A STUDY IN STANDARDS IMPLEMENTATION
IN ALGEBRA I AND ALGEBRA II

A Dissertation
Presented to
The Faculty of the Education Department
Carson-Newman University

In Partial Fulfillment
Of the
Requirements for the Degree
Doctor of Education
By
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March 2019
Dissertation Approval

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Abstract

The purpose of this qualitative research study was to determine secondary mathematics teachers’ knowledge of Tennessee’s new mathematics standards and how these standards relate to other mathematics courses. Additionally, the study sought to identify ways to assist teachers in interpreting the standards to develop a curriculum that is standards-based. Data for the qualitative study was collected from secondary mathematics teachers through an online survey, semi-structured interviews, and a focus group. Analysis of the data led to a deeper understanding of the implementation of secondary mathematics standards in Algebra I and Algebra II. The findings acknowledged that understanding of the standards begins with effective professional development on the standards and collaboration with peers about the standards and teaching practices. Teaching practices change and evolve through collaboration with peers on lesson planning and modeling of mathematics. Teachers are better able to implement standards when they understand the content at deep levels and learn from peers. Teaching mathematics requires continuous learning and improvement of practice.

Keywords: secondary mathematics, standards, Algebra I, Algebra II
Acknowledgements

This has been a labor of love. I have been blessed by the support system I have had through this whole process. I can never express the depth of my gratitude for all the people who have taken this journey with me. Without you all I could not have reached this dream. My husband, Chris, you are my rock. You have been beyond supportive through this whole endeavor, always encouraging me. I love you always. Nathaniel, my pride and joy, you turned my world upside down, but your smiling face and exuberance for life were always a welcome distraction when I needed a break. My in-laws and babysitters were willing and ready to snuggle Nathaniel and keep him entertained so I could spend countless hours researching and writing. To my mom, who spent hours upon hours, reading the equivalent of Greek, as you edited my chapters, often questioning if something was a math thing. To my daddy, you inspired me to reach for this goal. To Heather and Kristy, you are my best friends and best motivators. To my friends and colleagues, you motivated me to keep going and never give up. To my students, you are the driving force behind every endeavor I undertake to become a better teacher. Thank you all for making my life better.

I would like to thank my committee members. Dr. Dean, you have been an amazing chairperson, as you have listened, supported, and challenged me through this entire crazy process. Dr. Taylor, your belief in me and your enthusiasm for my topic has aided my confidence of my place in the world of mathematics and teaching. Dr. Sobiech, you have worked tirelessly on breaking me of my love for passive voice; you have aided me in becoming a better writer. Finally, Dr. Rines, thank you for expanding my vocabulary as you edited my writing, increasing the power of my writing. I have learned abundantly through this process.
Dedication

I dedicate this study to my husband and son; you are my world. I love you.
# Table of Contents

Dissertation Approval Form ................................................................. ii
Copyright ................................................................................................ iii
Permission Statement ................................................................. iv
Abstract ...................................................................................... v
Acknowledgements ..................................................................... vi
Dedication ................................................................................... vii
List of Tables .............................................................................. xiv

I. Introduction ......................................................................................... 1

  Research Problem ................................................................. 2
  Purpose of the Study ............................................................... 3
  Theoretical Framework ......................................................... 3
  Research Questions ............................................................... 4
  Rationale for the Study ........................................................... 4
  Limitations ............................................................................... 5
  Delimitations ............................................................................ 5
  The Researcher .......................................................................... 6
  Definition of Terms .................................................................. 6
  Summary .................................................................................... 7

II. Review of Literature ........................................................................ 9

  Introduction ............................................................................... 9
  Standards .................................................................................. 10
    Definition of a Standard ....................................................... 10
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of Mathematics in the United States</td>
<td>10</td>
</tr>
<tr>
<td>National Council of Teachers of Mathematics Standards</td>
<td>12</td>
</tr>
<tr>
<td>Tennessee State Standards of Mathematics</td>
<td>16</td>
</tr>
<tr>
<td>Structure of Tennessee Mathematics Standards</td>
<td>17</td>
</tr>
<tr>
<td>Algebra Standards</td>
<td>18</td>
</tr>
<tr>
<td>Theoretical Framework</td>
<td>19</td>
</tr>
<tr>
<td>Constructivist Theory</td>
<td>19</td>
</tr>
<tr>
<td>Constructivism and Mathematics</td>
<td>20</td>
</tr>
<tr>
<td>Definition of Teaching Methodology</td>
<td>21</td>
</tr>
<tr>
<td>How Teaching Affects Student Learning</td>
<td>22</td>
</tr>
<tr>
<td>Standards-Based Curriculum</td>
<td>23</td>
</tr>
<tr>
<td>Elements of a Standards-Based Classroom</td>
<td>24</td>
</tr>
<tr>
<td>Implications of Standards-Based Classroom</td>
<td>25</td>
</tr>
<tr>
<td>Criticism of Standards-Based Curriculum</td>
<td>26</td>
</tr>
<tr>
<td>Standards-Based Grading</td>
<td>27</td>
</tr>
<tr>
<td>Mathematical Teaching Practices</td>
<td>29</td>
</tr>
<tr>
<td>Teaching Practices Supporting the Mathematical Practices</td>
<td>29</td>
</tr>
<tr>
<td>Change</td>
<td>30</td>
</tr>
<tr>
<td>Definition of Change</td>
<td>30</td>
</tr>
<tr>
<td>Leading Change</td>
<td>30</td>
</tr>
<tr>
<td>Professional Learning Communities</td>
<td>32</td>
</tr>
<tr>
<td>Structure</td>
<td>32</td>
</tr>
<tr>
<td>Goals and Objectives</td>
<td>34</td>
</tr>
<tr>
<td>Study Groups</td>
<td>36</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td>Testing Data</td>
<td>37</td>
</tr>
<tr>
<td>Need for Future Research</td>
<td>39</td>
</tr>
<tr>
<td>Summary</td>
<td>41</td>
</tr>
<tr>
<td><strong>III. Methodology</strong></td>
<td>42</td>
</tr>
<tr>
<td>Qualitative Research</td>
<td>42</td>
</tr>
<tr>
<td>Research Approach</td>
<td>43</td>
</tr>
<tr>
<td>Research Setting and Participants</td>
<td>43</td>
</tr>
<tr>
<td>Sampling</td>
<td>44</td>
</tr>
<tr>
<td>Data Collection Procedures</td>
<td>44</td>
</tr>
<tr>
<td>Survey</td>
<td>45</td>
</tr>
<tr>
<td>Semi-Structured Interviews</td>
<td>45</td>
</tr>
<tr>
<td>Focus Group</td>
<td>46</td>
</tr>
<tr>
<td>Data Analysis Procedures</td>
<td>47</td>
</tr>
<tr>
<td>Survey</td>
<td>47</td>
</tr>
<tr>
<td>Semi-Structured Interviews</td>
<td>48</td>
</tr>
<tr>
<td>Focus Group</td>
<td>48</td>
</tr>
<tr>
<td>Ethical Considerations</td>
<td>48</td>
</tr>
<tr>
<td>Trustworthiness Techniques</td>
<td>49</td>
</tr>
<tr>
<td>Summary</td>
<td>49</td>
</tr>
<tr>
<td><strong>IV. Presentation of the Findings</strong></td>
<td>50</td>
</tr>
<tr>
<td>Research Questions</td>
<td>50</td>
</tr>
<tr>
<td>Description of Participants</td>
<td>50</td>
</tr>
</tbody>
</table>
Presentation of Results: Survey Questions and Responses

Question 1: Which of the Algebra standards do you feel are areas of strength to teach?

Question 2: Which of the Algebra standards do you feel are of greatest difficulty to teach?

Question 3: Which of the eight mathematical practices do you feel are the most challenging to implement in your classroom?

Question 4: Which of the eight mathematical practices do you feel are the easiest to implement in your classroom?

Question 5: I am confident in implementing and teaching the content standards for the class (specific grade/subject/level) I teach.

Question 6: I understand how my standards fit into the larger picture of secondary mathematics?

Question 7: The standards for my class affect how I teach the class.

Question 8: The level of class I teach affects how I teach the standards.

Presentation of Results: Analysis of Teacher Interview Data

Research Question 1: What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?

