. By the 2015-2016 school year, all public schools in Tennessee were tested over Tennessee Ready Standards which are for the most part The Common Core State Standards (CCSS) with a different name. While the standards have changed somewhat for grades kindergarten through eight and the first three courses in high school math (Algebra 1, Geometry, Algebra 2, and Integrated Math 1,2,3), mathematical practices have also been added.

The mathematical practices demonstrate ways in which the student should develop mathematically in order to be a proficient mathematical student. The student can then apply the mathematical practices in real world situations. When educators are looking for curricula, assessments, and professional development, these practices should connect to the mathematical content through the instruction.

The Standards for Mathematical Content are a balance between procedure and understanding. A connection is seen between the mathematical practices and standards when teachers expect students to explain their understanding of mathematical problems. Students who lack understanding may rely on procedures too often which prevents the student from becoming proficient. Students need both an understanding of the content, as well as, procedures on how to solve mathematical problems and situations. This can be achieved when the mathematical practices and standards are combined effectively.

In American society, students are expected to have a deeper understanding of mathematics with standard based instruction. If teachers use meaningful and mindful classroom practices, a deeper understanding can be achieved (Barlow & Drake, 2008). When teachers use the mathematical content standards the teacher can see how to effectively implement the mathematical practices into their classrooms where learning important mathematics is meaningful for students (Wenrick, Behrend, & Mohs, 2013).

Implementing new strategies, models, and frameworks often help teachers explore and design new methods of teaching. The Talk How you Identify to Notice and Keep Solving (THINK) model is a framework that students can use when problem solving. This framework is based on two instructional methods that enhance mathematical reasoning (Thomas, 2006). The first is cooperative learning. When students interact with one another to solve problems a deeper understanding is formed (Campbell, 1997). The second is metacognition, which is higher order thinking skills. When teachers allow students time for thinking, believe that young children can solve problems, listen carefully to their justifications, and structure an environment that promote problem solving, it will promote students innate problem solving inclinations and encourage them to persevere (Buschman, 2003). Giving teachers resources and knowledge on how to implement the mathematical standards will promote teacher input and student achievement.

The focus of this study was to look at the new mathematical practices that have been adopted into the state of Tennessee mathematics curriculum. The study discusses the relationship between mathematical practices and the mathematical content. The rationale and reasoning behind the shift in thinking about mathematics is from teacher lead instruction to student inquiry. Lastly, this study explores various models of implementation strategies that can be utilized by classroom teachers.

**Purpose of the Study**

The purpose of the study was to see how the mathematical practices being implemented affect student's mathematical achievement. Over the years, research indicated that children's approach to learning mathematics is distinctly different from that of an adult (Campbell, 1997). Children want to solve problems and get enjoyment out of solving problems if they are permitted to solve these problems in ways that make sense to them (Buschman, 2003).

The study also explored how teachers implement the mathematical practices into curriculum. Implementation of new strategies and skills is often a time consuming task for teachers. However, if teachers understand the standards of mathematical practices it enables them to effectively implement the newly adopted standards. In each grade band there are focus standards. These focus standards should be taught over the bulk of the school year. Depending on the grade, this can be anywhere from two to three critical areas; however, the mathematical practices are to be used across all grade levels.

**Research Questions**

The research questions allowed the researcher to assess the implications of the mathematical standards on student achievement. The question also allowed the researcher to gather information on the various methods and strategies that teachers are using to implement these practices into their classrooms.

1. When the eight standards of mathematical practices are implemented into third through eighth grade mathematical classes, what effect do these practices have on student achievement test scores?
2. How do teachers implement the eight mathematical practices into the mathematical curriculum that is mandated by the Tennessee State Department?

Basic interpretative study will be used to understand the experience of the teachers. This information will be collected through interviews.

**Rationale for the Study**

This study is important because classroom mathematics teachers need to know how to implement the eight mathematical practices into the current mathematic curriculum. Educators are required to teach students to have a deeper understanding of the processes involved in mathematical problems. Therefore, educators need to know how to implement these practices effectively into their classrooms. The study compared student achievement scores prior to the implementation of the eight mathematical practices with the test scores once the practices were implemented. As standards and practices change, our students are expected to develop a deeper understanding of the mathematics they are studying. When teachers use problem writing in their mathematical classes, teachers can assess this type of knowledge (Drake & Barlow, 2008). Students can draw important conclusions about mathematics when they hear alternate approaches to problems (Newton, 2010). The study provides information to educators to expand their knowledge about the mathematical practices and the ways in which they are implemented.

**The Researcher**

The researcher has taught in the public education setting for the last thirteen years. All of that time consisted of teaching mathematics in fifth and sixth grade. The researcher participated on various committees, training programs, and workshops dealing with the implementation of mathematical standards, as well as, the mathematical practices. During the 2016 National Council of Teachers of Mathematics regional conference, the researcher presented mathematical concepts and strategies that teachers can use when teaching fractions with pattern blocks. Throughout various school years, the researcher contributed to creating pacing guides for the district and implementation of strategies for the new Tennessee State Performance Indicators, the Common Core Standards, and the TNReady Standards. The topic and information gathered in the study will be used to help mathematics teachers implement strategies for teaching the mathematical practices in relation to the content.

## Definitions of Terms

**Common core mathematical standards**. These standards build on the best of high-quality math standards from states across the country. The standards also draw on the most important international models for mathematical practice, as well as research and input from numerous sources, including state departments of education, scholars, assessment developers, professional organizations, educators, parents and students, and members of the public. The math standards provide clarity and specificity rather than broad general statements. These standards define what students should understand and be able to do in their study of mathematics. Mathematical understanding and procedural skill are equally important, and both are assessable using mathematical tasks of sufficient richness (Tennessee Department of Education, 2015).

**Mathematical practices**. According to the Tennessee Department of Education (2015) website, the mathematical practices describe multiple levels of expertise that mathematic educators should seek to develop in their students. These practices are broken down into two categories: National Council of Teachers Mathematics (NCTM) process standards and strands of mathematical proficiency according to the National Research Council's report (Klein, 2003). The NCTM process standards include problem solving, reasoning and proof, communication, representation, and connections. The National Research Council's report includes adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition. These mathematical practices are used from kindergarten through high school. There are eight standards for mathematical practice.

1. Make sense of the problems and persevere in solving them. Students are able to understand the problem and look for ways in which to solve the problem without giving up. Students are able to monitor themselves and work through problem solving skills.
2. Reason abstractly and quantitatively. Students are able to break apart the math problem with pictures or standard algorithms and solve the problem.
3. Construct viable arguments and critique the reasoning of others. Students are able to use mathematical language to support or oppose others work.
4. Model with mathematics. Students are able to understand the world around them. The student can organize data and solve real world problems.
5. Use appropriate tools strategically. Students are able to choose the appropriate tools to solve mathematical problems. For example, the students are able to determine when a yard sick or a meter stick is needed.
6. Attend to precision. Students solve mathematical problems meticulously and with exactness.
7. Look for and make use of structure. Students are able to find patterns and repeated reasoning that can be used in other mathematical problems. For younger students this can be recognizing fact families; however, older students will need to be able to break numbers apart and look for relationships.
8. Look for and express regularity in repeated reasoning. While students are working on the details of the problem the big picture needs to be considered as well. Students need to be able to generalize his or her own thinking (Klein, 2003 p.2).

**TCAP standardized testing**. Standardized public testing program used in Tennessee until 2015 school year. TCAP is an achievement test given in grades 3-8. The scores were returned by the beginning of the next school. While Tennessee attempted to use TNReady for the 2015-2016 school year testing did not occur for students. For the 2016-2017 school year, Tennessee has chosen to test students with TCAP again.

## Summary

It is important that educators shift student and teacher thinking from simply getting the right answer; to how did we get the right answer and can we apply that strategy to other mathematical concepts. The Mathematical Practices are to help with student understanding. These Mathematical Practices are the why and how of math. It is time for teachers to be flexible and willing to try new teaching strategies to insure students are becoming mathematicians and are ready for rigor and demand that college and career life can bring.

# CHAPTER 2

# REVIEW OF LITERATURE

## Historical Background

Education in the United States is ever changing and evolving. Content and pedagogy have been at the forefront of education and often seem to be conflicting with one another. The content is what is taught while pedagogy is how educators teach it. These two ideas should work hand and hand simultaneously in the classroom. Like many things in education both content and the way in which teachers teach the content is changing and evolving as students are changing and evolving.

Before the 1920's, standards or what teachers thought students should know, was set up locally. These standards were realistic for what was needed in that area, time, and culture. In society standards have become more universalized. Most major countries have standards in place that all districts follow to some extent. Even with these national standards states are able to choose how they are implemented or if they are implemented at all. While the Common Core Standards are content based, the way teachers teach the content has also become more universalized through the mathematical practices (Klein, 2003).

In the 1920's, the National Council of Teachers of Mathematics (NCTM) was formed to counter the progressivist and educational reformers of the time. The organization stated that it would "keep the values and interest of the mathematics before the educational world" (Klein, 2003, p.176). In 1923 a comprehensive report, *1923 Report,* was published about school mathematics it discussed learning mathematics, the psychology of mathematics, and the value of mathematics. The report also suggested curriculum that would be applicable. This report came to influence some of public education (Klein, 2003).

In the 1930's, the movement of teachers to teach students and not curriculum was being pushed. School districts based what was being taught on the needs of the students. This created wide-spread gaps across the country. A combination of personalized learning and standard reform was the direction education was moving towards in 2010's. This is interesting because this is the direction education is heading currently or at least a combination of personalized learning and standards reform. This same type of mind-set is seen again in the 1990's when the motto was: *We teach children, not subject matter* (Klein, 2003). By the 1940's however, there was much discussion over the amount of mathematics being taught to students. The military began to complain that recruits lacked basic mathematical skills that were required to enter in service. An educational program was implemented in schools across the country called the Life Adjustment Movement (Klein, 2003). At the time of the Life Adjustment Movement, 60% of public school students were not intellectually capable of college work or able to work in skilled occupations. The report also stated that students were not prepared for everyday living in the real world (Klein, 2003). Parents and students were not able to adjust to this new program and it was not accepted.

In the 1950's and 1960's, New Math became a common term in education. It combined skills and understanding. This was the first time that higher education mathematicians became involved in the public school curriculum and offered advice as to what needed to be taught. This was the start of collaboration between elementary education and college/universities. New Math was hard for students to understand. Many of the concepts were based on powers of ten and the standards were too complex for elementary students. These same instructional strategies and ideas can be seen in the Common Core math standards nearly half a century later. New Math and Common Core math standards share many of the same characteristics. Both math programs promise to connect different areas of mathematics under a merging set of principles. There is a strong emphasis on conceptual understanding and foundational laws. The main focus is on the student's problem-solving ability (Phillips, 2015). Some correlation can be found between New Math and Common Core.

By the 1970's, New Math was out and schools returned to the basics. During this time period, many states created standardized tests that students had to pass in order to graduate high school. Many of these tests began to see a decline in scores up into the 1980's. By the 1980's it was evident that math and science scores were on the decline and something needed to be done to keep American students up to par (Klein, 2003).

During the 1980's two prominent reports were published to give the American population a synopsis of mathematics in public school. *A Nation at Risk* reported the areas in which public education was lacking. It set off a flood of reforms. The report found little good in public education. The report included numerous forms of statistical evidence to prove that 23 million American adults were illiterate (Graham, 2013). *A Nation at Risk* (1983), found the 40% of minority youth were functional illiterate and about 13% of seventeen years were considered functionally illiterate. Test scores were quickly deteriorating and the average high school was achieving lower than before the Sputnik launch in 1957. Americans were fearful that students in our country would not be able to compete with students from other countries. The report also found that only one-fifth of 17 year olds could write a persuasive essay. It also stated that between 1975 and 1980 remedial mathematics courses in college increased by 72 (A Nation at Risk, 1983). Not only did the report focus on students and how they were achieving it also focused on teachers. The report found that teaching salaries were at an all-time low. There was a high turnover rate and poor teacher training programs were in place in the educational field.

This report gained enormous media attention and backlash from the community (Graham, 2013). The second report was *An Agenda for Action* (Graham, 2013). This report listed eight areas of focus for public schools in mathematics. Each had a specific purpose and focus. Problem solving was a big focus for this report and nearly every mathematic textbook began to incorporate problem solving into it. In *An Agenda for Action* Recommendations for School Mathematics for the 1980's stated, that a lot of the mathematical strategies and ideas of the time came from this report. This report was used as the guiding block when the Curriculum and Evaluation Standards for School Mathematics was published by the NCTM in 1989(na, 2004).

In 1989, NCTM Standards were created (Phillips, 2015). The standards that NCTM created returned to the basics but had focus and high standards. Later, the NCTM created two other documents as part of its standards. The first, *Professional Standards for Teaching Mathematics*, was published in 1991 and focused on pedagogy. The other was published in 1995, *Assessment Standards for School Mathematics*, and focused on testing. However, by 1997 many states adopted mathematics standards with close configuration to these two documents (Klein, 2003). Unlike other reforms these standards were taken well by many in the public and in the educational realm. It still appeared American students were falling behind students from other countries in mathematics and sciences.

Common Core Standards were released in 2009 and implemented in forty-five states by 2010. These standards were created due to the lack of standardization of test scores across the country and the different levels of rigor. Despite the No Child Left Behind (NCLB) document, that all states were required to adopt content standards, vary widely in coverage, rigor, specificity, and clarity (Shepard, Hannaway, & Baker, 2009). Two categories were formed when the standards were developed. The first was college and career readiness and the second was the kindergarten through twelfth grade standards. The standards used in the classroom are evidence based (Everette, 2013).

The Common Core Standards were created with a focus on the curriculum. Along with the curriculum standards' Common Core also has eight mathematical practices. These practices were created from the NCTM five standards of proficiency and US's National Research Council *Adding It Up* report (Dossey, Halvorsen, & McCrone, 2012). These practices are the same in grades kindergarten through eighth grade. The Standards for Mathematical Practice define competencies that all educators should seek to develop within their students. The first practices are taken from part of the NCTM standards which are process standards of problem solving, reasoning and proof, communication, representation, and connections. However, the second part of the mathematical practices are the strands of mathematical proficiency which were specified by the National Research Council's report *Adding It Up*. Those are adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition (Illustrative Mathematics, 2016).

**Standardized test.**

The earliest record of standardized testing comes from China (Fletcher, 2009). This was done for people seeking government jobs to be tested over knowledge of Confucian philosophy and poetry. In the Western World, the exams that were given favored essays. However, as the Industrial Revolution took children from the farm to the classroom, standardized test emerged as an easy way to test a large number of students easily. It is not until later that these tests become a focus in the everyday culture of classrooms (Fletcher, 2009).

James Bryant Conant wanted an intellectual elite society (Fetcher, 2009). He believed in students taking standardized tests so that specific students could make up an intellectual society and be educated with specific goals in mind (Public Broadcasting Service, 2014). Conant was appointed president of Harvard College and established scholarship programs for students. Henry Chauncey recommended using the Scholastic Attitude Test for apportioning these scholarships. After World War II, Chauncey arranged for all of the major testing organizations to merge into what is now known as the Educational Testing Services (ETS).

While standardized testing is highly controversial between law makers, teachers, parents, and students; there are pros and cons to this type of testing. The biggest advantage to standardized testing for law makers is accountability for students and teachers. Depending on the district and state law the data from the test can used on students report cards (Meador, 2014). Teachers are also held accountable for these scores. These scores are factored into a teacher's overall effectiveness score on evaluations. They can be used when deciding on retention of a teacher and are a factor for receiving tenure.

When using standardized testing, the data allows students to be compared to other students within the district, the state, and even the country. At one time Tennessee's data appeared that students were testing at the top of the top. However, the data were not the same type of scores.

Another advantage to standardized testing is establishing standards or instructional frameworks for each subject and grade level. This can also insure that students who move from school to school are not behind or ahead in their new school (Meador, 2014).

Finally, data is a large advantage of standardized testing. Not only can standardized test provide data for each classroom and the school; these tests can provide data for sub-groups, as well. These sub groups can include socioeconomic status, ethnicity, or special needs. This data can be used to develop programs and services for these sub-groups.

For each of the advantages of standardized testing there are disadvantages. While these tests can hold students and teachers accountable, they only evaluate the student's performance on one particular day and does not take into account external factors. External factors play a key role in a student's performance. If the morning before a test the parents of student were in a fight this could affect the student's performance (Meador, 2014). Chances are the student will not be able to focus (Fletcher, 2009).

Unfortunately, the accountability that comes along with standardized test can cause teachers to "teach to the test" (Meador, 2014). This process can hinder a student's overall learning potential. As the stakes get higher and higher we see this practice increasing. Teachers are under a lot of pressure to get the students ready for the test. The atmosphere is often boring and lacks creativeness. Many times this practice gets them ready for the exam, but neglects to teach students skills that go beyond the test (Meador, 2014).

**Theoretical Lens**

In a study conducted by Burns, Pierson, and Reddy (2014), the collaborative environment in which students and teachers work in was analyzed. The study took place in two school districts in Indiana. One district had a higher free and reduced lunch rate than the other. In this study teachers were taught how to have student centered and active learning in mathematical classroom. The data used in this study were qualitative teacher case study surveys, teacher and student observation, student and teacher focus protocol groups, and self-reporting tools. The results indicated students and teachers were excited and enthusiastic about this new way of learning.

The teachers in Indiana from both school districts were involved in a six month professional development program for math and science teachers. It focused on making mathematical classrooms that were student centered and student driven. While the classrooms were led by the students, the teachers and educators controlled the curriculum and content that was to be studied. The learning styles that this study focused on are the basis for the mathematical practices as learners have different aptitudes and intelligences. Each student learns differently and the way in which he or she processes information is unique to the individual (Burns, Pierson, & Reddy, 2014). The framework suggests that some students learn better working alone, some work better collaborating, and some work better in pairs. All of these strategies are embedded into the mathematical practices.

When teachers are given the knowledge to promote student-centered classrooms and see the positive outcomes, they are more likely to continue the practices (Burns, Pierson, & Reddy, 2014). In both districts positive effects were seen; therefore, there is no socio-economic barrier. Most teachers were willing to change to this method of teaching and begin to use the collaborative process daily in his or her classrooms. However, it challenges the teachers who still do not want to use the new methods even when the educator had seen the positive effects. This brings up the question, what can administrators or educators do to motivate teachers and students? If teachers are able to collaborate with one another positive effects can be seen. Professional learning communities are a great avenue for educators to use when implementing any new strategy (Eaker & Keating, 2016).

Professional Learning Communities (PLC) allow teachers to collaborate and generate new ideas to increase student achievement. Since PLC's are continual and open-ended, they allow for failure and renewal. Teachers are able to implement new strategies and come back with what works and what doesn't. Studies have found a correlation between PLC's and students' learning. The Missouri Assessment Program (MAP) data showed a 24.1 % gain in advanced and proficient scores for communication arts between 2001 and 2005. Also in first-grade students scoring on grade level on the Developmental Reading Assessment end-of-year test increased 12.2 % between 2001-2002 and 2006- 2007 (Rentfro, 2007). Teachers noted that collaboration allowed for renewed reading ideas. This lead to more student involvement and in-turn higher achievement scores (Kelly, 2015). Research found that allowing teachers to emerge as leaders gave them new found confidence and allowed for better relationships built within the building (Harris, 2010).

Teachers are the heartbeat of the school. Without good teachers it is impossible to have good schools. Professional learning communities are teams of teachers that are always investigating student learning. The team reflects on the effectiveness of the teachers' professional practice including classroom management, curriculum, and teaching strategies. The team is constantly seeking to expand on student learning and increase their effectiveness in the classroom. One of the most significant attributes of a professional learning community is to make meaningful achievable goals (Eaker & Keating, 2016).

Professional development, in-service, or staff development may not always be well received by veteran teachers. These are typically day long workshops that the teacher must sit and listen to the so called experts. Over the last two decades, education reforms have been focused on standard based reform movements. The focus of this reform effort is to have effective professional development that can generate a knowledge base that can be implemented and reorganized effectivity so that teachers can make quality schools (Quattlebaum, 2012). This approach is unfocused and typically does not address school wide needs or problems. Through professional learning communities a new understanding of state development can occur and leave the school feeling renewed and refreshed. Through staff development, teachers must learn to work together and have the greatest impact on their school and students.

The top three characteristics for professional development are chances for active learning, content knowledge, and the overall coherence at the school and team level (Quattlebaum, 2012). Authors DuFour and Eaker (1998) concur with the published standards for teacher professional development. Furthermore, they hold that development of the staff cannot be under-rated or under-prioritized. In order for these opportunities of the top three characteristic the staff development must be attentive to teacher application of learned material (Quattlebaum, 2012).

Professional development should be research based, in order for the skills and strategies teachers are implementing have been proven to accomplish the proposed results. While initial training must occur, professional development must move beyond this so teachers can improve areas in their skill set. Professional development needs to allow teachers to expand skills and address the diverse learning styles of students. Students learn in a multitude of ways and the professional development must address this (Buschman, 2003).

Professional development content must be school focused, embedded in the job, and foster the teacher, as well as the school. Professional development must be supported by central office staff that is encouraging shared values and collaborations while focusing on results and the continuous improvements of schools. Professional development should be content specific to the educator's daily work. Having professional development in conjunction with PLC's can build trust, give direction, and inspire commitment to the individual teacher and the school (DuFour, & Eaker, 1998).

The research from the Indiana study indicated that when teachers collaborate and use professional development adequately it can have a positive effect on students (Burns, Pierson, &

Reddy, 2014). During this study many aspects of the mathematical classroom were analyzed including the various ways to implement mathematical practices and student centered classroom effectively (Burns, Pierson, & Reddy, 2014).

Another study compiled a literature review of math professional development events on various mathematical topics, some of which dealt with implementing new teaching strategies. The researchers reviewed 910 professional development opportunities dealing with math and found that very few were effective when teachers began to implement these new practices into their classroom. Out of the 910 professional developments 643 were kindergarten through twelfth grade teachers in the United States. Thirty-two focused on teacher professional development to examine the level of effectiveness when implementing new standards. Out of the 32, only five of the professional developments met the standards of the study. However, of those five only two showed positive math proficiency in students. It states that some of the data is not as accurate because districts used their best judgement to decide about effectiveness until more data becomes available (Gersten, Taylor, Keys, Rolfhus, & Newman-Gonchar, 2014).

Another study examined the effects of Connected Mathematics Project 2 (CMP2) on 6$^{th}$ grade students' mathematics success and engagement. This was a quantitative study designed to allow students to be responsible for their learning by exploring different solution pathways, sharing their ideas with other students, listening to the ideas of others, and questioning each other. When asking students questions and encouraging them to share their thinking, compare their thinking with others, and make connections between representations of problems and solutions teachers are ensuring that the mathematics standards of the lesson are being addressed and that students are able to develop a conceptual understanding. According to the findings of the study student centered classrooms are beneficial to student success in mathematics. Teachers and students alike saw benefits from the implementation of new strategies. The testing data in 6$^{th}$ grade did not show an increase in student scores (Martin, Brasiel, Turner, & Wise, 2012). Many times in education time is not given when implementing a new strategy. Rarely is instant success seen.

*Math in Common* was a five year initiative funded program to implement the new common core mathematical standards into ten California school districts (Martin, Brasiel, Turner, & Wise, 2012). It was intended to provide relevant and important information to districts about Common Core math and the mathematical practices. The overall themes that were focused on are shifting teachers' instructional approaches related to the Common Core Standards, change students' proficiency in mathematics, change-management processes at the school district level to support the implementation of Common Core Standards, and to develop Math in Common Community of Practice. The Math in Common Community of Practice was strategies and ideas that teachers in the community can use across all grade levels. The initiative used WestED to develop an evaluation system to cover these four areas are being used effectivity. WestED provided timely and relevant information to help the district meet these goals (Martin, Brasiel, Turner, & Wise, 2012).

The ten districts in this study came from a variety of backgrounds. Some of the school districts were rural while others were urban districts. All of the districts had different history and cultural diversity. Even though these districts were vastly different WestED evaluated all of the schools using the same criteria since Common Core Mathematical Standards and Practices are the focus (Martin, Brasiel, Turner, & Wise, 2012).

The first implementation was putting in a classroom observation system. This allowed educators to focus on Common Core Mathematical Standards and individual needs of the school.

The districts found that setting up individual classroom observation systems was beneficial based on what the school's need. Teachers were able to change mathematical classrooms based on the observations the program provided. WestED provided a rubric that schools could use when implementing classroom observations. A framework was used, however, each school was able to set up their own classroom observation system. Purpose, focus, and reliability of classroom observation was the basis for the framework. Training was extremely important when implementing classroom observations. When observers were trained more reliable, consistent data was gathered. This is then used to inform the team on ways to improve the implementation system (Perry, Seago, Burr, Broek, & Finkelstein, 2015).

When having an effective classroom observation system in place, educators and administrators began to collaborate and discuss mathematical concepts, strategies, and implementation practices. The observation framework that WestED had compiled in the research report is a guide that could be modified to any school district. Using a classroom observation system that focuses on math, the Common Core Standards, and the mathematical practices can improve the implementation process.

Educators need to control teaching with high level tasks. One way to promote success in the classroom is through detailed planning prior to the lesson. One way to ensure success for some educators was to use the Thinking Through a Lesson Plan, known as the TTLP. There were three detailed parts to this plan. The process was time consuming and should have great thought put into it, such as: in what ways does this task build on prior knowledge, what concepts or ideas do students need in order to begin the task, and what are all the ways the task can be solved (Smith, Bill, & Hughes, 2008). This study suggest that implementing new strategies, mathematical practices, or mathematical standards was time consuming. This was one factor as to why so many teachers do not want or like change. However, it demonstrated why it was beneficial to the students (Smith, Bill, & Hughes, 2008).

The National Council of Mathematics Teachers (NTCM) recommended that educators connect the standards of mathematical practices to promote better understand of mathematical concepts by students. When teachers understood the process of the practices they were able to implement them into mathematical lessons. The study discussed some of the mathematical practices in detail and ways in which to integrate them into an educator's everyday mathematics class. The research based article supported the question of do these practices provide a better foundation for students? Once students applied these mathematical practices in the classroom, they began to make connections in the real world (Wenrick, Behrend, & Mohs, 2013).