Standard Domains

Mathematical Practices

Research Question 2: How are classroom practices influenced by changes in secondary mathematics standards?
Research Question 3: What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards? .................. 76

Principal Support ........................................................................................................ 76
Teacher Leader Support .............................................................................................. 77
Supporting New Teachers ............................................................................................ 77
Professional Development ............................................................................................ 78
Final Thoughts .............................................................................................................. 80

Presentation of Results: Analysis of Focus Group Data ............................................. 80

Findings ......................................................................................................................... 83

Research Question One: Best practices to increase secondary mathematics teachers’ understanding of teaching current standards. ........................................ 83
Research Question Two: Classroom practices influenced by changes in secondary mathematics standards ........................................................................ 84
Research Question Three: Supports needed by secondary mathematics teachers to effectively implement the secondary mathematics standards ........................................ 85

Summary ....................................................................................................................... 86

V. Findings, Implications, and Recommendations .................................................... 88

Findings ......................................................................................................................... 89

Research Question One: Best practices to increase secondary mathematics teachers’ understanding of teaching current standards. ........................................ 89
Research Question Two: Classroom practices influenced by changes in secondary mathematics standards ................................................................. 91
Research Question Three: Supports needed by secondary mathematics teachers to
effectively implement the secondary mathematics standards ........................................... 94

Conclusions of the Findings ............................................................................................ 95

Limitations/Delimitations ................................................................................................. 96

Recommendations for Future Research ...................................................................... 97

Summary ............................................................................................................................ 98

References ......................................................................................................................... 99

Appendices ......................................................................................................................... 107
List of Tables

Tables

Table 4.1 Subject Areas Taught by Survey Participants....................................................... 51
Table 4.2 Years of Experience by Survey Participants.......................................................... 51
Table 4.3 Subgroup Participants............................................................................................. 54
Table 4.4 Question 1: Which of the Algebra standards do you feel are areas of strength
to teach? .................................................................................................................................. 55
Table 4.5 Question 2: Which of the Algebra standards do you feel are of greatest
difficulty to teach? ..................................................................................................................... 56
Table 4.6 Question 3: Which of the eight mathematical practices do you feel are the
most challenging to implement in your classroom? ................................................................. 58
Table 4.7 Question 4: Which of the eight mathematical practices do you feel are the
easiest to implement in your classroom? ................................................................................... 59
Table 4.8 Question 5: I am confident in implementing and teaching the content
standards for the class (specific grade/subject/level) I teach................................................. 60
Table 4.9 Question 6: I understand how my standards fit into the larger picture of
secondary mathematics? ........................................................................................................ 61
Table 4.10 Question 7: The standards for my class affect how I teach the class................. 61
Table 4.11 Question 8: The level of class I teach affects how I teach the standards............ 62
Table 4.12 Percentages Summary of All Likert Responses...................................................... 63
Table 4.13 Coding Research Question 1: What are best practices in increasing
secondary mathematics teachers’ understanding of teaching current
standards? ................................................................................................................................. 65
Table 4.14 Coding Research Question 2: How are classroom practices influenced by changes in secondary mathematics standards? .................................................. 66

Table 4.15 Coding Research Question 3: What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards? ................................................................. 67

Table 4.16 Interview Participants Most Proficient Standard Domains........................................ 68

Table 4.17 Interview Participants Least Confident Standard Domains................................. 70

Table 4.18 Most difficult to implement mathematical practices .............................................. 73
CHAPTER I: INTRODUCTION

Schools and education as a whole are ever changing. In Tennessee, The State Board of Education reviewed the mathematics standards at a minimum of every six years (Tennessee Department of Education, n.d.). Over the past 13 years, Tennessee mathematics standards at the secondary level have undergone several key changes. The initial change occurred with the removal of the traditional and technical paths. This came in the form of The Diploma Project, implemented in the 2009-2010 school year, which required all students to take four math classes: Algebra I, Geometry, Algebra II, and a fourth mathematics class at a higher level than Algebra II. This legislation did not change the standards, but altered how many classes were offered and how often they were offered. Subsequently, Common Core prompted a shift to task-based learning with multi-level questions as opposed to the traditional one-part single-answer questions, which initiated drastic transformation in the construction of curriculum standards (Common Core State Standards Initiative, 2018). In mathematics, the standards not only changed form, but the content shifted to different classes. The creation of the standards placed an emphasis on moving mathematics curriculum down in grades and making the content more rigorous in earlier grade levels. The Tennessee Department of Education rebranded Common Core as TNReady to provide distance from the negative stigma associated with Common Core. This change in name did not meaningfully impact standards but moved testing from paper-based to technology-based to promote online testing. Though there have been significant problems with the online testing, there is a continued initiative to continue with this practice. TNReady is still in its infancy and continues to undergo modifications. Finally, the standards in mathematics
have changed as classes have been reduced from the state curriculum and new classes have been created and implemented at the high school level. All of the changes have required training and modifications to the curriculum and teaching practices.

**Research Problem**

Mathematics standards in Tennessee have undergone a drastic overhaul due to influence from NCTM and the adoption of the Common Core Standards in 2010, which were to be fully implemented by the 2013-2014 school year (Common Core State Standards Initiative, 2018). Common Core Standards prompted a move from traditional practices of mathematics to leading students to develop a deeper conceptual understanding of the content. Educators created the standards from the best of mathematics standards from across the U.S., with the primary goal of making mathematics standards across the country more coherent and focused (Roberts, 2015). Changes in standards prompted a necessity to inform educators, with teachers undergoing trainings and professional development activities aimed at deconstructing the standards and methods for implementations. As teachers began implementing the standards, Reys and Reys (2011) posed several questions regarding Common Core Standards: “How significant will be its effect on textbooks? On student learning? Will CCSSM be maintained for this decade? Will these standards have a longer life? How long before they are revised or updated? Will they join the throng of old curriculum reports?” (p.11). Though many teachers underwent training, there is still a need for educators to be instructed how to teach mathematics using a conceptual approach as opposed to the traditional mathematics approach in which most educators are well versed.
Purpose of the Study

The study sought to determine secondary mathematics teachers’ knowledge regarding their standards and how these standards related to other classes. Additionally, the study sought to determine ways to help teachers interpret the standards and to develop curriculum that will be standards-based. The researcher chose Algebra I and Algebra II as the focus of the study because these relate to each other with overlapping standards and are a continuation of one another.

Theoretical Framework

The theoretical framework for this study was centered on constructivism. In constructivist theory, one constructs knowledge by an individual based on his/her own understanding and building on prior knowledge (Moursund, n.d.). Individuals construct their own knowledge and understanding of a concept by experiencing or doing, and then they reflect and discuss to make the learning more concrete (Educational Broadcasting Corporation, 2004). Students are active participants in their learning. Scholars credit Piaget with “constructing” the theory of constructivism with his work in child development, and Dewey and Vygotsky contributed to the theory in an educational context (Oxford, 1997). Dewey believed learning was social, but knowing does not occur by an outside spectator, but within. One must do in order to know. Vygotsky believed that the teacher was a guide in the learning process and provided scaffolding to students when needed and removed it as students became more self-directed in their studies (Oxford, 1997). Additionally, Bruner made major contributions to the theory with his three principles of constructivism in a learning environment: readiness, spiral organization, and going beyond the information given (Culatta, 2018).
In the context of this study, constructivism was the appropriate theoretical framework because it allowed for new knowledge and understanding as related to previous knowledge. Teachers used active techniques, experiments and problem solving, to further their knowledge of the standards and implementation practices. Through the survey and interview phases, teachers demonstrated their knowledge of their standards and what they needed to know. In the focus group, the teachers were both experts in their field and students. They were able to share their expertise of their standards and the topics in which they were most confident, while also learning from the others in the group. The varying levels of experience added to the focus group.

**Research Questions**

The researcher sought to determine what secondary mathematics teachers know about the current standards in their subject area, how their standards fit into secondary mathematics, and what teachers need to adequately implement the standards. The research study focused on the following questions:

1. What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?
2. How are classroom practices influenced by changes in secondary mathematics standards?
3. What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

**Rationale for the Study**

The researched conducted a thorough review of the literature on standards in secondary mathematics, and found numerous studies about standards as related to the National Council of Mathematics Teachers’ (NCTM) *Curriculum and Evaluation Standards for School Mathematics* and *Principles and Standards for School Mathematics*. These studies compared students using a
Standards-based curriculum with those using a traditional curriculum on various assessments (Harwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007). Studies have also discussed the foundation of what should be included in secondary mathematics standards and curriculum (Dingman, Teuscher, Newton, & Kasmer, 2013). Minimal research exists regarding what portions of the NCTM standards are most relevant to teachers and how they could be used to change teaching practices, along with how the NCTM standards relate to local standards and how teachers implement those standards (Research Advisory Committee, & Standards Impact Research Group, 2002). The findings in this study will add to the literature because it focused on teacher understanding of the secondary mathematics standards in a specific subject area and, as a whole, teacher implementation of the standards in individual classes (Algebra I and Algebra II), and best practices that promote positive implementation of the standards. The researcher’s goal was to find ways to aid teachers in understanding the reformed standards and positive ways to teach the standards.

Limitations

This study was limited to secondary mathematics teachers of Algebra I and Algebra II in a single, large school district in East Tennessee. This reduced the number of interview responses and the pool of focus group participants. The researcher expected that all research participants would be honest in answering questions on the survey, during interviews, and in the focus group, but this could not be verified. The opinion nature of some questions during the study and the group mentality of the focus group both impacted the research findings.

Delimitations

Delimitations for this study were the school selecting where the researcher conducted the study and the sample population. Participants were chosen based on their teaching assignments
in Algebra I and Algebra II. The researcher used quota and purposive sampling techniques for this study. Quota sampling was employed because the researcher needed a certain number of participants and purposive sampling was utilized because the researcher needed teachers that met certain criteria (teaching Algebra I and Algebra II) (Ary, Jacobs, & Sorensen, 2010, pp. 156-157, 428-429).

The Researcher

The rapidly changing standards in secondary mathematics and promotion within the school encouraged interest in the study’s topic. The researcher has 13 years of teaching experience in the secondary mathematics classroom, teaching the following subjects in grades 9-12: Foundations I, Foundations II, Algebra I, Algebra II, Advanced Algebra and Trigonometry, Precalculus, and Calculus. The teacher has taught all levels of students, beginning with standard and remedial Foundations and Algebra I for nine years. Over the past five years, the educator has added Algebra II, Advanced Algebra and Trigonometry, Precalculus, and Calculus at the honors level, along with some skills and standard classes. Experience with all levels of students has allowed the researcher to fully explore the role of a secondary mathematics teacher. The role of the teacher has transformed along with the expectations and standards in secondary mathematics. In this study, the researcher utilized a survey, semi-structured interviews, and a focus group pertaining to what secondary mathematics teachers know about the current standards in their subject area and how their standards fit into secondary mathematics, along with what teachers need to adequately implement the standards.

Definition of Terms

1. *Academic Standard:* A guide for the expectations of what content should be taught and what skills students should have mastered at the end of a specific class or grade level (Tennessee Department of Education, n.d.).
2. **Secondary Teacher**: In the state of Tennessee, a teacher with a secondary licensure that teaches in grades 6-12 (Tennessee Department of Education, 2014).


4. **Algebra I in Tennessee**: This secondary mathematics course “emphasizes linear and quadratic expressions, equations, and functions. This course also introduces students to polynomial and exponential functions with domains in the integer. Students explore the structures of and interpret functions and other mathematical models. Students build upon previous knowledge of equations and inequalities to reason, solve, and represent equations and inequalities numerically and graphically”. (“Tennessee Math Standards,” 2018, p. 85).

5. **Algebra II in Tennessee**: This secondary mathematics course “emphasizes polynomial, rational and exponential expressions, equations, and functions. This course also introduces students to the complex number system, basic trigonometric functions, and foundational statistics skills such as interpretation of data and making statistical inferences. Students build upon previous knowledge of equations and inequalities to reason, solve, and represent equations and inequalities numerically and graphically”. (“Tennessee Math Standards,” 2018, p. 106).

**Summary**

Standards are the foundation of any academic class. To ensure coherence, educators need a full understanding of their standards, as well as where their class fits into a large-scale curriculum. With the changes in the standards, teachers need professional development. A focus
group is one method that can be used for this professional development. This qualitative study explored what secondary mathematics teachers know about their standards, how they relate to other classes, ways to help teachers interpret the standards, and to develop curriculum that will be standards-based.

The researcher organized this study into five chapters. Chapter I developed the background, purpose, and rationale of the study relating to standards change in Tennessee. Chapter II is a review of the literature: standards, theoretical framework, how teaching affects student learning, standards-based curriculum, mathematical teaching practices, change, professional learning communities, testing data, and areas where further study is needed. Chapter III explains the methodology, focusing on the research approach, setting and participants, data collection and analysis procedures, ethical considerations, and the trustworthiness techniques employed during the study. Chapter IV outlines the results. Finally, Chapter V states the conclusions drawn from the results of the study and future implications.
Chapter II: LITERATURE REVIEW

Introduction

Teachers educate students in their field, and are expected to be experts in both content and teaching methods relevant to their curriculum. This study is designed to assess the knowledge of secondary mathematics teachers with regards to their content standards and how the standards fit into a broader scope of secondary mathematics. Further, the study focused on collaboration among teachers in the form of a focus group in order for teachers to share their best practices and become students to learn how to more successfully implement standards in their classes. The goal for this study was to determine what teachers currently know and how to aid them in better implementation of the standards in a classroom setting.

This literature review gathered available information for analysis to create a foundation of secondary mathematics standards and implementation in the classroom. This review of the literature explored standards from a historical and professional standpoint, looking at structure, and focused on Tennessee state standards of secondary mathematics. The reviewer evaluated the implementation of the standards as a curriculum, along with standards-based grading and how teaching affected student learning. Professional Learning Communities (PLC) are an important tool for teachers to mentor, learn, and grow as an educator. The reviewer explored the importance of PLC’s and focus groups, and examined testing data as a component of standards-based teaching.
Standards

Definition of a Standard

An academic standard is a guide for the expectations of what content should be taught and what students should know and be able to do at the end of a specific class or grade level (TN Department of Education, n.d.). Standards are the learning goals for a class and are not a curriculum (Common Core State Standards Initiative, 2018). A curriculum for a specific class is the overall structure of the class set up as units of content with individual lessons built around the standards.

History of Mathematics in the United States

Mathematics curriculum began in the United States of America in the late 1800s as a way to establish standardized high school mathematics with the sequence of algebra, geometry, and then algebra again. The 1920s fostered further reform with the need to transition between subjects and connect content from one class to the next (Reys & Reys, 2011). In the 1940s, Ralph Tyler first introduced the concept of curriculum through backwards design (Wiggins & McTighe, 2011). The 1950s and 1960s brought an increased focus on rigorous mathematics curriculum, which aimed to prepare students for postsecondary education. The 1980s brought the largest change to date in mathematics curriculum design when The National Council of Teachers of Mathematics (NCTM) encouraged an increase in problem solving and championed for national standards. NCTM’s arranged their standards recommendations for all K-12 mathematics into grade bands, which supported integration of topics from one class to the next (Reys & Reys, 2011). A final major change occurred to the standards in in 2010 with the advent of Common Core Standards (CCS) (Rosales, 2013).
CCS emphasized mathematics and English/language arts. The new standards for mathematics were constructed from the best high-quality standards from various states and best practices from other countries (Common Core State Standards Initiative, 2018). During the development, Common Cored emphasized how students learn mathematics and what mathematics would be necessary for college, career, and life outside of school. Common Core created a distinct set of math skills and concepts that are organized in a manner for student learning to be continuous during the school year and across consecutive grades or classes. They encourage students to become real-world problem solvers. One key component of the CCS mathematics standards was that students did not merely perform mathematics operations to solve a problem: they had to construct a solving method and justify the method used to show a deeper understanding of the content (Common Core State Standards Initiative, 2018). CCS were supported and endorsed by NCTM, The College Board, The National Council of Supervisors of Mathematics (NCSM), The Association of State Supervisors of Mathematics (ASSM), and The Association of Mathematics Teacher Educators (AMTE) (Roberts, 2015). These organizations supported the goals, principles, and positions of CCS for mathematics in four specific areas. Students are expected to develop mathematical practices of solving problems, make connections, understand multiple representations, communicate personal algorithms, and justify reasoning. They must gain conceptual and procedural knowledge. Curriculum is to reflect what researchers found regarding how children learn mathematics. Teachers then must also provide students with opportunities to make sense and reason about mathematics curriculum so students are able to believe that mathematics understanding is reachable and useful.

Common mathematics themes have emerged. The definition of high level mathematics and its expectation have continued to change as time has evolved. Efforts continue to be made
for the improvement of school mathematics. One area of improvement is in curriculum evolution. There is a downward movement with mathematics content as more advances concepts are being moved to lower grades and students are being exposed to and learning content on an accelerated timeline. Another improvement is in the differentiation of material. There are several organizational paths for high school mathematics. A common goal remains of aiding students in their understanding and making sense of mathematics. Finally, improving teaching of mathematics is essential for any successful reform initiative (Reys & Reys, 2011).

**National Council of Teachers of Mathematics Standards**

The National Council of Teachers of Mathematics (NCTM) is an organization of professional educators, who are knowledgeable about mathematics, the educational setting, and teaching mathematics. Trends in International Mathematics and Science Survey (TIMSS) conducted many studies that indicate the U.S. repeatedly underperforms compared to other countries (Vatterott, 2015). TIMSS and its predating studies have been collecting data since the 1960’s (National Center for Educational Statistics, n.d.). As a result of the low achievement, NCTM outlined eight recommendations for mathematics:

- problem solving be the focus of school mathematics in the 1980’s;
- basic skills in mathematics be defined to encompass more than computational fluency;
- mathematics programs take full advantage of the power of calculators and computers at all grade levels;
- stringent standards of both effectiveness and efficiency be applied to the teaching of mathematics;
- the success of mathematics programs and student learning be evaluated by a wider range of measures than conventional testing;
- more mathematics study be required for all students and a flexible curriculum with a greater range of options be designed to accommodate
the diverse needs of the student population; mathematics teachers demand of themselves and their colleagues a high level of professionalism; public support for mathematics instruction be raised to a level commensurate with the importance of mathematical understanding to individual and society. (National Council of Teachers of Mathematics, 1980, p.1)

As a result of these recommendations, a new set of content became the basis of school mathematics: problem solving, spatial visualization and awareness, mathematics as communication, technological literacy, and appropriate computational skills (Hartwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007).

NCTM continued to make recommendations for mathematics standards with the publication of *Curriculum and Evaluation Standards for School Mathematics (Standards)* in 1989 (Suydam, 1990), which show what educators valued in mathematics education (Frye, 1989). There were three reasons behind the creating of this document: ensure quality, indicate goals, and promote change (Suydam, 1990). This was the first time a professional organization instead of the government made suggestions on what students should be learning. According to Hirsch (1990), traditionally, high school mathematics has been structured with advanced levels of mathematics for an elite few and a miniscule amount of mathematics for the majority. Only about a fourth of all college majors require calculus-based mathematics; most of the rest require mathematics derived from the fields of probability, statistics, or discrete mathematics. NCTM created *The Standards* as a framework for grades 9-12 promoting a more balanced mathematical approach serving the needs of both college and non-college bound students. The main topics of algebra, geometry, trigonometry, and functions remain at the core of the curriculum with a new emphasis put on the addition of data analysis, statistics, probability, and discrete mathematics
Mathematics should be for everyone, and students should be given the opportunity to learn on a broad spectrum (Suydam, 1990). The *Standards* encouraged a de-emphasis on the exclusivity of mathematics and promoted providing scaffolding for students where teachers should create lessons based on what students can do, not on what they are incapable of doing (Hirsch, 1990). There were five goals for students: learning the value of mathematics, learning to reason mathematically, learning to communicate in a mathematical way, becoming confident in their own mathematics abilities and becoming mathematical problem solvers (Suydam, 1990, p.2).