**Theory in the classroom.**

Wong (2004) had a proactive approach to classroom management. His emphasis was on preparedness, procedures, and routines rather than disciplinary actions. For a classroom to be successful the room is ready, work is ready, and the teacher is ready; for all that the teacher must be prepared. Part of being prepared is to understanding new concepts as they were implemented. Trainings and professional learning communities allowed time for teachers to discuss and strategize how to implement the mathematical practices. He espouses that the first day of school can set the tone for the rest of the school year. This was the time the teacher should go over procedures, rules, and routines; however, he does not expect this to happen only on the first day, he says practicing these routines each day is key. Teachers who used the mathematical practices in lessons each day found the implementation process easier over time (Campbell, 1997).

Greeting students was another component that was key to effective classrooms. When students enter the classroom work should be ready. The teacher should not just take roll. Even nonverbal communication is important.  Students perceive how the teacher is feeling. Time was also important in the classroom getting the students started with the day not only uses time effectively, it also keeps them from getting distracted and misbehaving.

Students should know what is expected of them.  This can be done if teachers set clear procedures and routines.  According to Wong, to be an effective teacher, one must have a discipline plan that does not degrade a student, make good eye contact, use body language, provide a copy of plans for the students, enforce rules consistently, teach consequences and responsibility, and have confidence in their abilities (Wong, 2004).  Implementing the mathematical practices allowed teachers to have confidence in their teaching abilities and in the students (De Villiers, 1998).

***Relevancy.***

Harry Wong's method was an effective strategy especially for first year teachers.  In his book, *How to be an Effective Teacher: The First Days of School,* Wong gave three characteristic that teachers should exude in order to have an efficient and smooth running classroom.  During the first few days of school the teacher will be tested.  These days will make or break the teacher. The procedure, attitudes, and routines will set the tone for the rest of the school year.  The first few days of school can be used as an accurate indicator of how the rest of the school year will be (Wong, 2004).

First, the effective teacher has to have positive expectations for student success.  This should not be confused with high standards, but rather high expectations. An expectation is knowing what you can or cannot achieve or what the person believes will or will not happen. This means that the teacher believes in the student and the student can learn.  When an educator has a positive attitude it not only benefits the student, but the teacher as well.  Wong (2004) says there was not a correlation between family background, race, origin, financial status or even educational accomplishments, but there was a correlation with success and that of one's attitude. It takes the same amount of energy to be positive as it does to be negative so why not be positive?

Secondly, the effective teacher is an extremely good classroom manager. Classroom management consist of practices and procedures that maintain the environment so instruction can occur. Wong believes that this step has very little to with discipline. His example, was that you do not discipline a store you manage it. Being organized was essential especially as a first year teacher, but even in the years that follow. Students know when a teacher is unorganized and this typically gets the students off track (Wong, 2004). Teachers that plan and work out detailed steps in their lesson were able to be effective teachers when implementing new strategies (Kelly, 2015).

Consistency is key in the classroom. When a teacher has a set of procedures and routines in place, these mathematical practices need to be consistently used the same way. You cannot change them and expect the students to follow suit easily. It was very easy for an administrator to tell if a classroom is well managed. Are students deeply involved in work? Do students know what is expected of them? And are they doing it? Is there confusion or wasted time? Is the climate of the classroom work oriented? While these procedures and routines take time educators have gained their time back throughout the school year as the students automatically know what to do. Teachers that used the mathematical practices consistently in the classroom had students to perform mathematical task more efficiently (Wenrick, Behrend, & Mohs, 2013).

Finally, according to Wong the effective teacher knows how to design lessons for student mastery. He believed in order for teachers to teach for mastery they must do two things. First, know how to design the lesson so that a student were able to learn the concept or skill. Second, know how to evaluate the learning that took place in order to determine if the student had mastered the concept or skill. Assessment used correctly can indicate understanding and misunderstanding in students work and in the mathematical practices (Barlow & Drake, 2008). Wong believed, the student's attitude and effort that he or she puts into the work is an indicator of success. The student must also do his or her part in order to be successful (Wong, 2004). To be effective at this a teacher must learn how to allocate time in order to maximize student achievement.

Wong (2004), broke *time* down into four types: allocated time, instructional time, engaged time, and academic learning time. Allocated time is the total amount of time given to the student to learn. Instructional time is the time that the teacher is actually teaching. Wong said, this takes up 90% of the allocated time. The teacher is center stage. Engaged time is when the student is involved or engaged in the task. Academic learning time is the time the teacher can prove or demonstrate that the student mastered the skill. This has nothing to do with worksheets, board-work, lecturing, videos, or discussions. During this time two questions should be answered. Did the student learn what you wanted them to? Can you prove they learned it? Students that were able to discuss the mathematical task and critique others work when performing mathematical task had a better understanding of the mathematical practices (Kuper & Kimani, 2013).

Educators' attitudes and expectations need to be positive, so they are positive for the students. Some students have said, "I have never been good at math" or "I hate math". Educators need to try especially hard to reach these students and show them how fun math can be and all the things that can be done with math (Wenrick, Behrend, & Mohs, 2013). While he or she may not be the highest achieving student, their attitude can change. Teachers must be careful of the attitude they convey towards a subject. The attitude of the teacher will be substantial in creating students desire to learn (Bhargava & Pathy, 2014).

Typically, the first two weeks of school the educator should be modeling procedures and routines for the classroom. Harry Wong's (2004) philosophy of being consistent with procedures and routines can positively affect the mathematical classroom when implementing new standards or practices. For an educator it is important when substitutes leave notes for the educators that say the students followed classroom routines without directions. When students were able to continue with their day even though the teacher is not at school, procedures and routines have been established. The same was seen when students apply the mathematical practices to real world math problems (Newton, 2010).

According to Harry Wong (2004), the teacher is center stage almost every minute. Now, with Common Core and new Mathematical Practices, there is an opposite shift in education. Typically, educational practices shift in and out as seen in the history of education. However, with Common Core and the new pedagogy the teacher is being the facilitator rather than the lecturer. When students were engaged in learning instead of the teacher simply lecturing much more knowledge is gained. Many veteran teachers were having a hard time transitioning to this style of teaching. When teachers were in front of the class demonstrating and explaining they are learning a great deal, but often the students are not. When students began to explain and demonstrate what they have learned, then learning begins for the student (Reinhart, 2000).

Harry Wong (2004) discused the teacher as a professional. This gets at the heart of what makes a teacher a teacher. He discussed the differences in a worker and a leader. "Leaders have careers. People who are constantly enhancing their work lives have careers rather than jobs" (Wong, 2004, p.301).

***Motivation.***

Motivate is a Latin word which means to move (Ciaccio, 2004). Administrators want to move teachers and students towards an end goal. In the text by Owens and Valskey (2015), motivational theories are discussed. The three motivational theories that can be applied to teachers and students when implementing the mathematical practices and common core standards are Maslow's motivation as a hierarchy of needs and Herzberg's two-factor theory of motivation.

Intrinsic motivation is an internal value based motivation. This means it is within the individual. Within intrinsic motivation there are two perspectives; a cognitive perspective and a humanistic perspective. A cognitive perspective on motivation is based on the belief that human beings want to understand the world, make sense of the world, gain control over their lives, and become self-directed. These characteristics motivate people to work towards their individual goals (Owen & Valskey, 2015). On the other hand, the humanistic perspective is the need to constantly grow and develop personal self-esteem and human relationships. Intrinsic motivation is not something that is done to the individual, but rather inside the individual. The opposite of intrinsic motivation is extrinsic motivation. Extrinsic motivation is external with tangible rewards or punishments. Most people who are trying to motivate others use this method. If educators or students do something well or correctly a reward is given. If they do not succeed, with the task a consequence is administered. For example, teachers who receive incentive pay. If your students perform well on standardized test then extra monies will be given.

Abraham Maslow (2015) developed hierarchy of needs by studying the motivation patterns shown by people where they lived.  All human needs start with survival, then continue in a hierarchal pattern.  Deficiency needs are the lower four levels.  The deficiency needs include basic physiological needs, security and safety, social affiliation, and esteem.  If these four needs are not met, it is hard for the person to move onto the growth needs.  Once survival needs are met, the growth needs can begin to be met.  However, the growth needs are never fully met. As stated in *Organizational Behavior in Education,*

> The hierarchy-of-needs view of motivation envisions the realistic possibility of generating enormous psychic energy within and among teachers and principals, and seeing that energy expand and increase over time, first, by meeting their deficiency needs and, second, by encouraging their growth and development needs (Owens & Valskey, 2015, p.121).

Herzberg proposed that motivation is not a single dimension but rather two separate factors.  In Herzberg's theory, an intrinsic factor is job satisfaction while an extrinsic factor is related to job dissatisfaction.  Herzberg has three main ideas for anyone wanting to practice this theory: enrich the job, increase autonomy, and expand personnel administration (Owens & Valesky, 2015).

Schools across the country are implementing new programs and strategies yearly. Although most teachers and paraprofessionals have been to training on these programs, many are reluctant to begin.  Some of the complaints are:

- The training did not prepare them.
- More work is being demanded from teachers and paraprofessionals.
- The students are being pushed in different directions.

- Can these programs actually show growth?

Education is forever changing. As an educator one must be flexible and willing to change. Even though most classroom teachers realize this, they are still reluctant at times to change. When teachers complain that the training did not train them properly, typically the problem is they have not worked with the material enough to effectively use it. One way to help motivate the staff is to let curriculum coaches guide the teachers and paraprofessionals through the process if they are struggling. If teachers are still having a hard time the curriculum coaches could model a lesson. Once staff members become more familiar with the material, motivation to use the curriculum will increase. The same can be said when implementing the mathematical practices. As teachers become more familiar with the practices, motivation to use the practices increases (Ciaccio, 2004). .

Educator must take an active role in what is being accomplished. Having the right attitude is a good first step toward personal and professional growth (Ciaccio, 2004). While more is being demanded of these teachers, having the right attitude and cultivating the right climate will motivate the educators. When the administration is on board with the program and has the right attitude this will filter down to the teachers and paraprofessionals. This is exactly what Maslow is describing when he says the motivator should be encouraging the growth and developmental needs.

Most teachers did not become a teacher because of the status or for the salary. They became teachers because they had a true calling or passion to teach. Once testing takes place and teachers can see student growth, motivation will occur. This is an intrinsic motivation. A powerful motivation tool for teachers is seeing student growth. As teachers see the mathematical practices and Common Core Standards improving student mathematical achievement motivation will occur.  When people realize their effectiveness, it motivates them to do more (2011).  If the program is truly working and they have the right attitude, they will be motivated to work the program and help the students grow.  Too much testing is a complaint but, without testing growth cannot be seen.  Motivation is important in all aspects of learning, including the teacher as a learner.  Implementing the mathematical practices in relation to the content standards was difficult and time consuming, but positive outcomes were seen in student achievement (Rigeiman, 2007).  As teachers see these positive outcomes of their students, they were motivated to continue implementing the mathematical practices (Martin, Brasiel, Turner, & Wise, 2012).

Herzberg has two main motivational practices that could be applied to this situation.  The first is enriching the job.  If teachers can see the program is effective, they will be motivated to work it.  Secondly, increase in autonomy is an effective motivational practice (Owens & Valesky, 2015).  This can be accomplished by having teachers work with curriculum coaches.  The more the teachers actually work the program the more motivated they will be.  "In other words, it is not inspiring visions, moral exhortation, or mounds of irrefutable evidence that convince people to change, it is the actual experience of being more effective that spurs them to repeat and build on the behavior"(Fullan, 2011, p.).

While it will take time to see the student growth, motivation can still occur as students are reading more fluently in classroom activities.  Teachers are motivated by student achievement and student motivation.  Teachers should change their own thinking and behavior instead of trying to change the students thinking or behavior.  When having the right attitude, it can inspire teachers to look inward for solutions (Ciaccio, 2004).

## Literature Related to the Mathematical Practices

### Mathematical Practices.

What is a mathematical practice? According to the Tennessee Department of Education (2015) website, the mathematical practices describe multiple levels of expertise that mathematic educators should seek to develop in their students. These practices are broken down into two categories: National Council of Teachers Mathematics process standards and strands of mathematical proficiency according to the National Research Council's report. The NCTM process standards include problem solving, reasoning and proof, communication, representation, and connections. The National Research Council's report includes adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition. These mathematical practices are used from kindergarten through high school. There are eight standards for mathematical practice.

1. Make sense of the problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Not all of these mathematical standards will be present in every lesson; however, all can be connected to math content. These standards and practices set high expectations for Tennessee students to prepare them for the rigorous demands of understanding mathematical process for college and career.

1. **Make sense of problems and persevere in solving them.** For students to be proficient with the first mathematical practice they start by explaining the meaning of the problem to themselves and looking for an entry point to begin solving. These students analyze the problem and make conjectures about the problem instead of skipping all around. While the student is working, they monitor themselves and the progress they are making. Mathematical proficient students check their answer and look to see if it makes sense.
2. **Reason abstractly and quantitatively.** To be proficient within this practice, students need the ability to do two things: de-contextualize and contextualize. If a student can de-contextualize they can take numbers out of context and work with them mathematically. When a student can contextualize they can put the numbers in a real world context and work the problem mathematically.
3. **Construct viable arguments and critique the reasoning of others.** Students are proficient when they can use stated assumptions, definitions, and prior knowledge to construct arguments. These students can justify their answers and communicate this to other students. They can also reason inductively about data and make plausible arguments when discussing mathematical problems. No matter the age group, these students listen or read the arguments of others and decide if it makes sense or ask questions based on the problem.
4. **Model with mathematics.** When proficient students can apply the mathematics they know to everyday life, society, and the workplace they are modeling with

mathematics. These students are able to identify important quantities and use them in practical ways such as tables, maps, flowcharts, and formulas.