The thought behind the idea of mathematics as a teachable subject moved from being a set of abstract concepts and operations to be memorized to a focus on using mathematics to represent the world and using it for real-world problem solving where it would actually occur (Hirsch, 1990). Math should not be approached in isolation; the *Standards* promoted that students be provided frequent opportunities to approach mathematics problems from different views: verbally, numerically, graphically, and symbolically. In these different ways, mathematical thinking and fluency could be developed with notation for each context. Many mathematical concepts could be taught on different levels of understanding; it is important that the complexity of the method increased with the maturity of the students.

The *Standards* was the first push for technology integration in mathematics education. For grades 9-12, NCTM recommended that students have access to a scientific calculator with graphing capabilities at all times and that classrooms be equipped with a computer for demonstration purposes (Hirsch, 1990). Students should have access to computers for individual and group work when appropriate, and all students should be provided instruction on how to use computers for processing information and computational purposes for problem solving (Suydam,
1990). Moving forward, curriculum needs to be designed to embrace advances made in technology.

In 2000, NCTM updated the Standards with the Principles and Standards for School Mathematics (PSSM) (National Council of Teachers of Mathematics, 2000). The new version incorporated the Professional Standards for Teaching Mathematics from 1991 and Curriculum and Evaluation Standards for School Mathematics from 1995 with the Standards from 1989 (National Council of Teachers of Mathematics, n.d.). NCTM divided all of the content into five main content standards: number and operations, algebra, geometry, measurement, and data analysis and probability. Under each heading, standards were divided into grade bands: K-2, 3-5, 6-8, and 9-12. The standards were not divided into specific classes, as there was the expectation that mathematics is fluid and should be taught using multiple methods. Content from previous knowledge should be reinforced as a skill is reused and advanced with new concepts. There were also process standards not divided by grade band that were to apply to all levels of mathematics: problem solving, reasoning and proofs, communications, connections, and representation.

In 2006, NCTM (2018) published the supplemental material Curriculum Focal Points that specified the most critical content for each grade level K-8 and educators viewed it as a guide for implementing the standards; however, NCTM did not address 9-12 mathematics. In 2009, NCTM (2018) published Focus in High School Mathematics: Reasoning and Sense Making, which aided educators in developing curriculum that supported the standards in PSSM and focused on reasoning and sense making as an integral part of everyday mathematics (National Council of Teachers of Mathematics, n.d.). NCTM defined reasoning as “the process of drawing conclusions on the basis of evidence or stated assumptions” (National Council of
Teachers of Mathematics, n.d., slide 11). They also defined sense making as “developing understanding of a situation, context, or concept by connecting it with existing knowledge” (National Council of Teachers of Mathematics, n.d., slide 11). These were found to be the foundation of mathematical competence in conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (National Council of Teachers of Mathematics, n.d., slide 15). NCTM was and is an integral part of constructing standards for high school mathematics in the United States.

**Tennessee State Standards of Mathematics**

Tennessee requires all standards be reviewed at a minimum of every six years (Tennessee Department of Education, “Academic Standards,” n.d.). The state reviewed current mathematics standards in 2016 and implemented in classrooms in the 2017-2018 school year. The Tennessee Department of Education prepared the standards with a set of learning goals in mind for students once they had completed K-12 mathematics (“Tennessee Math Standards,” 2018). The first goal is that students, outside of the educational setting, would be able to both recall and use mathematical knowledge. This goal is focused on the idea of retention of knowledge. The second goal is that students have both a procedural fluency and conceptual knowledge of the content, with a subset being students are able to reason mathematically in both work and non-work situations and critically analyze reasoning from others. Procedural fluency is working through mathematics procedures with accuracy, efficiency, and flexibility. This is having the ability to know what procedure is necessary to solve a problem, not just computational ability. Procedural fluency can incorporate both proven methods and personal algorithms for problem solving activities. Application and problem-solving concepts are woven throughout the mathematics standards from Kindergarten through secondary classes, building in complexity.
The final goal is that students who have completed K-12 mathematics would have a foundation to be mathematically ready to pursue post-secondary educational opportunities.

**Structure of Tennessee Mathematics Standards**

The Tennessee Mathematical Standards for all grades of mathematics are accompanied by eight mathematical practices that students should exhibit while performing mathematical tasks:

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. (Tennessee Department of Education, “Mathematics,” n.d.)

In addition to the eight mathematical practices, the Tennessee K-12 mathematics standards also detail four literacy standards incorporated as an integral component: “use multiple reading strategies, understand and use correct mathematical vocabulary, discuss and articulate mathematical ideas, and write mathematical arguments” (Tennessee Department of Education, “Mathematics,” n.d.). The standards were divided into four parts: content standards, clusters, domains, and conceptual categories (“Tennessee Math Standards,” 2018, p. 5). For high school courses, there are five conceptual categories: number and quantity, algebra, functions, geometry, and statistics and probability (“Tennessee Math Standards,” 2018, p. 4). The conceptual
categories are further detailed into domains or categories of standards. For Algebra I and II, some domains include: seeing structure in expressions, creating equations, and interpreting functions (“Tennessee Math Standards,” 2018, p. 85). The clusters further group the standards into smaller categories. The content standards are the individual concept that students should know, understand, and be able to do at the end of a specific class (“Tennessee Math Standards,” 2018, p. 5).

**Algebra Standards**

In Algebra I, the main focus is on linear and quadratic expressions, equations, and functions with an introduction into polynomial and exponential functions (“Tennessee Math Standards,” 2018, p. 85). The following are the domains for the Algebra I standards:

- Seeing Structure in Expressions
- Arithmetic with Polynomials and Rational Expressions
- Creating Equations
- Reasoning with Equations and Inequalities
- Interpreting Functions
- Interpreting Categorical and Quantitative Data
- Quantities
- Building Functions
- Linear, Quadratic, and Exponential Models (“Tennessee Math Standards,” 2018, p. 85)

Algebra II focuses on polynomial, rational and exponential expressions, equations, and functions with an introduction to the complex number system, basic trigonometric functions, and foundational statistics skills such as interpretation of data and making statistical inferences
The following are the domains for the Algebra II standards:

- The Real Number System
- Seeing Structure in Expressions
- Arithmetic with Polynomials and Rational Expressions
- Reasoning with Equations and Inequalities
- Interpreting Functions
- Building Functions
- Making Inferences and Justifying Conclusions
- Quantities
- The Complex Number System
- Creating Equations
- Linear, Quadratic, and Exponential Models
- Trigonometric Functions
- Interpreting Categorical and Quantitative Data

**Theoretical Framework**

**Constructivist Theory**

Bruner is a major contributor to the theory of constructivism, building on work related to Piaget’s child development research (Culatta, 2018). The theory of constructivism centers on the idea that knowledge is constructed based on individual’s understanding and is unique to the individual (Moursund, n.d.). When applied as an educational theory: constructivism is found in
the classroom when students learn concepts and construct a deeper understanding of the new ideas by relating back to what they already have learned (Oxford, 1997). Individuals discover knowledge, not given in the form of instruction from others; one must learn for themselves (Liu & Matthew, 2005). Bruner provided three principles that should be the driving force behind constructivism in a learning environment: readiness, spiral organization, and going beyond the given information (Culatta, 2018). Readiness deals with structuring instruction so that it relates to students experiences to make them more willing and able to learn. Spiral organization is the structure of the instruction in such a way that it is easy for students to understand. Finally, with the concept of going beyond, instruction needs to be applicable to different situations.

**Constructivism and Mathematics**

Moursund (n.d.) linked constructivism and Garner’s theory of multiple intelligences together, where one can be more logically and mathematically brained, when explaining how people learn mathematics in the following causal proof:

1. People are born with an innate ability to deal with small integers (such as 1, 2, 3, 4) and to make comparative estimates of larger numbers (the herd of buffalo that we saw this morning is much smaller than the herd that we are looking at now.)

2. The human brain has components that can adapt to learning and using mathematics.

3. Humans vary considerably in their innate mathematical abilities or intelligence.

4. The mathematical environments that children grow up in vary tremendously.

5. Thus, when we combine nature and nature, by the time children enter kindergarten, they have tremendously varying levels of mathematical knowledge, skills, and interests.
6. Even though we offer a somewhat standardized curriculum to young students, that actual curriculum, instruction, assessment, engagement of intrinsic and extrinsic motivation, and so on varies considerably.

7. Thus, there are huge differences among the mathematical knowledge and skill levels of students at any particular grade level or in any particular math course. In addition, there are considerable differences in their ability to learn mathematics.

8. Thus, mathematics curriculum, instruction, and assessment needs to appropriately take into consideration these differences. One way to do this is through appropriate use of constructivist teaching and learning principles. (Moursund, n.d., para. 14)

The researcher employed constructivism theory in the focus group portion of this study. Teachers shared what they knew about their standards and constructing new knowledge and understanding about the secondary mathematics as it relates to their previous knowledge. The NCTM standards are a guide used in constructing many states’ individual standards. Constructivist views and theory heavily influenced the development of these curriculum standards (Oxford, 1997).

**Definition of Teaching Methodology**

A teaching methodology is essentially the way in which a teacher chooses to explain or teach material to students so they can learn the material. There are many different methodologies that can be utilized by a teacher, and the methods chosen often depend on the educational philosophy and preferences of a teacher. It is also not uncommon for a teacher to utilize multiple methods within a single lesson or over the course of several lessons. A methodology of teaching can include the use of lecturing, group or small group discussion activities, and
engaging students as teachers for their peers. (Conjecture Corporation, 2018, para. 1)

**How Teaching Affects Student Learning**

Teaching practices, though they may follow certain trends, are unique to each educator. How a teacher understands and interprets the standards, how they are implemented in a classroom, and what effect they have on student learning and understanding are the foundation of education in a classroom (NCTM Research Committee, 2013). Challenging content is not the only factor that leads to high achievement in students (Stigler & Hiebert, 1999, p. 58). Material must also be presented in a manner that students are able to relate to in order to gather understanding and knowledge of the content. Often teachers struggle to teach for higher-level thinking, and students flounder as expectations grow and change (Vatterott, 2015). Teachers must have proper training in order to effectively teach (Owens, & Valesky, 2015). Mathematics has traditionally taught with the same basic methods for a century (Hiebert, 1999), and one cannot expect a different result from the same practice. The method used to teach mathematics needs to change. In order to teach mathematics in a deeper way, it needs to be taught with conceptual understanding as the main focus as opposed to isolated concepts (Stigler & Hiebert, 1999, p. 11). Teachers need to deemphasize computational procedures (Hiebert, 1999). Procedures need to be connected with the use of conceptual understanding. This requires a full evaluation of the topic: what it is, how it fits into mathematical thought, how it applies in a real world context, and finally how to actually do the math.

Stigler and Hiebert (1999) described how United States mathematics classrooms differed from those in Japan and Germany. One of the most telling differences between Japan and the U.S. was how the countries developed content. In Japanese classrooms, the content was very
conceptual, whereas in the U.S. classrooms, only one-fifth of lessons contained developing content, with four-fifths of the content only stated as fact without showing why. Researchers found the content to be repetitive, unfocused, and undemanding (Hiebert, 1999). The “why” is vastly important in mathematical knowledge but often missing. Many view mathematics as just the “how.” Teachers need to know the “why” and “how” in order to sufficiently teach it to others (Brahier, Leinwand, & Huinker, 2014). Educators need to challenge students in math classes in order to be fully engaged in mathematical reasoning. Students will learn what they are given the opportunity to learn (Hiebert, 1999).

**Standards-Based Curriculum**

Teachers are inclined to teach what is presented in their curriculum and are influenced by the presentation of material in how they further explain and teach content to students (Reys, Reys, Lapan, Holliday, & Wasman, 2003). Standards-based curriculum was a shift in focus from skills and content that moved from lower-order thinking skills to higher-order thinking skills (Vatterott, 2015). This required students to think their way to understanding, not merely rely on memorization, procedural, and computational skills. Traditionally, mathematics is structured in a linear manner, with content building as one advanced through the curriculum. A class moved together as a whole through the content with a teach-review-test-move-on model. Standards-based curriculum is a vastly different model. Not all students learn at the same rate or with the same method. In this form of curriculum, students have a sense of freedom to work at a rate that benefits an individual’s learning ability. This is individualized and follows the model: teach, check for understanding, apply learning, get feedback, revise learning, and get more feedback until students achieved mastery. Feedback is a key component as it creates a dynamic situation where both student and teacher learn about individual needs. Students who are quick learners...
need teachers to provide enrichment opportunities so they can extend their learning. Those who struggle need teachers to provide them with differentiated instruction and remediation that aids the learning process. Students are not the same; differences should be acknowledged and respected. Grouping student is another characteristic of a standards-based classroom (Jitendra, 2013). Grouping students allows students to talk about mathematics and share mathematical ideas in a controlled environment. Using technology and creating personal algorithms for problem solving are also important for standards-based curriculum. Educators designed this curriculum with the goal for students to create their own algorithms and discuss different solution paths when faced with a new type of problem (Jitendra, 2013). The standards required teachers to create a more adventurous and ambitious teaching style, presenting a more challenging approach to problem solving and encouraging students to develop unique solution paths (Stigler, & Hiebert, 1999, p.155). This is in opposition to a traditional approach of demonstrating procedures for problem solving and providing worksheets for practice.

Elements of a Standards-Based Classroom

There are several basic elements that are necessary to be considered a standards-based classroom (Rosales, 2013). Students need to have a clear understanding of what teachers expected of them, which can be achieved by clear, descriptive statements of goals and examples of what is considered to be high-quality work. Specific learning goals give the student and teacher understanding of what skills and concepts are needed and direct the focus of study. After learning goals are established, students need to determine what they currently know and what they need to know in order to reach the new learning goals. Self-assessment is an integral component of a standards-based classroom and must be a developed skill. Finally, students need a practical and reasonable action plan for how they will reach the learning goal. In a standards-
based classroom, the repeated assessment until mastery is reached is a crucial element. Students work at their own pace, collaborating with the teacher about developing knowledge and abilities. According to Vatterott (2015), the following are main ideas that come out of a standards-based curriculum: learning can be difficult but is achievable; mistakes are an integral part of the learning process; lack of understanding does not equate to stupidity; struggle is not bad so long as support is given. Student ownership of learning is important for a standards-based classroom to function. As part of self-assessment, students need to understand how they best learn and what strategies aid them in gaining knowledge. Progress is the goal; students need to be moving forward toward a learning goal. Those who are actively engaged in learning are more likely to reach higher-order thinking skills. Williams (2010) stated that the process is just as if not more important than the answer, with students expected to explore several solution paths when completing a few problems.

Implications of Standards-Based Classroom

There were several commonalities and implications of having a standards-based classroom. The first factor was students have a deeper understanding of concepts and how they relate (Wang, & Odell, 2002). This idea directly contradicts the practice of rote memorization of isolated facts or theories. Teachers challenged students to combat their misconceptions, and connect learning to personal experiences and real-life contexts. Active discovery was an integral part of student learning, and students should discuss their findings. Finally, students should seek excellence without regard to race, gender, or social-economic backgrounds.

Webb, Cichon, and Ellis found that students who had completed three years of required mathematics using a Standards-based curriculum were more likely to electively take mathematics as seniors, and most of those continued on to postsecondary education (Hartwell,
Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007, p. 76). Students were found to have a higher confidence in mathematics abilities and positive attitudes in mathematics than students from a traditional mathematics curriculum path. The confidences were in solving problems, believing that mathematical ideas make sense, and believing that mathematical ideas are inherently interesting. Programs that were designed to emphasize conceptual development were capable of facilitating significant mathematical learning while still enforcing skill proficiency as students learn content and skills while conducting problem solving activities (Hiebert, 1999).

**Criticism of Standards-Based Curriculum**

Standards-based curriculum has received criticisms. The first area of criticism deals with symbolic manipulation and the use of technology (Hartwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007, p. 75). Standards-based focuses on conceptual understanding with a decreased emphasis on symbolic manipulation. This study found that students in 11th grade who had used a Standards-based curriculum did not perform as well as students using a traditional mathematics curriculum on problems requiring symbolic manipulation without the use of a graphing calculator. This shows an increased dependence on technology for students learning with a Standards-based curriculum. Another criticism of Standards-based curriculum was that it stifled individuality in curriculum choice (Wang, & Odell, 2002). Others feared that this could lead to a decrease in intellectual engagement with teaching and an increase in teachers as technicians. The standardizing of mathematics curriculum could lead to a decrease in teacher creativity and decreases the ability to differentiate for individual needs (Dingman, Teuscher, Newton, & Kasmer, 2013). Some believed that Standards-based curriculum would reduce the collaborative culture among teachers (Wang, & Odell, 2002). A lack of proper implementation of a new curriculum increases the likelihood of failure (Hiebert, 1999).
Standards-Based Grading

Standards-based grading does not stand alone; it is a small portion of an entire change in the teaching-learning process (Vatterott, 2015). Only that which students learned should be graded. Grades should be used to show mastery of content, not behavior or work ethic. Grading reflects what a student knows, not what they have completed. With a standards-based grading model, students do not receive a single grade in a class, but rather a series of mastery checks of the various standards for the class, with retesting as needed until mastery of the content is gained (Rosales, 2013). Traditional grading can be an obstruction to the learning process as it damages motivation and can be viewed as a form of punishment for what is not yet learned, not an indicator of what still needs to be learned (Vatterott, 2015). Growth mindset is at the foundation of standards-based grading. Dr. Dweck coined the term with the idea that fixed mindset and growth mindset describe peoples’ beliefs about their own intelligences and how they learn (Mindset Works, 2017). This idea encompasses many goals that educators strive to achieve: student learning, hard work, self-confidence and higher achievement. Duckworth (2013) described growth mindset as the belief that the ability to learn is not fixed and can change based on one’s effort. The opportunity to reassess after feedback allows students to grow their knowledge and confidence through learning (Vatterott, 2015). In standards-based grading the control of a student’s grade shifts to the student not the teacher. The student has individual learning progress and only that which is learned is graded. Feedback from the teacher directs the learning that will occur based on what has already been learned. Work habits do not factor into an academic grade, and homework is for practice as it checks for understanding. Homework should not be graded as this score should not be kept as part of practice. Finally, tests are for mastery; students have the ability to improve grades as they reach further mastery. Careful
consideration needs to be given to what forms of activities will be given after an initial “test” is not mastered. It is crucial for a student and teacher to know what is the cause of the non-mastery and what will aid the student in having a better understanding of the content moving toward the next attempt at mastery.