5. **Use appropriate tools strategically.** Some of the tools that a student might consider using are paper and pencil, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a statistical package, or geometry software. Proficient students are familiar with the tools and use them appropriately. Another component of this practice is being able to use technological tools to develop and explore understanding. Students must also recognize which tool to use and why that specific tool was chosen.
6. **Attend to precision.** Student that are proficient within this practice communicate precisely to others. These students use clear definitions and state the meaning of symbols which are used accurately. These students calculate accurately and efficiently while using the appropriate units of measure.
7. **Look for and make use of structure.** In this practice the students look for patterns and sequences among the structure of the problem. These students can step back away from the problem and shift perspective when solving other problems. Complicated things such as algebraic expression can be composed after working with several problems.
8. **Look for and express regularity in repeated reasoning.** In this practice the students notice if calculations are repeated they look for general methods of solving, as well as, shortcuts. Proficient students maintain oversight of the process while paying close attention to the details. They are continually checking for reasonableness.

**Mathematical Practices in the Classroom.**

Meghan Everette (2013) described the mathematical practices and ways in which the practices should look in a mathematical classroom.

1. Give students tough tasks and let them work through them. Allow wait time for yourself and your students. Work for progress and "aha" moments. The math becomes about the process and not about the one right answer. Lead with questions, but don't pick up a pencil. Have students make headway in the task themselves.
2. Have students draw representations of problems. Break out the manipulatives. Let students figure out what to do with data instead of boxing them into one type of organization. Ask questions that lead students to understanding. Have students draw their thinking, with and without traditional number sentences.
3. Post mathematical vocabulary and make your students use it. Work on your classroom environment from day one so that it is a safe place to discuss ideas.
4. Have students use math in science, art, music, and even reading. Use real graphics, articles, and data from the newspaper or other sources to make math relevant and real. Have students create real-world problems using their mathematical knowledge.
5. Don't tell students what tool to use. Try to leave the decision open ended and then discuss what worked best and why. For example, if an educator wanted their students to find their height. The student had measuring tapes, rulers, and meter sticks among their math tools. Once everyone found their height, the students discussed which tools worked best and why. Leave math tools accessible and resist the urge to tell students what must be used for the task. Let them decide.

6. Push students to use precise and exact language in math. Measurements should be exact, numbers should be precise, and explanations must be detailed. Students have to explain exactly what they do and do not understand and where their understanding falls apart.
7. Help students identify multiple strategies and then select the best one. Repeatedly break apart numbers and problems into different parts. Use what you know is true to solve a new problem. Prove solutions without relying on the algorithm. For example, when students are changing mixed numbers into improper fractions. They should prove to the teacher that they have the right answer without using the "steps".
8. Students do not need to work fifty of the same problem; take mathematical reasoning and apply it to other situations.

Looking at these mathematical practices, teachers will find that they currently already use most of them within their classroom instruction. The key is to be sure you are using the mathematical practices correctly and consistently. In order to incorporate most of these practices into the classroom, the class will need to be student driven while the teacher facilitates. That does not mean hand the students a task and walk away. The questions should lead the students down a mathematical sound path. Do not revert back to teacher lead instruction. Education is moving into the time that teacher should facilitate student learning.

A good strategy to become familiar with the mathematical practices is to work with other math teachers within the same grade level or one grade level above or below. It is always effective to see what was taught the previous year. Sometimes teachers assume that was a skill from the previous grade and find out it wasn't after all. Really discuss these practices and the ways the mathematical practices are already being used in the classroom, as well as, new ways to implement them. Teachers get their best ideas from fellow teachers.

The Tennessee State Department of Education (2015) states that, these standards are based on a balance between understanding and procedure. Students need a flexible base to apply practical mathematics to situations. These standards engage students to grow with the subject matter. Any information regarding the Mathematical Practices can be found on the Tennessee Department of Education Website.

**Content to practices.**

These mathematical practices illustrate ways in which students should develop discipline as they grow into mathematicians. When educators are looking for curricula, assessments, and professional development, these practices should connect to the mathematical content through the instruction.

The Standards for Mathematical Content are a balance between procedure and understanding. When students are expected to understand this balance a good connection between the practices and standards is in place. Students who lack understanding may rely on procedures too much which prevents the student from becoming proficient within the grade level. Students need both understanding of the content, as well as, procedures on how to solve. This can be achieved when the mathematical practices and standards are combined effectively.

Etienne Wenger has created the Theory Social Practice (as cited in Mirci, P. & Jungwirth, L., 2014, p. 23). This involves the specific functions that teachers do in the real world, such as, how a person is engaged with the world. Opposite of that is Wenger’s theory of identity, which deals with the social formation of the person. This deals with class, gender, ethnicity, age, and other characteristic forms.

If teachers use meaningful and mindful classroom practices this can be achieved (Barlow & Drake, 2008). When teachers use these Mathematical Content Standards they can visualize how to effectively implement the Mathematical Practices into their classrooms where learning important mathematics is meaningful for students (Wenrick, Behrend, & Mohs, 2013). In the past, the student's role was to work individually and learn passively. In a problem solving environment students work in groups and actively learn (Kuper & Kimani, 2013). As students engage in problem solving they began to develop their reasoning skills and turn into mathematicians (Rigeiman, 2007). Teachers want thinking to take place throughout the entire lesson; therefore, as soon as the teacher says the answer is correct then thinking stops. Instead of saying it is correct teachers should extend students' knowledge and ask "what if?" to advance student learning and thinking (Reinhart, 2000).

#### ***Challenge.***

It is important that educators shift student and teacher thinking from simply getting the right answer; to how did we get the right answer and can we apply that strategy to other mathematical concepts? The mathematical practices are to help with student understanding. They are the why and how of math.

## Specific Literature Related to the Current Study

### Implementing mathematical practices into the mathematical content.

Many times in the classroom teachers tell the answers and show students shortcuts; however, that is taking away the students responsibility and cheating them of the opportunity to make sense of the problem (Reinhart, 2000). While there are many models to help teachers implement strategies into a lesson the Thinking Through a Lesson Protocol prompts teachers to think deeply about the lesson specifically and advance students' mathematical understanding (Smith, Bill, & Hughes 2008). As classroom teachers, we want students to be flexible and fluent thinkers, as well as, willing to take challenges and persevere to make sense of the problem (Rigeiman, 2007).

Over the years, research has proven that children's approach to learning mathematics is distinctly different from that of an adult (Campbell, 1997). Children want to solve problems and get enjoyment out of solving problems if they can solve these problems in ways that make sense to them (Buschman, 2003). As standards and practices change, students are expected to develop a deeper understanding of the mathematics. When students are using problem writing in daily mathematics classes teachers can assess this type of knowledge (Drake & Barlow, 2008). When students hear alternate approaches to problems they can make important conclusions about mathematics (Newton, 2010).

**Implementation.**

Implementation of new strategies and skills is often a time consuming task for teachers. However, if teachers understand the standards of mathematical practices it enables them to effectively implement the newly adopted standards. Within each grade there is focus of standards that should be taught over the bulk of the school year. Depending on the grade, this can be anywhere from two to three critical areas; however the mathematical practices are to be used across all grade levels.

**THINK Framework.** THINK is a framework that students can use when problem solving. This framework is based on two instructional methods that enhance mathematical reasoning. One focuses on metacognitive and the second focuses on cooperative learning. It was found that classroom instruction that combine both of these strategies had higher problem solving achievement than when used alone (Thomas, 2006). When teachers allow students time for thinking, believe that young children can solve problems, listen carefully to their justifications, and structure an environment that promote problem solving it will promote students innate problem solving inclinations and encourage them to preserve (Buschman, 2003). As teachers use problem solving as an assessment, it can reveal understanding and misunderstanding of a concept and guide the teacher towards the next step in his or her instruction (Drake & Barlow, 2008).

The **THINK** Framework is an interaction framework for students to use. Talk about the problem with one another when students describe the situation. Students will explain what the problem is asking and talk about all important information. How can the problem be solved and what are some of the various ways it can be solved? Identify a strategy for solving the problem and use it. Students will talk about how the strategy worked and decide if another strategy should be used. Notice how the strategy helped the teacher to solve the problem and have students share how this helped their problem solving. Keep thinking about the problem and decide if the answer makes sense, as well as solve the problem using a different strategy (Thomas, 2006). When students are asked to share their solutions and ideas with partner or the class it opens a window of learning and understanding around mathematical ideas (Siegel & Ortiz, 2012).

According to the study conducted by Kelli Thomas (2006), students that used the THINK model enhanced their abilities to internalize and in turn use the problem solving process. When students participate in cooperative groups using the THINK model metacognitive skills are developed.

**Thinking Through a Lesson. E**ducators need to control teaching with high level tasks and one way to promote success is detailed planning prior to the lesson. A way to ensure success is by using the Thinking Through a Lesson Plan, known as the TTLP. There are three detailed parts to this plan. First, select and set up a mathematical task. This process is time consuming and should have great thought put into it. As teachers work through the process they should see what ways the task builds on prior knowledge, what concepts or ideas do students need in order to begin the task, and what are all the ways the task can be solved (Smith, Bill, & Hughes, 2008). Changing a little at time by selecting and refining task can show incremental growth (Reinhart, 2000).

Secondly, this model supports student exploration of the task. This is the educator's time to ensure students stay engaged on the task without giving them an answer or ways to solve (Smith, Bill, & Hughes, 2008). This is a time when getting the "right" answer is not as important as "how do you know" (Wenrick, Behrend, & Mohs, 2013). Teachers need a detailed plan on what assistance the teacher will give, what to do if a group is finished early, and what to do if a group focuses on the non-mathematical aspects (Smith, Bill, & Hughes, 2008).

Finally, educators need to plan on how to share and discuss the task. How will the educator have the class discuss the mathematical goals and practices that were accomplished? Educators need specific questions that they will ask students to ensure they have made sense of the problem, question the solutions that are shared, make connections along the way, look for patterns, and begin to form generalizations (Smith, Bill, & Hughes, 2008). When students are in an environment where they become the authority to determine right or wrong reasoning, they will thrive (Wenrick, Behrend, & Mohs, 2013). Communicating mathematical ideas to classmates is another step in understanding mathematics (Thomas, 2006).

**Problem Solving.** In the article, *A Pathway for Mathematical Practice,* (Wenrick, Behrend, & Mohs, 2013), the authors take a look at how the classroom teacher integrates the standards for mathematical practices. To begin the class she put four true or false statements on the board to explore and extend their understanding of the commutative property of addition, decomposition of numbers, number relationships, and the meaning of the equal sign. The teacher takes a poll once the students have time to formulate an answer. While the students were discussing their answers they were listening. Some of the undecided students began to formulate opinions based on their classmates' responses. The students work in pairs and were allowed to use manipulatives of their choice to solve the problem.

This teacher has implemented three of the Mathematical Practices in this lesson: problem solving, communication, and reasoning. This class is engaged in the learning and has connected the Mathematical Practice to the content (Wenrich, Behrend, & Mohs, 2013). The standards and the practices suggest that problem solving should enable students to build knowledge, solve problems that arise in mathematics and beyond, apply and adapt strategies to mathematical concepts in the real world (Rigeiman, 2007). This teacher has applied these practices to the content; as states adopt these standards teachers need to be mindful about the implantation of the practices within the content (Wenrich, Behrend, & Mohs, 2013).

While teachers know that education reform suggests students need to increase problem solving abilities, that does not ensure focus is on student understanding and problem solving skills (Rigeiman, 2007). A fundamental flaw that teachers are making is when they are in front of the class demonstrating and explaining the students are not learning a great deal (Reinhart, 2000). If teachers are doing all the talking students are not learning as much as they could be if the students were doing the talking and discussing. According to Reinhart (2000), there are a few techniques that teachers can use to increase problem solving skills. First, never say anything a kid can say. Instead turn the students statement into a question. Second, ask good questions. This takes practice and time, but the best questions are open ended. Replace lecture type lessons with sets of questions that require students to reflect, analyze, and explain their thinking and reasoning. Finally, be patient. Wait time is very important. Increasing wait time by five seconds can result in more and better responses.

**Lesson Implementation.** In a mathematical classroom students should be taking risks and trying to solve mathematical problems. For example, a lesson that is dealing with division of fractions should not just be the teacher saying multiply the reciprocal. It is essential you do multiply the reciprocal, but why? Many adults are not sure why you do that. Students should be using problem solving skills and strategies to understand the why of math. One of the easiest ways to do that when teaching division of fractions is with pattern blocks. Eventually, the students will learn that we are just multiplying the reciprocal but if they know why and how this works. Then they can apply that strategy to other math concepts.

**Communication.** Many of the Mathematical Practices involve the students communicating their reasoning. This is not the same thing as communicating the correct answer to the question, but rather why is that the answer. A shift has to be made from traditional teaching to problem solving. In traditional teaching the role of the teacher was to lecture the class, assign seat work, and dispense knowledge. In a problem solving environment the teacher's role is to guide and facilitate student learning, pose challenging questions and help students share knowledge (Kuper & Kimani, 2013). Teachers who expect all students to explain and justify their strategies or solutions do not presume that all answers will be correct (Campbell, 1997). These teachers know that this wrong answer can guide some of the most influential discussions.

In the past, the student's role was to work individually and learn passively. In a problem solving environment, students work in groups and actively learn (Kuper & Kimani, 2013). As students engage in problem solving they began to develop their reasoning skills and turn into mathematicians (Rigeiman, 2007). Teachers want thinking to take place throughout the entire lesson; therefore, as soon as the teacher says the answer is correct then thinking stops. Instead of saying it is correct teachers should extend students' knowledge and ask "what if?" to advance student learning and thinking (Reinhart, 2000).

**Lesson Implementation.** Every lesson in a mathematical classroom should have clear communication between the students and the teacher. For example, when students are working on a task dealing with the area of irregular shapes they need to be able to communicate their understanding of how to find the area. As a teacher your communication should be guiding the students thinking with good questions. When students discuss their strategies for solving they should be able to communicate and critique each other's process. This is often a great learning tool for a classroom teacher. Students respond well when their peers explain strategies.

**Defining.** In many math classrooms the teacher gives the students terms and the students either listen to definitions from the teacher or look them up in the glossary. When this happens the students learn the concept after the definition. Another approach to this is when teachers teach the concept first and then it is presented with vocabulary term as a way to name it (Stephen, McManus, Dickey, & Arb, 2012). This is known as descriptive definitions because it involves describing an already known mathematical concept (De Villiers ,1998). The constructive method is another way to teach definitions which involves students modifying previous understanding of a term and creating a new idea. When using descriptive and constructive strategies for defining words, students have a more meaningful connection to the word (Stephen, McManus, Dickey, & Arb, 2012). If students are able to transition from concrete to abstract as they use definitions' correctly it will support students' development of functional thinking (Markworth, 2012).

**Lesson Implementation.** When teaching a math lesson about geometry there are many definitions that come into play. For example, instead of telling the students what defines different quadrilaterals have the students make conclusions about these shapes. The teacher should of course guide students thinking and conclusions without giving too much away. If the students come up with the definitions their conceptual understanding will be much higher.

## Conclusion

It is important that educators shift student and teacher thinking from simply getting the right answer; to how did we get the right answer and can we apply that strategy to other mathematical concepts. The Mathematical practices help with student understanding. The mathematical practices are the why and how of math. It is time for teachers to be flexible and willing to try new teaching strategies to insure students are becoming proficient in mathematics and are ready for rigor and demand that college and career life can bring.

# CHAPTER 3

# METHODOLGY

## Description of the Research

This study dealt with both qualitative and quantitative analysis; therefore, it was a mixed methods study. "Practitioners, evaluators, policymakers and funding agencies now recognize that combining multiple forms of data within a single study is not only legitimate but also, at times, preferable" (Ary, Jacobs, Sorensen, & Walker, 2014, p.590). The Tennessee Comprehensive Assessment Program (TCAP) test scores were from the 2009-2010 school year and the 2011-2012 school year. The 2009-2010 TCAP test scores were completed before the Mathematical Practices were mandated by the state of Tennessee. These scores were compared to the 2011-2012 school year TCAP test. This was the first school year that the state of Tennessee mandated the implementation of Mathematical Practices in grades kindergarten through 12th. For the purpose of this study only grades third through eighth were considered. These were the grades in which TCAP testing is required.

The students in the groups varied from year to year as the study is comparing the scores from the teachers that taught both the 2009-2010 school year and the 2011-2012 school year. Therefore, the test scores are unrelated groups since different students were tested from year to year. The study is comparing the teachers test scores prior to implementation of the mathematical practices to when the scores were implemented. The scores were taken from the teachers overall achievement scores and gains scores per year. The individual students' scores were not followed. This is an ex post facto design with a purposive selection of teachers and the chosen years of TCAP data that were used. It is a sample of convenience to insure the data included teachers that taught mathematics both school years. The independent variable was the mathematical practices implemented during the second set of TCAP data. The dependent variable was the TCAP test scores.

The data used were the TCAP test scores pre-mathematical practices and post-mathematical practices. The achievement scores and gain scores were both used. These practices were adopted in 2010 and implemented into the curriculum between 2011-2014 school years.

The t-test for independent samples allowed the researcher to interpret results and compare the scores. The first set of data were the TCAP test scores prior to implementation of the mathematical practices and the second set of data were the TCAP test scores after implementation was mandated. By using the t-test for independent samples the researcher interpreted and compared scores between the two sets of data. The value or the error term was calculated from the difference within the two sets of data. This was the standard error of the difference between the two means. The level of significance is 0.05 since this is educational research. The degrees of freedom for the t-test of independent sample was $n_1+n_2-2$. This is a nondirectional test since the mathematical practices could have a positive or negative effect on student achievement (Ary, Jacobs, Sorensen, & Walker, 2014).

The second aspect of the study was the qualitative piece. This was a basic interpretative study. The purpose was to understand the experience of the teachers and the ways in which he or she implemented the mathematical practices into his or her classroom. The study also compared the six teachers' personal interviews about implementing the eight mathematical practices. The interview questions enabled the researcher to gain insight on the ways in which the mathematical practices were implemented and how the educators assess students understanding of the mathematical practices. The interviews along with the TCAP testing data were needed to gain a better understanding of the effectiveness of the mathematical practices in the classroom. The TCAP test scores were used to triangulate the data with the interview and the implementation of the mathematical practices.

**Description of the Study Participants and Setting**

The participants for this study were from elementary and middle school mathematics teachers in grades third through eighth. The six participants taught in the 2009-2010 school and the 2011-2012 school year. These teachers taught mathematics before Common Core was mandated and the mathematical practices were implemented, as well as the years that followed when they were mandated and implemented. The teachers were a purposive sample due to the fact that these six teachers met the requirements set forth by the study. Each teacher taught in the 2009-2010 school year and the 2011-2012 school year. Each teacher attended summer training mandated by the state department to learn strategies and ways to implement the mathematical practices. Each teacher had TCAP data to compare achievement scores prior to the mandating the practices, as well as, after the state mandated the mathematical practices.

All participants for this study worked in a Title I pre-kindergarten through eighth grade public school. The free and reduced population fluctuates between 80-85%.

The teachers that meet the requirements were asked for involvement in the study during the 2016-2017 school year. Once the teachers agreed to the interview process, a date was set up that was convenient for the teacher and the researcher. The interviews took place one-on-one and lasted between forty-five minutes to an hour.

**Data Collection Procedures**

Data were collected through teacher interviews and summative TCAP test scores. While the interviews were qualitative, the TCAP data were quantitative. This was a mixed methods study since the TCAP test scores and interviews were both used. This study was to learned how the mathematical practices effect student achievement; therefore, it was a basic interpretative study. “The purpose is to understand the world or experience of another” (Ary, Jacobs, Sorensen, & Walker, 2014, p. 32). The researcher used data to observe what has occurred in mathematical classrooms. The study included interviews, as well as comparing TCAP data prior to mathematical practices and post implementation of the mathematical practices.

Teacher interviews focused on questions pertaining to the topic of mathematical practices and the teaching style of the teacher. The questions are in appendix A. These interviews were semi-structured, so the researcher can modify the questions or the format if need be. For the interviews, the researcher asked the teachers open-ended questions about the ways in which mathematical practices are used in their classrooms. Questions dealing with classroom strategies and implementation of student centered classrooms were also be asked. At the beginning of the interview a checklist was used to survey the teachers in regards to demographics and experience information. This consisted of five questions about the teacher’s career thus far. Then the researcher interviewed the participants on the specific question focus on the mathematical practices. The interviews were personal interviews with each teacher that is participating in the study. The interviews lasted between forty-five minutes to an hour.

The summative test scores were TCAP scores from the 2009-2010 school year and the 2011-2012 school year. The data being used was TCAP scores pre-mathematical practices and post-implementation of mathematical practices. Two types of scores used were achievement and growth scores. The achievement scores used showed the percentage of advanced or proficient for mathematics. The growth scores used showed the gain made by year. Both sets of data were compiled into two groups. The first group was the TCAP scores prior to the mandated mathematical practices in comparison to TCAP scores after the state mandated the implementation of the mathematical practices. The data were also broken into subgroups by grade level. These grade levels were third through eighth grade. These practices were adopted in 2010 and implemented into the curriculum between 2011-2014 school years. Since actual implementation did not occur until the 2011 school year, the 2010 school year will be not be considered in the study. The scores were collected from the school which were on file. The scores can also be accessed through public data bases.

**Ethical Considerations**

To ensure confidentiality no teacher, student, or school names will be used. Each teacher signed a consent form allowing the researcher to interview the participant. The consent form can be found in appendix B. These forms are kept on file in a locked cabinet. The scores that were being used can be accessed through public data bases. No student or teacher name was used in the study. There was no harm to the teacher, student, or school for this study.

**Limitations and Delimitations**

All mathematics teachers that taught in the 2009-2010 school year and the 2011-2012 school in grades third through eighth were chosen for the study. This was a limited sample. External validity is caused due to the generalizability of the research findings in comparison with the setting and population. The interviews and surveys could contain bias as the teachers are self-reporting. Teachers were being asked to remember events from the past; therefore, selective memory could occur. If the events were not remembered accurately. Exaggeration or attribution could occur as the teachers report information. The teachers could tell the researcher what they think they want to hear.

The school is a Title 1 school which is a low socioeconomic status, but has its own culture and climate. The delimitations of the study were all of the students are from grades third through eight. The groups of students vary from year to year and from teacher to teacher.

**Data Analysis Procedures**

"Good qualitative study based on semi-structured interviews relies on the knowledge, skills, vision and integrity of the researcher doing that analysis" (Rabionet, 2011, p.565). The interview questions were tested for validity by having colleagues who are familiar with mathematics and this study to review the questions. None of these individuals participated in the study; however, they have background knowledge of the content, curriculum, and practices. The colleagues judged the questions and determine if they were appropriate and representative of the sample under investigation. To ensure reliability the participants read over and reviewed their typed responses from the interview. This enabled the interviewee and the researcher to ensure accuracy.

The information gathered from the interviews was compiled and coded. First, the data were broken apart into smaller sections to make categories. Within the categories, themes were identified and compiled. Once the themes and categories were refined, the researcher looked for relationships and patterns within the data. Some pre-determined categories were (a) personal teaching efficacy beliefs; (b) teaching outcome expectancy beliefs; (c) beliefs about the teacher's role during mathematics instruction; (d) beliefs about the student's role during mathematics instruction; and (e) classroom teaching practices. While these were pre-determined categories, other categories were added once the data were gathered and coding.

The summative data were analyzed using the t test for independent samples to determine the difference between the two means of mathematical practices and student achievement. The data that was used is TCAP test score pre-mathematical practices and post-implementation of mathematical practices. The data were compiled into two groups. The first group was TCAP test scores prior to the mandated mathematical practices in comparison to TCAP test scores after the state mandated the implementation of the mathematical practices. The data were also to be broken into subgroups by grade level. "The t-test for independent variables is a straightforward ratio that divides the observed difference between the means by the difference expected through chance alone" (Ary, Jacobs, Sorensen, & Walker, 2014, p. 185). By using the t-test for independent samples, the researcher was able to interpret results and compare the scores of two different sets of data. The level of significance is 0.05 since this was educational research. The data were analyzed and calculations were determined the probability that these same results will occur again.

The first set of data were the mathematical TCAP test scores from the 2009-2010 school year. The second set of data were the mathematical TCAP test scores from the 2011-2012 school year. This was the dependent variable. The independent variable was the mathematical practices implemented during the second set of TCAP data.

**Summary**

The researcher used both qualitative and quantitative data to have a deeper understanding of the effectiveness of the mathematical practice on student achievement. The methods used to compare the summative test scores allowed comparison between years without the mathematical practices and years with the mathematical practices. The study furthered analyzed data from teacher interviews to give the researcher insight as to how the mathematical practices look in a classroom and various methods of implementation. Both types of data were needed to see a balanced comparison and evaluation of the mathematical practices.

# CHAPTER 4

# ANALYSIS OF DATA

## Introduction

The research questions allow the researcher to assess the implications of the mathematical standards on student achievement. It also allowed the research to gather information on the various methods and strategies that teachers are using to implement these practices into their classrooms.

## Research Question 1

When the eight standards of mathematical practices are implemented into third through eighth grade mathematical classes what effect do these practices have on student achievement test scores?

The t-test is used when comparing the averages of two separate groups. The t-test requires two independent samples with data that is normally distributed. The first t-test is the TCAP growth scores from the 2009-2010 school year and the 2011-2012 school year. The 2009-2010 TCAP growth scores were used for the first treatment the data is shown in table 1. The 2011-2012 TCAP growth scores were used for the second treatment the data is shown in table 2. After mathematical practices were implemented, growth scores were higher ($M= 3.94$, $SS= 241.77$) than before the mathematical practices were implemented ($M= -3.78$, $SS= 89.31$), $t= -1.89743$, $p= 0.04717$.