The Third International Math and Science Study (TIMSS) found that the U.S did not match up with other countries academically, and the gap became larger as students advanced in grades (Schmidt, Houang, & Cogan, 2002, p. 2). The study found curriculum makes a difference as teachers did teach what they were supposed to and students in general learn what they are taught. The issue for the U.S. was with the curriculum. The curriculum was not focused, with far too many topics for each class; it was highly repetitive with re-teaching content over and over again; it is not as demanding or challenging as the counterparts in other countries; and it is incoherent with a long list of standards of separate topics without connections (Schmidt, Houang, & Cogan, 2002, p. 3). The government developed The Common Core standards out of a need for a deeper understanding of mathematics (Common Core State Standards Initiative, 2017).

Stigler and Hiebert (1999) proposed that there is a gap between educational policy and classroom practice. Further, they established the need for educators to improve teaching practices as related to the standards. The problem historically with mathematics was that it was “a mile wide and an inch deep” (Common Core State Standards Initiative, 2017, p. 3). Common Core addressed this problem by creating a set of fewer standards, but that contain clarity and specificity. For coherence, a standard needs to evolve from particular focused content to deeper structures that are an integral part of mathematics (Schmidt, Houang, & Cogan, 2002). “These Standards endeavor to follow such a design, not only by stressing conceptual understanding of key ideas, but also by continually returning to organizing principles such as place value or the properties of
operations to structure those ideas” (Common Core State Standards Initiative, 2017, p. 4). Educators created the standards with the goal of preparing students for college and career readiness.

**Mathematical Teaching Practices**

The workshop model provides a deliberate structure for critical thinking (Billings, Coffey, Golden, & Wells, 2013). It has four components: making connections, focus, activity, and reflection. Through making connections, students reflect on what they already know, creating connections with past experiences and knowledge prior to working on a new skill or topic. Focus sets the expectations for the lesson through the introduction of the theme and the main question for the lesson for exploration or a possible mathematical strategy to practice. During the activity phase of the lesson, students work to solve problems and construct new knowledge and skills either collectively or independently. Finally, the reflection phase allows students time to consolidate their learning through reflection in either written or verbal form. The workshop method provides a process for teachers to implement the mathematical practices throughout a lesson.

**Teaching Practices Supporting the Mathematical Practices**

There are several teaching practices that can both promote and support the mathematical practices outlined in the Tennessee State Standards for mathematics (Bartell, Wager, Edwards, Battey, Foote, & Spencer, 2017). First, teachers should draw on students’ stored knowledge. With this practice, teachers build on students’ experiences or interests and connect the current instruction to previous knowledge. Next, they need to establish classroom norms for participation. This practice incorporates the ideas that students have a relevant voice and discussions should be designed to encourage the development of mathematical background from
both those strong and weak in the subject matter. Students should be groomed for success, both socially and academically. Curriculum should exist to both aid and challenge, providing students opportunities to have meaningful input and decision making tasks. Teachers should communicate clear expectations to students of their responsibilities, and their strengths should be targeted to be expanded. Teachers should focus on students’ mathematical thinking. It is crucial for teachers to be able to recognize and understand where students are in their mathematical thinking and aid students in refining and further developing these skills. Teachers must also determine what mathematical thinking is developmentally appropriate for students and not expect students to compete and produce beyond that level.

Change

Definition of Change

Change is an all-encompassing aspect of being an educator. According to the Merriam-Webster dictionary (2018), change is defined as “to undergo transformation, transition, or substitution.” Schools and education as a whole are ever-changing.

Leading Change

Change is inevitable in the education setting, and Fullan (2011) proposes methods for becoming a more effective leader of a changing environment by describing seven-step approach to dealing with change as an effective change leader who actively participates in the organization as a learner for improvement. First, by combining moral purpose with empathy, a leader’s effectiveness is fueled by his/her motivation to strive for more. Next, confidence and humility aid leaders in adapting to change in an ever changing school environment. Starting with taking an active role in the evolution of an organization, leaders can work to improve all of its aspects. Those that are motivated to do more will have a more positive attitude toward dealing with
changes that are thrust upon them. Collaboration also promotes positive change, allowing educators to observe methods that others have found to work and then adapt to meet their own needs in their educational context. In the educational world of testing, data about proficiency rates and student growth remain significant; thus, it is important for educators to be familiar with the different forms of data and how to use the statistics to improve the educational process. Finally, where change is involved, keep things simple when possible. Persistence is essential. All of these steps can help make the process of change in an educational setting less stressful.

Motivation is an essential concept regarding educational change. Leaders are responsible for protecting the educational setting from exterior negative influences (Owens, & Valesky, 2015). Teachers need to be supported and motivated as new educational changes are created and implemented. Further, they need to be trained on any new technology, curriculum, or instructional practices they are expected to use, which supports Fullan’s (2011) idea that teachers are motivated when they acquire and develop a skill (p. 82). In addition to the training, this model for motivation employs the idea that working with others helps gain understanding and success. Glazer, Hannafin, and Song (2005) propose a way to spur teacher motivation and ongoing support is through community-wide goals with educators supporting fellow learning. Teachers will be more receptive to change when they are motivated to embrace it and are given the tools necessary to implement the change required. Allowing teachers to work together and learn from one another further aids in the transitional periods when changes are occurring in an organization.

The Professional Standards for Educational Leadership (PSEL) are a set of guidelines for professional leadership. Several of the standards relate to how an educator should adapt to changes in education. PSEL Standard 1 endorses effective leaders to implement change in the
form of developing and implementing a mission, vision and core value system for an institution (Green, 2017). For this change to occur the leader must consider the community surrounding the organization and model the ideas for all involved to encourage others to be accepting of the new goals. In PSEL Standard 4, leaders deal with leading change by creating an effective structure of curriculum, instruction, and assessment that encourages students to learn and be relevant for all grades and subject areas involved in the process. This type of change requires leaders to employ and promote strategies that are pedagogically appropriate and aid students to develop. Teachers need to challenge student so they can explore their strengths. Another key aspect is for leaders to encourage the use of technology to create a stronger learning environment. Implementing new curriculum and technology always requires time and training for those involved.

PSEL Standard 10: “effective educational leaders act as agents of continuous improvement to promote each student’s academic success and well-being” relates to change in several instances (Green, 2017, p. 26), which addresses effective leaders making changes toward the goal of school improvement. Change should be a continuous process and not a single event. According to this standard, changes should be aimed at continuous improvement that works to “achieve the vision, fulfill the mission, and promote the core values of the school” (Green, 2017, p. 26). This standard also suggests that before change occurs, a leader must prepare the community and help develop knowledge and skills needed for these changes.

**Professional Learning Communities**

**Structure**

A professional learning community (PLC) is a group of educators who have meetings to share information that will assist students in gaining academic success (Solution Tree, 2017). The Glossary of Education Reform (2014) further describes a PLC as a structured group of
teachers who meet at regular intervals in order to work collaboratively to share their own areas of expertise and improve their teaching skills for increased student academic performance. A PLC is a process where educators work collaboratively in frequent meetings of investigation to find ways to attain better results from their students ("All things PLC," n.d.). These meetings should be a learning experience for the educator so that he/she may bring the success back to his/her classes and should be a continuous ongoing process where education has a profound impact on the structure and culture of the school and the expectations and performance of the professionals within the school (Solution Tree, 2017). The meetings have two main components: teachers collaborating by sharing ideas on professional concerns or discussing educational issues and teachers exchanging ideas to enhance both student and teacher growth. Provini (2012) quoted the Association for Middle Level Educators on PLC's, saying they are "the most powerful professional development and change strategy available" for the continuous improvement of faculty and the student population.

One attribute that has been linked to successful professional learning communities is that they are made up of individuals who contain different levels of knowledge and teaching experience. Collaboration is a key component in PLCs. Interaction is enhanced when individuals are given frequent opportunities to gather and share (Hord, 1997). The school year can be exhausting, and teachers reach that proverbial roadblock. All teachers find some topics problematic, and there are some topics students struggle to understand. Having other teachers with whom they can collaborate and discuss difficulties helps teachers improve their teaching practices, thus aiding in improving student learning.

A PLC should help empower educators and administrators to work together to create instruction practices that are high quality and make student learning the main focus. On a
national scale, the influence of PLCs on student learning is inspiring. On a Missouri state assessment, schools that were using the PLC plan had a 12.2% increase from 2002-2007 on 1st grade students who are now scoring at grade level on their end of the year Developmental Reading Assessment. In Ohio, the 7th grade mathematics benchmark was not met. The teachers were to use their PLC to create, implement, and analyze assessments to help with timely feedback. Educators used the results to help create strategies to assist with areas of weakness and create three math intervention programs. At the end of implementing these math intervention programs, the math score increased 20% within a year (K-12 Blueprint, 2014). These schools helped increase student learning by prioritizing student learning. These teachers used a PLC plan to ensure students were getting the proper education by working together for a common goal.

**Goals and Objectives**

When a PLC is constructed, there should be a set of goals and objectives clearly communicated at the beginning to ensure the PLC would be a successful as a learning environment for educators (DuFour, 2004). The first idea for a successful PLC is creating a culture of collaboration. Isolation is a chronic problem for teachers. They need to begin working together for the bettering of the school. The process of teachers acting in the PLC meetings will denote the success of the PLC. Collaboration needs to be geared toward school improvement. Teachers should collectively work to identify the state standards that students are required to learn for each unit or chapter and then develop common formative assessments for students. After students complete the assessments, results should be analyzed and this data used to drive teacher lesson planning. Results can be used to show strengths and weaknesses of each teacher. Thus, teachers are learners as well and can learn from one another. Teachers should
discuss with each other which lesson activities and teaching strategies work and which ones do not work to strengthen the learning experience for all.

It is essential to remember that all components of a PLC are important. The learning aspect of the process is to absorb from discussions and the community as a whole. Individuals all have their own special talents, experiences, and expertise they can bring to the group. It is important to utilize the greatest resource, the people surrounding one another every day. Teachers can learn from each other, enhance their teaching practices, and ultimately improve student performance. When principals introduce the idea of PLCs to faculty, administrators should inform teachers that they are to have learning situations, not arguments on what is right and what is wrong. The conversations in the PLC can be discussions where people disagree, but they need to be on topic and present a valid point (Ullman, 2009).

A supportive environment is also a method of implementing a PLC into a school. A collaborative environment has been described as the primary factor in deciding if a PLC will be successful in a school (Morrissey, 2000). There are two supportive structures found within a PLC: structural conditions and collegial relationships (Hord, 1997). Structural conditions include use of time, communication procedure, size of the school, proximity of teachers, and containing a staff development process. Collegial relationships emphasize the human side of a community. They include positive attitudes, commonly shared vision or sense of purpose, standards for continuous critical inquiry and improvement, respect, trust, and positive caring relationships. It is necessary to find ways to create common time and resources for the whole faculty to work together on the school’s PLC. If the school helps create supportive conditions, it will help grow and develop a community of professional learners.


**Study Groups**

Study groups are an approach for a collaborative, teacher-centered professional development (Arbaugh, 2003). In a study group, individuals gather together regularly for the purpose of learning. In the case of teachers, the study group would be for the purpose of exploring different educational aspects. The research on the effectiveness of study groups in secondary mathematics defined study group as a group of educators who meet on a set schedule for the purpose of supporting each other through the collaborative process in order to develop professionally and make their teaching practices better. One important aspect of the research was the number of members in the study group. The participants in the research believed that in order to have enough diversity of experience, at least four members are needed, but too many, over 10, reduces the effectiveness of the group. The meetings occurred every two weeks, and participants believed this to be useful because this time period allowed for retention of topics and relevance. Additionally, the meetings did not interfere with other life obligations.

Teachers are often isolated in their daily professional lives and are not given the opportunity to collaborate in a way that is useful (Stigler & Hiebert, 1999). Arbaugh (2003) determined that the study groups were a productive form of professional development for mathematics teachers. The first positive outcome from this research was the collaborative nature of the study group. Having common plan time or required departmental meetings is not enough to induce productive change (Stigler & Hiebert, 1999). Teachers need concentrated time to collaborate and build community where learning can take place. Building community is an important aspect of the teaching profession. Community aids in the retention of teachers, the ability of teachers to remain informed in educational developments in their subject, and builds a student community as they have a model to follow (Arbaugh, 2003). In addition to meeting as a
group to formulate ideas, teachers must also practice, which can occur through a lesson study where teachers meet regularly over time to work on the design, implementation, testing, and improvement of one or several lessons (Stigler & Hiebert, 1999). Through this process of lesson tuning and observations, teachers will both improve teaching practices and have the possibility of learning content at a deeper level.

Arbaugh’s (2003) research found that the study group was a productive way for teachers to learn and grow. The teachers in the study group found that the meetings allowed them time to study teaching and learning that would not have been possible in a different setting. This provided teachers with an avenue where they could link theory and practice, increase their knowledge about mathematics teaching and learning, and a place to perform reflection. The participants found the study group to be beneficial with the ability to collaborate regularly and helped them reflect on their own teaching practices. Arbaugh (2003) noted that after the research ended, several mathematics teachers from the same school began another study group to focus on teaching algebra (p. 158).

Research has shown that study groups are an effective means of professional development for teachers; Arbaugh’s (2003) study determined that a study group is an effective form of professional development for high school mathematics teachers. The research emphasized the importance of mathematics teachers having forum for collaboration with their peers and forming a community of mathematics teachers.

Testing Data

Researchers conducted a study in Massachusetts on students in grades 4-8 who had used a Standards-based textbook (set to align with NCTM Standards) for at least two years (Reys, Reys, Lapan, Hollliday, & Wasman, 2003). Researchers compared these students to students not
using a *Standards*-based textbook on a state mandated test. The students using the *Standards*-based textbook were found to score significantly higher than those who had not, with differences seen in various problem types, content strands, and different student. Researchers found performance gains were more substantial for groups of students who had been using the *Standard*-based textbooks for at least four years. Another study in Michigan determined that students using *Standards*-based instructional materials scored significantly better than their counterparts who had not used the materials. The National Science Foundation was investigating *Standards*-based materials found that different materials have different focuses, thus students using any particular type of learning material will score better on the content geared for that material. *Standards*-based materials aim at problem solving and exposure to a wide range of curriculum topics that had not previously been a part of mathematics curriculum in younger grades.

Schoen and Hirsch conducted another study that tested students using Contemporary Mathematics in Context (CMIC), a *Standards*-based curriculum found that student in 9th grade or Course I outperformed a similar group of students studying pre-algebra, algebra, and accelerated geometry on problems that relate to real-world context, and students in 10th grade or Course II outperformed similar students on contextualized problems (Hartwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007, p. 74). Another study of students using the CMIC curriculum found that 11th grade students scored significantly better than students using a traditional curriculum on problems in context with problem solving. In studies using standardized tests, researchers found students using *Standards*-based curriculum scored significantly higher for students in Course I when compared with students taught using traditional curriculum, with no significant difference found for students in Course II. There was also a statistically significant increase found for
students scoring in the top quartile on some different standardized tests and scoring above the national mean on the SAT-9 test (Hartwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007, p. 74). Regarding college aptitude tests: ACT, SAT, and PSAT, there was no significant difference found between students using a Standards-based curriculum and those using a traditional mathematics curriculum (Hartwell, Post, Maeda, Davis, Cutler, Andersen, & Kahan, 2007, p. 76).

**Need for Future Research**

In 1999, NCTM established the Standards Impact Research Group (SIRG), modeling it after the *Principles and Standards for School Mathematics* was published, in order to conduct research in the following areas: inform NCTM leadership about the impact of the publication with a focus on how this knowledge could be used to guide standards-based reform, aid in creating research studies related to NCTM standards and standard-based reform, and oversee a program that would investigate the effects of the publication (Research Advisory Committee, & Standards Impact Research Group, 2002). The main goal of this research group was to promote research surrounding NCTM standards. They do not want research that is completely positive in regards to implementing the standards, but prefer research that makes an effort to summarize the current knowledge with regards to high-quality mathematics teaching, the curriculum, and student learning. The research from SIRG has aided standards-based reform in the areas of systemic reform, curricular innovation, teacher education, and state policy. SIRG also proposed questions for future research:

- How have professional organizations, particularly NCTM, responded to the introduction of nationally developed standards?
• Which lines of research, such as exploration of the role played by *Principles and Standards* in NCTM’s Professional Development Academies or interpretations of key ideas in the Standards by NCTM members, could be investigated most profitably?

• Within the area of teachers and teaching practice, which research issues raised in SIRG conversations and pertaining to *Principles and Standards* should be pursued?

• What aspects of *Principles and Standards* are most salient to teachers, and in what ways to they enact those ideas in their teaching practice?

• How do local policy contexts interact with teachers’ efforts to implement ideas related to the Standards? (Research Advisory Committee, & Standards Impact Research Group, 2002)

The last two questions were integral in the formulation of the research questions in this study. There is a gap in the research regarding teacher understanding of the standards. The government developed the new standards with the expectation for teachers to teach them. There is a need for research to verify that teachers know and understand their specific content standards. Further, in order for a deeper conceptual understanding for students, teachers also need to develop these skills. It is crucial for teachers to understand the full breadth of secondary mathematics for coherence. Finally, teachers need professional development on implementing the new standards. This study will focus on teacher understanding of the secondary mathematics standards in a specific subject area and as a whole, teacher implementation of the standards in individual classes (Algebra I and Algebra II), and best practices that promote positive implementation of
the standards. This study specifically targets standards implementation in a large rural school district.

Summary

Standards are the foundation of a mathematics class. They influence the curriculum and teaching practices implemented. NCTM called for reform in mathematics teaching with the publication of *Curriculum and Evaluation Standards for School Mathematics*. The new standards proposed a radical change from teaching static topics unconnected to teaching for a deeper conceptual understanding of mathematics, focusing on the why as much as the how. This was the catalyst for the changes that began to take place in the United States, and in particular, in Tennessee. Common Core standards were the country’s way of answering NCTM’s call to action. These standards were more focused in content, required students to think with a different mindset that would lead to a deeper understanding of mathematics, and reviewed previously taught material when it was appropriate for the new topic under investigation. Common Core standards and the TNReady standards, which vary slightly from the Common Core standard, required teachers to alter the way they thought about mathematics and develop new curriculum, along with a new approach to teaching mathematics. Teachers need to understand the new standards for their specific class and how the standards relate and build. These new endeavors cannot be breached alone. Teachers need to work together to develop new practices that are beneficial to the student learner. This can be accomplished through professional development and professional learning communities.
CHAPTER III: METHODOLOGY

The researcher conducted this study to determine what secondary mathematics teachers know about the current standards in their subject area, how their standards fit into secondary mathematics, and what teachers need to adequately implement the standards. This study utilized a qualitative research approach to obtain data related to teachers’ knowledge of secondary mathematics standards, to determine areas where teachers struggle to implement the standards, and to find best practices for implementation of the secondary mathematics standards.