Table 1

*TCAP Growth Scores2009-2010*

| Treatment 1 (X) | Diff (X-M) | Sq Diff (X-M) |
|---|---|---|
| -4.9 | -1.12 | 1.25 |
| -9.1 | -5.32 | 28.3 |
| -4.4 | -0.62 | 0.38 |
| 3.9 | 7.68 | 58.98 |
| -4.4 | -0.62 | 0.38 |
| | M: -3.78 | SS: 89.31 |

Table 2

*TCAP Growth Scores 2011-2012*

| Treatment 2 (X) | Diff (X-M) | Sq Diff (X-M) |
|---|---|---|
| 5.5 | 1.56 | 2.43 |
| -7.7 | -11.64 | 135.49 |
| 11.8 | 7.86 | 61.78 |
| 9.5 | 5.56 | 30.91 |
| 0.6 | -3.34 | 11.16 |
| | M: 3.94 | SS: 241.77 |

The result was significant at $p < 0.05$ since $p = 0.04717$. The TCAP growth scores per grade level during the 2009-2010 school in comparison to the 2011-2012 school years are shown in figure 1. These are the scores that were used in treatment one and two of the t-test. After the mathematical practices were implemented into the curriculum growth scores of students increased. The results of the t-test show a statically significant outcome.

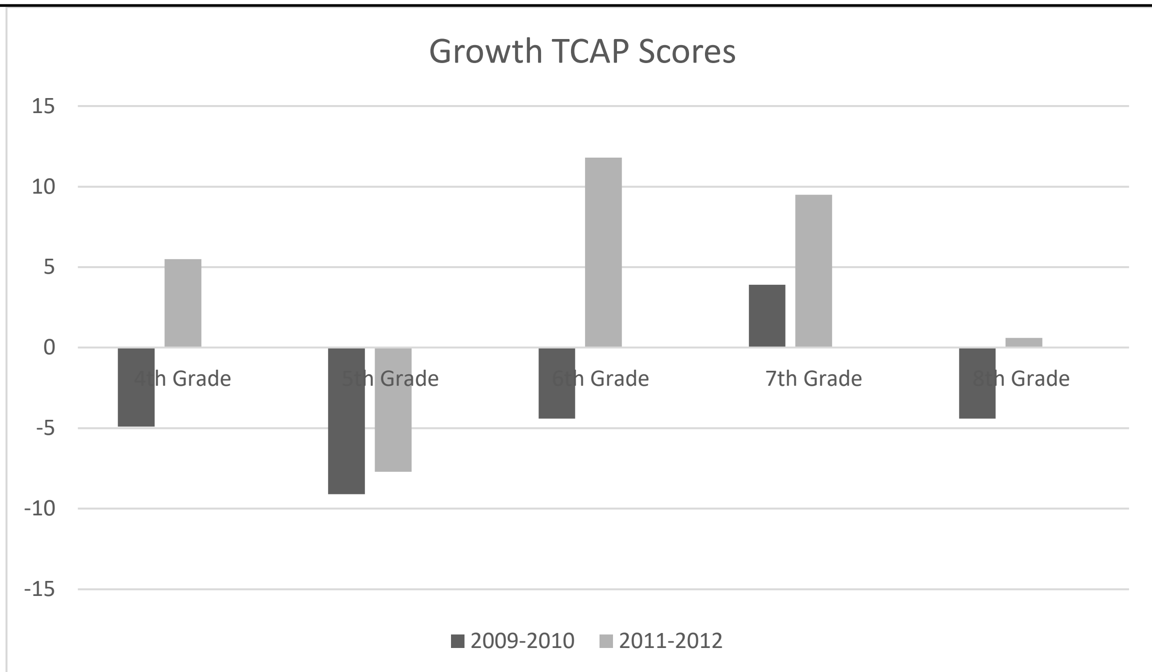


Figure 1. TCAP Growth Comparison Scores for 2009-2010 School Year and 2011-2012 School Year. Figure 1 shows the TCAP growth scores from the 2009-2010 school year in comparison to the 2011-2012 school year. Any information regarding the TCAP scores can be found on the Tennessee Department of Education Website (2015).

The second t-test were the TCAP achievement percentage of advanced or proficient test scores from the 2009-2010 school year and the 2011-2012 school year. The percentages used are the percent of students that were advanced or proficient per grade level. The 2009-2010 school year percentages are the first treatment found in table 3. The 2011-2012 school year percentages are the second treatment data found in table 4. After mathematical practices were implemented percent of students advanced or percent were less (M= 45.12, SS= 301.53) than before the mathematical practices were implemented (M= -94.42, SD= 33.21), t= 14.75897, p= 0.00001.

Table 3

*TCAP Achievement Percentages of Students who were Advanced and/or Proficient2009-2010*

| Treatment 1 (X) | Diff (X-M) | Sq Diff (X-M) |
|---|---|---|
| 96.5 | 2.08 | 4.34 |
| 96.5 | 2.08 | 4.34 |
| 97 | 2.58 | 6.67 |
| 91.5 | -2.92 | 8.51 |
| 91.5 | -2.92 | 8.51 |
| 93.5 | -0.92 | 0.84 |
| | M: 94.42 | SS: 33.21 |

Table 4

*TCAP Achievement Percentages of Students who were Advanced and/or Proficient2011-2012*

| Treatment 2 (X) | Diff (X-M) | Sq Diff (X-M) |
|---|---|---|
| 59.3 | 14.18 | 201.17 |
| 46.8 | 1.68 | 2.83 |
| 44.8 | -0.32 | 0.1 |
| 42.8 | -2.32 | 5.37 |
| 40 | -5.12 | 26.18 |
| 37 | -8.12 | 65.88 |
| | M: 45.12 | SS: 301.53 |

The result was significant at $p < 0.05$ since $p = 0.00001$. In comparison at all grade levels a decrease in advance and proficient students is seen. However, between these two school years a new testing format and testing company was used. The scale scores and cut scores between the years are not the same. More rigorous standards were in place after the mathematical practices were implemented. Even though a decrease in advanced and proficient students is seen there is still a statistically significant outcome from both t-tests. When analyzing the data using both the achievement scores and the growth scores a significant relationship was found after the mathematical practices had been implemented into the classroom.

**Research Question 2**

> How do teachers implement the eight mathematical practices into the mathematical curriculum that is mandated by the Tennessee State Department?

Basic interpretative study was used to understand the experience of the teachers. This information was collected through interviews. The participants for this study were from elementary and middle school mathematics teachers in grades third through eighth. The teachers are labeled Teacher A-F throughout the study when reporting comments or direct quotes. In order to follow confidentiality guidelines as stated in chapter three, the teachers are not in alphabetical order. This is important to protect the identity of the interviewee. The six participants taught in the 2009-2010 school year and the 2011-2012 school year. The selected teachers taught mathematics before Common Core was mandated and the mathematical practices were implemented, as well as the years that followed when they were mandated and implemented.

Of the six teachers, two teachers have taught more than twenty-six years, two taught between fifteen and twenty years, and two have taught between ten and fifteen years. The six teachers have different educational backgrounds. One of the six teachers has earned a doctorate degree, two teachers have earned an education specialist degree, one teacher has earned a masters degree, and one a bachelor degree. All teachers have taught mathematics during their entire teaching career at various grade levels. All teachers taught in rural communities during the 2009-2010 school year and the 2011-2012 school year. The six teachers were asked seven open ended questions about mathematics, the mathematical practices, and implementation. As described by John Creswell (2014), an interview protocol was followed by the researcher who recorded information from the interview by audio taping and making handwritten notes.

The information gathered from the interviews was compiled and coded. First, the data were broken apart into smaller sections to make categories. Within the categories and themes were identified and compiled based on recurrent themes. Once the themes and categories were refined, the researcher looked for relationships and patterns within the data. This is an issue-focus analysis to determine what can be learned about specific issues from the interviewee. Coding took place by linking what the respondent said to the concepts and categories of the study. Then sorting took place to organize the excerpts of the interview according to the categories and concepts. The categories were (a) personal teaching efficacy beliefs; (b) teaching outcome expectancy beliefs; (c) beliefs about the teacher's role during mathematics instruction; (d) beliefs about the student's role during mathematics instruction; (e) classroom teaching practices; (f) methods of implementations of the mathematical practices; and (g) the impact of the mathematical practices on student learning.

Before the mathematical practices were implemented, two teachers reported the role of the teacher was to lecture to the students when teaching the material. Once the lecture was over, the students are to work independently on mathematical concepts then this would be assessed by the teacher. Another teacher reported the role of the teacher was to guide the student learning through various task, modeling procedures, and group work. Teacher A responded, *Students cannot simply be handed a task and let loose. They need guidance and modeling throughout the math lesson*. This teacher reported that various methods were used to assess students, such as: participation, group work, guided, and independent practice. Three teachers reported the role of the teacher before the mathematical practices were implemented was to model mathematics with the students. Once modeling occurred then students would work independently on a mathematical concept or task. This work would then be assessed. Based on the teacher's belief, all six teachers believed that they meet the role of the teacher that he or she described. Each teacher stated they meet this role due to student participation and grades received in the classroom for comprehension of skills.

Now that the mathematical practices have been implemented into the curriculum, all teachers reported the role of the teacher has shifted to a facilitator role. The two teachers that reported the role of the teacher was to lecture reported that the teacher's role is still to present the skill or lesson to the students but to incorporate more interaction among the students throughout the lesson. Four of the six teachers reported that the role of the teacher is to guide student knowledge and the thinking process without simply stating the procedure, but allowing the students to figure out the procedure as the teacher facilitates the lesson. Of the six teachers only one reported confidence as a facilitator in the classroom. The other five teachers have incorporated more strategies to allow the facilitator role, but report that many times students give up because they are not sure what to do. This in turn reverts teaching back to a lecture or modeling style of teaching in the classroom.

A common theme in all six interviews was the role of the student in the classroom. Each teacher stated the student's role was to focus on the mathematical content and perform the various tasks and procedures taught in the classroom. The ways in which the students showed performance in the task or procedure was where the differences occurred. Two teachers reported the role of the student was to listen to the teacher explanation and then use the strategies the teacher taught to perform the various mathematical task or procedures. Four of the six teachers reported the role of the student was to be an engaged learner and to participate in the strategy process of the mathematical practices.  Two teachers reported allowing students to use various methods to solve problems.  All teachers reported that at various times there have been students that were not able to fill the role he or she believed the student should have in the classroom. Various reasons were reported as to why students were not able to fill this role, such as: home support, motivation, attention span, and lack of prior knowledge.

A common theme from the interviews when asked what the role of the student was once the practices were implemented was that student should be an independent thinkers.  The six teachers reported that the student should seek to solve the mathematical task with various procedures.  The six teachers all reported more responsibility should be placed on the students as the learners.  When asked if students were able to fill this role two themes occurred.  Four out of six teachers reported yes with practice.  While two out of six teachers reported “no” the students are unsure what to do.  Three teachers reported that students were able to be independent thinkers once procedures and guidelines were set in the math class.  For example, one teacher reported that for the first two weeks of school student’s practice working together, designing strategies, and ways to persevere through mathematical task.  This teacher reported that students often wait for the teacher to give the answer or strategy; therefore, the goal is to make the students manipulate the problem and design a strategy to use on the mathematical task.  This same teacher reported that having these strategies posted in the classroom reminds the students and gives them confidence to persevere.  Teacher C responded, *When students know what is expected of them they will typically meet these expectations.*  Two teachers reported that depending on the mathematical task students were able to be independent thinkers.  They reported that when problems became too difficult or unfamiliar many times students gave up and waited for the teacher or classmates to give the answers.  One teacher stated that some students were unsure of what steps to take without guidance and assistance from the teacher. This teacher said that many times students would give up on the problem because they could not come up with the steps in order to answer the mathematical task. *When students lack prior knowledge they will often give up*. According to this teacher, some students give up on a problem due to gaps in prior knowledge. All six teachers conveyed that some students were able to fill the role of the student and they believed the student should have in the mathematical classroom at various rates and times.

The six teachers were asked how you incorporate the mathematical practices into your classroom. Each teacher also made note that not every practice is used or seen in every mathematical lesson. The following list contains the various methods the teachers reported by mathematical practice.

- Mathematical Practice 1: Make sense of problems and persevere in solving them.
    - Encourage students to use their own thinking when solving a problem.
    - Do not give up when the task at hand is hard.
    - Give students tasks that can be solved in various ways.
    - Tasks that are given should be rich in problem based application.
    - Allow students to brainstorm strategies in order to solve the problem.
    - Once an answer has been derived check to see if it reasonable.
- Mathematical Practice 2: Reason abstractly and quantitatively.
    - Teachers should facilitate opportunities for students to discuss mathematical task.
    - Teachers should encourage the use of properties and relationships between numbers as students solve problems.

- Provide chances for students to decontextualize and/ or contextualize the mathematics they are learning.
- Real world application should be used.

- Mathematical Practice 3: Construct viable arguments and critique the reasoning of others.
  - Provide opportunities for students to listen to the solutions and strategies of other students.
  - Discuss alternative solutions.
  - Allow students time to defend their ideas.
  - The teacher should ask higher order thinking questions to encourage students to develop and describe their solutions and strategies.
  - Provide time for students to think critically about the mathematics they are learning.
  - Classroom environment should be a conducive learning environment where mistakes are welcomed.
- Mathematical Practice 4: Model with mathematics.
  - Incorporate appropriate mathematical models into the lesson.
  - Encourage students to use mathematical models.
  - Remind students that throughout the task various models can be used to represent the problem.
- Mathematical Practice 5: Use appropriate tools strategically.
  - Provide students with access to materials, tool, models, and technology based on what is needed for the task.
  - Allow students to decide what tool is appropriate.

    - Help students decide what tools could be used and why.
- Mathematical Practice 6: Attend to precision.
    - Use precise definitions, notations, and vocabulary in the classroom.
    - Emphasize the importance of precise communication and have the students focus on language usage.
    - Encourage students to express answers accurately and efficiently in context of the problem.
- Mathematical Practice 7: Look for and make use of structure.
    - Provide activities so that students can demonstrate their flexibility when representing mathematical numbers.
    - Engage students to discuss relationships between topics and mathematical strategies.
    - Explore quantitative relationships.
- Mathematical Practice 8: Look for and express regularity in repeated reasoning.
    - Allow for discussions to relate to repeated reasoning.
    - Students need strategies prerequisites that are necessary to solve a problem.
    - Encourage students to continually evaluate the reasonableness of their results.

A recurrent theme heard when teachers were asked how they implement the eight mathematical practices into the mathematical curriculum was allowing time for more student-centered learning. As shown in Table 5 four of the six teachers stated that time is now given for students to think through the task and share with ideas with their peers before beginning the lesson. Teacher C stated that, *Students can learn a great deal from their peers, but must be given the opportunity to do this*. Five of the six teachers stated that allowing time for more group work permitted students to accomplish more of the mathematical tasks. Teacher D reported, *Group work allows students who are not confident in math become more confident as they work alongside their peers*. Three of the six teachers stated that asking open-ended higher order thinking questions encouraged students to dig deeper into the mathematical task and use more of the mathematical practices in his or her work. According to teacher D, *Questions are essential to lead students down a particular path. Teachers should have a list of questions generated before the lesson begins*.

Table 5

*Recurrent Themes Seen When Implementing the Mathematical Practices*

| Percent of Teachers | Implementation strategy |
|---|---|
| 67% | allow students more time to think and share with peers |
| 83% | allow students more time to work in groups |
| 50% | ask students open-ended higher order thinking questions |

All six teachers reported that during the math lesson students should be engaged in the lesson and participating in the task at hand. Each teacher in the interview stated various ways in which the students showed that they were engaged and participated in the lesson. Two of the six teachers reported that students demonstrated engagement in the lesson when the task was completed correctly. Two of the six teachers reported that students proved engagement in the lesson when students were actively participating and working towards the goal of the mathematical task even if the incorrect answer was achieved. Two of the six teachers reported engagement in the lesson was seen when students were generating ideas and strategies to solve the problem.

For each mathematical topic and goal, the six teachers reported the classroom can look very different. All six teachers said that mathematical classrooms had modeling, guided work, and independent practice. Three of the six teachers commented on the use of technology in the classroom and using different forms of technology to incorporate into the lesson.

Two of the six teachers made comments that since the implementation of mathematical practices have been implemented, they are making more of an effort to become the facilitator in the classroom. All six teachers made remarks that since the mathematical practices have been implemented, the teachers are planning and carefully choosing guided questions to lead students down a path of inquiry. Four of the six teachers reported that they are no longer simply stating "this is how we do the math now you try it". They are allowing time for the students to make the decisions of the why and how of math.

When the teachers were asked if the mathematical practices were useful in their classroom they all reported yes. However, four stated that some practices were more important than others. Teacher A said, *I think that persevering and making sense of the problem is the most important practice the others will follow if students can make sense of the problem*. Five teachers stated that many of the practices were already being used in their classroom to some extent before implementation occurred. This illustrated importance of mathematical practices. All six teachers believed the mathematical practices are important and helped students to gain a deeper understanding of mathematical concepts and help to build a stronger mathematical foundation.

All six teachers indicated that their teaching had an impact on student learning. Three reported that since students have become more independent thinkers, they saw an increase in mathematical comprehension in their students. Two teachers reported that students have made comments from previous years about the lesson and activities that the teacher used and how it has helped them in future math classroom. Four teachers reported that they still see students struggling with mathematics even though the mathematical practices have been implemented. Teacher A stated that, *Often the higher level learners struggle with the modeling and manipulating the mathematical problem while the struggling math student may find modeling easier*. These same four teachers commented that math will always be harder for some students than others, but with new strategies and practices in place, students are grasping concepts better.

**Conclusion**

The t-test showed a significant relationship between the achievement test scores and the growth scores after the mathematical practices were implemented. In all grades an increase was seen in growth scores. In all grades a decline was seen in the number of students that were advanced or proficient. Even though the number of advanced and proficient students dropped, a significant outcome was seen. The interviews gave insight into the classroom and the implementation of the mathematical practices. The classrooms teachers are seeing a positive relationship when using the mathematical practices in their math lessons with the overall comprehension of mathematical skills achieved by students. The t-tests support the teachers and show a statically significant outcome after the mathematical practices were implemented. The interviews along with the TCAP testing data were needed to gain a better understanding of the effectiveness of the mathematical practices in the classroom. The TCAP test scores were used to triangulate the data with the interview and the implementation of the mathematical practices.

# CHAPTER 5

# FINDING, CONCLUSIONS, RECOMMENDATIONS

## Introduction

The purpose of this study was to determine if the mathematical practices have an effect on student achievement scores and to learn about the ways teachers implement the mathematical practices into their classrooms. TCAP scores from the 2009-2010 school year and the 2011-2012 school year where used to compare student achievement and growth scores. During the 2009-2010 school year, the mathematical practices were not mandated by the state department; however, during the 2011-2012 school year implementation was required. The 2010-2011 was omitted due to districts having the choice to implement the mathematical practices. Analysis was completed to see the difference in the TCAP scores from these two years. Teachers were also interviewed to gain insight into the implementation process of the mathematical practices. The interviews took place in a one-on-one setting with open ended questions. The information gathered from the interviews was then coded and compiled by categories and themes. A summary of the findings, conclusions, and recommendations is presented in this chapter.

## Mathematical Practices

According to the Tennessee Department of Education (2015) website, the mathematical practices describe multiple levels of expertise that mathematic educators should seek to develop in their students. These mathematical practices are used from kindergarten through high school. There are eight standards for mathematical practice.

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.

4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

The Standards for Mathematical Content are a balance between procedure and understanding. When students are expected to understand this balance a good connection between the practices and standards is in place. Students who lack understanding may rely on procedures too much which prevents the student from becoming proficient within the grade level. Students need both understanding of the content, as well as procedures on how to solve. This can be achieved when the mathematical practices and standards are combined effectively.

**Study**

This study dealt with both qualitative and quantitative analysis; therefore, it was a mixed methods study. The Tennessee Comprehensive Assessment Program (TCAP) test scores were from the 2009-2010 school year and the 2011-2012 school year. The 2009-2010 TCAP test scores were completed before the Mathematical Practices were mandated by the state of Tennessee. These practices were adopted in 2010 and implemented into the curriculum between 2011-2014 school years. These scores were compared to the 2011-2012 school year TCAP test.

The students in the groups varied from year to year as the study is comparing the scores from the teachers that taught both the 2009-2010 school year and the 2011-2012 school year. The scores were taken from the teachers overall achievement scores and gain scores per year. The data used were the TCAP test scores pre-mathematical practices and post-mathematical practices. The achievement scores and gain scores were both included. The t-test for independent samples allowed the researcher to interpret results and compare the scores.

The second aspect of the study was the qualitative piece. The purpose was to understand the experience of the teachers and the ways in which he implemented the mathematical practices into his classroom. The study also compared the six teachers' personal interviews about implementing the eight mathematical practices. The interview questions enabled the researcher to gain insight on the ways in which the mathematical practices were implemented and how the educators assess students understanding of the mathematical practices. The interviews along with the TCAP testing data were needed to gain a better understanding of the effectiveness of the mathematical practices in the classroom.

## Summary and Conclusions

This study included two research questions. The first research question was analyzed using two different t-tests. The second research question was analyzed through interviews from six teachers. Each research question is listed below with the findings and recommendations associated with each question.

## Research Question 1

Research Questions 1: When the eight standards of mathematical practices are implemented into third through eighth grade mathematical classes, what effect do these practices have on student achievement test scores?

Two separate t-tests were analyzed to test research question one. The first t-test used the growth scores from the 2009-2010 school year in comparison to the growth scores from the 2011-2012 school year. This included fourth through eighth grade. Third grade was omitted in this test as third grade does not have growth scores. Second grade students do not complete

TCAP test; therefore, there is no data available to find the growth of third grade students. In all grades from the 2009-2010 school year to the 2011-2012 school year, positive growth was seen. The t-test indicated a statistically significant outcome. This suggest that students made more gains once the mathematical practices were implemented.

The second t-test used the percent of students that were advanced or proficient during the 2009-2010 school year in comparison to the 2011-2012 school year. This included students in third through eighth grade. Third grade is included in this test since these students completed the TCAP test. The 2009-2010 percent of students that were advanced or proficient overall was higher than the 2011-2012 percent of students that were advanced or proficient. While all grade levels saw a decrease in the number of students that were advanced or proficient the results of the t-test still indicated a significant outcome. The second t-test had a significant outcome even though the scores dropped. Although, the test was formatted differently a positive outcome suggest that the mathematical practices have a positive effect on student achievement scores.

### Research Question 2

Research Question 2: How do teachers implement the eight mathematical practices into the mathematical curriculum that is mandated by the Tennessee State Department?

This information was collected through interviews. The participants for this study were from elementary and middle school mathematics teachers in grades third through eighth. The six participants taught in the 2009-2010 school and the 2011-2012 school year. These teachers taught mathematics before Common Core was mandated and the mathematical practices were implemented, as well as the years that followed when they were mandated and implemented. The information gathered from the interviews was compiled and coded. First, the data were broken apart into smaller sections to make categories. Within the categories, themes were identified and compiled. Once the themes and categories were refined the researcher looked for relationships and patterns within the data.

A common theme in all six interviews was the role of the student in the classroom. Each teacher stated the student's role was to focus on the mathematical content and perform the various tasks and procedures taught in the classroom. All teachers reported that at various times there have been students that were not able to fill the role he believed the student should have in the classroom. Various reasons such as: home support, motivation, attention span, and lack of prior knowledge were reported as to why students were not able to fill this role,

The six teachers were asked how he or she incorporates the mathematical practices were incorporated into the classroom. Each teacher also made note that not every practice is used or seen in every mathematical lesson. As stated in chapter four the teachers use various methods to incorporate the mathematical practices. The interviews support the ideas from Kuper and Kimani (2013), in a problem solving environment the teacher role is to guide and facilitate student learning, posing challenging questions and helping students share knowledge. Fifty percent of the teachers interviewed reported that they now ask students open-ended higher order thinking questions. Kuper and Kimani also noted that in the past the student's role was to work individually and learn passively. In a problem solving environment students work in groups and actively learn (2013). The interviews support this since 67 percent of the teachers reported that they now allow students more time for students to think and share with peers and 83 percent allow students more time to work in groups with peers. For each mathematical topic and goal the six teachers reported the classroom can look very different. All six teachers said that mathematical classrooms had modeling, guided work, and independent practice.

All six teachers indicated the mathematical practices are important and helped students to gain and deeper understanding of mathematical concepts and help to build a stronger mathematical foundation. When teachers use these mathematical content standards, they can visualize how to effectively implement the mathematical practices into their classrooms where learning important mathematics is meaningful for students (Wenrick, Behrend, & Mohs, 2013).

**Conclusions.** This analysis alone would not support the use of the mathematical practices to increase the TCAP mathematics scores. It does however, add to knowledge of supporting the mathematical practices. The data does show an increase in student growth from the 2009-2010 school year before the practices were implemented to the 2011-2012 school year once the mathematical practices were implemented. As Rigeiman (2007) discussed, the standards and the practices suggest that problem solving should enable students to build knowledge, solve problems that arise in mathematics and beyond, apply and adapt strategies to mathematical concepts in the real world. While more time and testing data is needed to determine the full impact of the mathematical practices and its effect on student growth and achievement. This study found increased growth between the 2009-2010 school year and the 2011-2012 school year. Results of these analysis support Drake and Barlow (2008), as standards and practices change our students are expected to develop a deeper understanding of the mathematics they are studying.

## Recommendations

As mathematical standards are becoming more rigorous, new mathematical practices are needed to ensure our students are becoming mathematically sound. Teachers need to be aware of the mathematical practices and the various ways these practices can be implemented into the classroom. Change is not easy, but with the right tools the transition into these mathematical practices can come with ease.

First and foremost, teachers need to become familiar with these mathematical practices. Teachers need be sure they fully understand the meaning of each mathematical practice. While that sounds simple enough, it is not so easy. Teachers need to delve deeply into these mathematical standards and give a summary of the practice meanings and ways it can be used in the classroom. Many of the mathematical practices can already be seen in the math classroom. The key is to be sure educators are using the mathematical practices correctly and staying consistent. In order to incorporate most practices into the classroom the class should be student driven while the teacher facilitates. That does not mean hand the students a task and walk away. The questions should lead the students down a mathematically sound path.

The best strategy to become familiar with the mathematical practices is to work with other math teachers within the grade level or one grade level above or below. It is always effective to see what was taught the previous year. Sometimes teachers assume that a skill was taught in the previous grade and find out it was not after all. Discuss these practices and the ways teachers are already using them in the classroom, as well as new ways to implement them. Teachers get their best ideas from fellow teachers.

Secondly, teachers need to recognize they cannot change every teaching strategy or technique. If teachers begin to change their entire teaching strategies and norms they will grow tired and revert back to their *old* ways. Harry Wong recommends, in one school year, teachers should change one or possibly two things about their teaching strategies or norms per year (2009). Questioning is another area that most teachers can work on. The questions that educators ask students are very important. Student thinking should be guided towards mathematically sound strategies without just giving them the answers or confirming they are correct. Changing a little at time by selecting and refining a task can show incremental growth (Reinhart, 2000).

**Recommendations for future research.** Results of this study indicated an overall positive impact once the mathematical practices were implemented into the mathematical classroom. Gains were seen in the growth scores from the 2009-2010 school year to the 2011-2012 school year. Results from both t-tests indicate a statistically significant outcome when comparing the growth scores and the achievement scores from the 2009-2010 school year and the 2011-2012 school year. The interviews supported the data and research from the study stating that the mathematical practices had a positive impact on students mathematical understanding and concepts. While the data and information gained from this study reported positive effects of the mathematical practices being implemented into the classroom, further analysis is needed. A study completed on a larger scale to include multiple districts and schools with varied demographics would provide valuable information. This study focused on test scores prior to the mathematical practice being implemented and then once the practices were implemented. Developing a study to monitor the effect of the mathematical practices on the classroom over a period of time to determine the effectiveness would allow one to assess the impact of the mathematical practices on student growth.

**Concluding statements.** The purpose of the study was to see how the implementation of mathematical practices affected student's mathematical achievement. Over the years, research has verified that children's approach to learning mathematics is distinctly different from that of an adult (Campbell, 1997). There is little research to negate the use of the mathematical practices in the classroom. Results from this study show that the mathematical practices have a positive effect on student achievement. The research topic can be expanded to include various school districts, various demographics, and over a longer period of time.

References

An agenda for action recommendations for school mathematics for the 1980s. (2004). Resource Prepared by the Center for the Study of Mathematics Curriculum. http://www.mathcurriculumcenter.org/PDFS/CCM/summaries/agenda4action_summary.pdf

Americans instrumental in establishing standardized tests. (2014). *PBS: Frontline.* http://www.pbs.org/wgbh/pages/frontline/shows/sats/where/three.html

Ary, D., Jacobs, L., Sorensen, C., and Walker, D. (2014). *Introduction to research in education.* California: Wadsworth.

Barlow, A. & Drake, J. (2008). Assessing understanding through problem writing division by a fraction. *Mathematics Teaching in the Middle School, 13*(6), 326-332.

Bhargava, A. & Pathy, M. (2014). Attitude of student teachers towards teaching profession. *Turkish Online Journal of Distance Education*, *15*(3), 27-36. (ERIC Document Reproduction Service No. EJ1043694).

Buschman, L. (2003). Children who enjoy problem solving. *Teaching Children Mathematics, 9*(9), 539-544.

Burns, M., Pierson, E., & Reddy, S. (2014). Working together: How teacher's tech and students learn in collaborative learning environments. *International Journal of Instruction, 1*(7), 17-31.

Campbell, P. (1997). Connecting instructional practice to student thinking," *Teaching Children Mathematics*, *4*(2), 106-110.

Ciaccio, J. (2004). Totally positive teaching a five –stage approach to energizing students and teachers. *Virginia: Association for Supervision and Curriculum Development*.

Creswell, J. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches.* Los Angeles: Sage.

De Villiers, M. (1998). To teach definition or to teach to define?. *Proceeding of the 22nd Conference of the International Group for the Psychology of Mathematics Education, 2,* 248-255.

Drake, J. & Barlow, A. (2008). Assessing students' levels of understanding multiplication through problem writing," *Teaching Children Mathematics, 14*(5), 272-277.

DuFour, R. & Eaker, R. (1998). *Professional learning communities at work: Best practices for enhancing student achievement* (47-56). Virginia: Solution Tree Press.

Eaker, R. & Keating, J. (2016). A new way of thinking: Schools as professional learning communities. *Source.* Retrieved from: http://www.advanc-ed.org/source/new-way-t hinking-schools-professional-learning-communities

Everette, M. (2013). A guide to the 8 mathematical standards. http://www.scholastic.com/teachers/top-teaching/2013/03/guide-8-mathematical-practice-standards

Fletcher, D. (2009). A brief history of standardized testing. *Time.* http://content.time.com/time/nation/article/0,8599,1947019,00.html

Fullan, M. (2011). *Change leader: Learning to do what matters most*. San Francisco, CA:Jossey-Bass.

Gersten, R., Taylor, M., Keys, T., Rolfhus, E., & Newman-Gonchar, R. (2014). Summary of research on the effectiveness of math professional development approaches. *Regional Educational Laboratory Southeast.*

Graham, E. (2013). A nation at risk' turns 30: Where did it take us? *neaToday*. http://neatoday.org/2013/04/25/a-nation-at-risk-turns-30-where-did-it-take-us-2/

Harris, A. (2010). Using professional learning communities to build teacher leadership capacity: Creating sustainable change in education. *School of Education and Counseling Psychology.* Dominican University of California: San Rafael, CA.

Illustrative Mathematics (IM). (2016). Practice standards overview. https://www.illustrativemathematics.org/practice-standards

Kelly, J. (2015). Collaboration, collegiality, and collective reflection: A case study of professional development for teachers. *Canadian Journal of Educational Administration and Policy, 169.*

Klein, D. (2003). A brief history of American K-12 mathematics education in the $20^{th}$ century. *Mathematical Cognition.* http://www.csun.edu/~vcmth00m/AHistory.html

Kuper, E. & Kimani, P. (2013). Responding to students' work on a rich task. *Mathematics Teaching in the Middle School, 19*(3), 164-171.

Markworth, K. (2012). Growing patterns: Seeing beyond counting. *Teaching Children Mathematics, 19*(4), 254-262.

Martin, T., Brasiel, S., Turner, H., & Wise, J. (2012). Effects of the connected mathematics project 2 (CMP2) on the mathematics achievement of grade 6 students in the Mid-Atlantic region. *Institute of Education Sciences.*

Meador, D. (2014). Pros and cons of standardized testing. *About Education.* http://teaching.about.com/od/assess/a/Standardized-Testing.htm

Mirci, P. & Jungwirth, L. (2014). A commentary on Etienne Wenger's keynote presentation at the 2012 California Association of Professors of Educational Administration

(CAPEA) Conference. *Educational Leadership and Administration: Teaching and Program Development*, *25*, 22-26.

Newton, K. (2010). The sweetest chocolate milk. *Mathematics Teaching in the Middle School, 16*(3), 148-153.

Owen, R, & Valesky, T. (2015). *Organizational behavior in education: Leadership and school reform* 11th ed. Boston: Pearson.

Perry, R., Seago, N., Burr, E., Broek, M. & Finkelstein, N. (2015). *Math in common classrooms observations documenting shifts in instruction for districtwide improvement*. San Francisco CA: WestEd.

Phillips, C. (2015). The new math strikes back. *Time.* http://time.com/3694171/the-new-math-strikes-back/

Quattlebaum, S. (2012). Why professional development for teachers is critical. *The Evellloution.* Retrieved from: http://evolllution.com/opinions/why-professional-development-for-teachers-is-critical/

Rabionet, S. (2011). How I learned to design and conduct semi-structured interviews: An ongoing and continuous journey. *Qualitative Report*, *16*(2), 563-566.

Reinhart, S. (2000). Never say anything a kid can say!," *Mathematics Teaching in the Middle School, 5*(8), 478-483.

Rentfro, E. (2007). Professional learning communities' impact student success: This school uses a professional learning community to target students' needs. *Leadership Compass*, *5*(2).

Rigeiman, N. (2007). Fostering mathematical thinking and problem solving: the teacher's role. *Teaching Children Mathematics*, *13*(6), 308-314.

Siegel, A.& Ortiz, E. (2012). Perimeter and beyond. *Teaching children Mathematics, 19*(1), 38-41.

Smith, M., Bill, V., & Hughes, E. (2008). Thinking through a lesson: successfully implementing high-level tasks. *Mathematics Teaching in the Middle School, 14*(3), 132-138.

Stephen, M., McManus, G., Dickey, A, & Arb, M. (2012). Defining supports geometry. *Mathematics Teaching in the Middle School*, *18*(2), 92-98.

Tennessee Department of Education. (2015). http://www.tn.gov/education/standards/math.shtml

Tennessee Department of Education. "Mathematical Practices PDF," (2015). http://www.tn.gov/education/standards/math/std_math_standards_mathematical_practice.Pdf

Thomas, K. (2006). Students THINK: A framework for improving problem solving. *Teaching Children Mathematics, 13*, 86-95.

Wenrick, M., Behrend, J., & Mohs, L. (2013). A pathway for mathematical practices. *Teaching Children Mathematics*, *19*(6), 354-362.

Wong, H. & Wong, R. (2004). *How to be an Effective Teacher The First Days of School.* Mountain View, CA: Harry K. Wong Publishers, Inc.

Appendices

# Appendix A

## Interview Questions

1. How long have you been teaching?

   __0-4 years __5-9 years __10-14 years __15-20 years __21-25 years

   __over 26 years

2. How long have you been teaching mathematics?

   __0-4 years __5-9 years __10-14 years __15-20 years __21-25 years

   __26 years or more

3. What grade level did you teach in the 2009-2010 school year and 2011-2012 school year?

   __pre-K-1 __2-3 __4-5 __6-8

4. What type of school district did you work in for the 2009-2010 school year and 2011-2011 school year?

   __urban __ rural

5. What degrees do you currently hold list any endorsements?

   __ bachelors __masters __ education specialist __doctoral

   Endorsements: ______________________________________

6. Before the mathematical practices were implemented what did you believe the role of the teacher was in the classroom? Were you able to fill this role? How?

7. Before the mathematical practices were implemented what did you believe the role of the student was in the classroom? Were they able to fill this role? How?

8. Now that the mathematical practices have been implemented what do you believe the role of the teacher is in the classroom? Are you able to fill this role? How?

9. Now that the mathematical practices have been implemented what do you believe the role of the student is in the classroom? Are they able to fill this role? How?

10. Describe how you incorporate the mathematical practices in your classroom? What does a math lesson look like? What are you doing as a teacher? What are the students doing?
11. Do you find the mathematical practices useful in your current teaching situation? If so, how? If not, why?
12. Do you believe your math teaching will impact your students' learning? If so, how? If not, why?

# Appendix B

## Consent to Participate in a Research Study

**Consent to Participate in a Research Study**

**Carson-Newman University: Jefferson City, TN**

**Title of Study**: Implementing Mathematical Practices within Mathematical Content

**Investigator Name**: Jennifer Partin **Phone**: 931-494-3183

**Introduction**

- You are being asked to be in a research study about implementing mathematical practices within mathematical content.
- You were selected as a possible participant because you taught in the 2009-2010 school year and the 2011-2012 school year, attended summer training mandated by the state department to learn strategies and ways to implement the mathematical practices, and have TCAP data to compare achievement scores prior to the mandating the practices, as well as, after the state mandated the mathematical practices.
- I ask that you read this form and ask any questions that you may have before agreeing to the study.

**Purpose of the Study**

The purpose of the study is to see how the mathematical practices that are being implemented effect student's mathematical achievement. The study also explores how teachers implement the mathematical practices into curriculum.

**Description of the Study Procedures**

- If you agree to be in this study, you will be asked to do the following things: one on one interview about mathematical practices and the implementation of the mathematical practices and read the type copy of your response to ensure accurate information. The interview will be no longer than 45 minutes.

**Risk/Discomforts of Being in this Study**

There are no reasonable foreseeable risk (or expected) risk. There may be unknown risk.

**Benefits of Being in the Study**

- The benefits of participation are that this study is important because classroom mathematic teachers need to know how to implement the eight mathematical practices into the current mathematic curriculum. Educators are required to teach students to have a deeper understanding of the processes involved in mathematical problems. Therefore, educators need to know how to implement these practices effectively into their classrooms.

**Confidentiality**

The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file. I will not include any information in any report I may publish that would make it possible to identify you.

**Right to Refuse or Withdraw**

The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or Carson-Newman University. Your decision will not result in any loss or benefits to which you are otherwise entitled. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

**Right to Ask Questions and Report Concerns**

You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, at any time feel free to contact me, Jennifer Partin at jpartin@grundyk12.com or by telephone at 931-494-3183. If you like, a summary of the results of the study will be sent to you. If you have any other concerns about your rights as a research participant that have not been answered by the investigators, you may contact Dr. Deborah Hayes at dhayes@cn.edu from Carson-Newman University.

**Consent**

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

Subject's Name: ________________________________________

Subject's Signature: ____________________________________ Date: __________________