The researcher developed the research topic from the change in standards in mathematics in Tennessee. The introduction of Common Core prompted a significant change in these standards. There was a shift in the teaching approach of secondary mathematics from memorization of unconnected topics to teaching with a focus on conceptual understanding of the content. This new approach to teaching mathematics influenced the research questions for this study.

1. What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?

2. How are classroom practices influenced by changes in secondary mathematics standards?

3. What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

Qualitative Research

The researcher designed this qualitative study to gather data through surveys of secondary mathematics teachers and by conducting semi-structured interviews and a focus group.
with Algebra I and Algebra II teachers. These data revealed participants’ knowledge of the standards in the course they teach and across all secondary mathematics. The goal was to determine implementation practices with regard to the standards. “Qualitative inquiry seeks to understand and interpret human and social behavior as it is lived by participants in a particular social setting” (Ary, Jacobs, & Sorensen, 2010, p. 420). This method of research is personal, and both the researcher and participants should attempt to omit personal bias. Data in qualitative research can be gathered through observation techniques, focus groups, interviews, and case studies (Regents of the University of Minnesota, 2018).

Research Approach

Grounded Theory is a method of qualitative research where theory is created based on empirical data gathered through interviews and observations (Ary, Jacobs, & Sorensen, 2010, p. 463). The data are analyzed with the focus being on finding similarities and differences between the responses from the participants. The data provides information on how standards are understood, how they fit into the bigger picture of secondary mathematics as a whole, and ways the standards can inform teaching methodology.

Research Setting and Participants

The researcher conducted this qualitative study with secondary mathematics teachers from a single large school district in East Tennessee. Mathematics teachers in grades 7-12 completed the survey with Algebra I and/or Algebra II teachers taking part in the semi-structured interviews. The research district consists of approximately 1,090 teachers and 14,717 students in 30 schools (Tennessee Department of Education, n.d.). The research district is comprised of 84.7% Caucasian students, 11.4% Hispanic or Latino, 2.1% African American, 1.5% Asian, and less than 1% Native American or Alaskan (Tennessee Department of Education, n.d.). The
district’s population of economically disadvantaged is 31.2% (Tennessee Department of Education, n.d.).

**Sampling**

Qualitative research is targeted at providing in-depth understanding of a specific group, type of individual, event, or process (Ary, Jacobs, & Sorensen, 2010, pp. 427-428). With this goal, the researcher used criterion-based sampling techniques specifically for this study quota and purposive sampling. Quota sampling was employed because the researcher needed a certain number of participants, and utilized purposive sampling because the researcher needed teachers that met a certain criteria (teaching Algebra I and/or Algebra II) (Ary, Jacobs, & Sorensen, 2010, pp. 156-157, 428-429).

The researcher sent the survey to principals of the schools within the district containing grades 7-12 to notify the principals about the study and request for their teachers to participate in the study via the survey being distributed electronically to the mathematics teachers in these schools. From the respondents of the survey, a purposeful sample was taken of eight mathematics teachers teaching Algebra I and/or Algebra II, who volunteered to participate in the study. The researcher chose teachers based on varying years of experience and those who taught different levels of the classes: skills, standard, and honors. These teachers contributed to the study by participating in both the semi-structured interviews and the focus group for data collection purposes.

**Data Collection Procedures**

This qualitative study focused on secondary mathematics teachers’ knowledge of the secondary mathematics standards and implementation of the standards. Approval was granted by the schools being surveyed, the Carson-Newman IRB, and the school system district-level
supervisor, prior to the beginning of the study. Data collection is information one gathers from a range of sources (Regents of the University of Minnesota, 2018). Three types of data were gathered and informed this study: an online survey, semi-structured interviews, and a focus group. The survey was used as the first component to obtain data and inform questioning for the second phase, the semi-structured interviews. Next, the researcher conducted the interviews with the teachers prior to the focus group meeting with all participants to determine individual knowledge and perceptions and to determine the goals of the group. Data were collected during the focus group in the form of field notes.

Survey

An online survey was used to determine secondary mathematics teachers’ knowledge of their specific content standards and to determine areas where further research was needed in the study for understanding and implementation of the standards. The survey was a combination of Likert scale questions and multiple select questions to direct the focus of the study. In addition to the literature review, the researcher used the data gathered to develop the interview guide for the semi-structured interviews and focus group portion of the study. The survey was administered using the Google platform with a Google Form.

Semi-Structured Interviews

A semi-structured interview is one where the researcher begins with a set of questions but can modify the questions during the interview process as needed (Ary, Jacobs, & Sorensen, 2010). The questions in this phase of the study were open-ended and allowed participants to state their insights on questions. Probing was the method used to encourage the participants to more deeply explain their reasoning. Eight Algebra I or Algebra II teachers volunteered through the survey to be interviewed and to be a part of the focus group phase of the
study. The teachers were interviewed, and the interviews were conducted at a time convenient to the research participants and were recorded using two forms of audio devices to ensure accuracy of results. During the data analysis phase of the study, the interviews were transcribed, and coding was used to search for themes for the focus group phase of the study.

**Focus Group**

Focus groups are more socially oriented than individual interviews and can increase the sample size in the study, but they allow less control than individual interviews and data can be more difficult to analyze. Focus groups should not be used in emotionally charged environments or in environments with unbalanced power dynamics. (Ary, Jacobs, & Sorensen, 2010, p. 440)

For this study, the focus group participants seven of the individuals who were interviewed in the semi-structured interviews. One teacher was unable to participate in the focus group for personal reasons unrelated to the study. A focus group allowed for collaboration among the research participants and served as a member check. The researcher employed the following techniques during this phase of the study:

- Ask questions when you do not understand.
- Trust your instincts and follow your hunches.
- Explore the participant’s experience, but beware of inserting the interviewer’s agenda.
- Avoid leading questions.
- Ask open-ended questions.
- Follow up, but do not interrupt.
• Ask participants to talk as if they were someone else or respond to you as if you were someone else.

• Ask them to tell a story.

• Ask them to reconstruct rather than to remember.

• Ask for concrete details.

• Do not take the ebb and flow of the interview too seriously.

• Rarely share your own experiences.

• Avoid reinforcing responses, either positively (“OK,” “yes,” and “uh huh”) or negatively.

• Explore laughter; it may reflect nervousness or be indicative of something else going on.

• Use the interview cautiously and avoid imposing your own interests.

• Tolerate silence. (Ary, Jacobs, & Sorensen, 2010, p. 441)

The focus group meetings were recorded using two forms of audio devices.

Data Analysis Procedures

Survey

The survey utilized a combination of Likert scale questions and multiple select questions to direct the focus of the study. The questions were researched-based pertaining to secondary mathematics teachers’ knowledge of their specific content standards and to determine areas where further research was needed in the study for understanding and implementation of the standards. Demographic data were also gathered pertaining to grade-level and the specific subject area taught. The results from the survey were used in the purposeful sampling for the semi-structured interviews and forming the focus group. The Likert scale questions used a four-
point scale, within the range of 1 for strongly disagree, 2 for disagree, 3 for agree, and 4 for strongly agree. The researcher used open coding to find key words and themes. The data gathered were used to develop the questions for the interview and focus group portion of the study.

**Semi-Structured Interviews**

The semi-structured interviews were recorded using two forms of audio devices. They were transcribed for analysis. Open coding was used to find key themes in the interviews. After an in-depth study of the transcriptions, axial coding was used to further organize the data into smaller, more precise groups with commonality. Finally, selective coding was used to determine the core topics in all of the data and regroup the data in relationship to the core topics. The in-depth analysis of the data from the interviews influenced the structure for the focus group portion of the study. The data allowed for formulation of questions to lead the initial discussion.

**Focus Group**

The focus group was recorded with two forms of audio devices and video. Discussions from the focus group sessions were transcribed and open coding was used to identify key themes. After an in-depth study of the transcriptions, axial coding was used to further organize the data into smaller, more precise groups with commonality. Finally, selective coding was used to determine the core topics in all of the data and to regroup the data in relationship to the core topics.

**Ethical Considerations**

The Carson-Newman University IRB and the appropriate supervisors in the research district granted approval for this research study. Ary, Jacobs, and Sorensen (2010) detailed four areas of ethical consideration for a qualitative study: “the kind of information obtained,
researcher’s relationship to the participants, reciprocation, and getting permission to conduct research” (pp.444-445). All laws were followed in the collection of data in this study. Prior to any data collection, informed consent was acquired from all participants in the survey, interviews, and focus group. The researcher expunged all bias and treated the study participants as unknown entities. Data were stored in a locked cabinet with all personal identifiers kept separate from the data. The researcher assigned all participants a pseudonym.

**Trustworthiness Techniques**

To safeguard the study, the researcher employed the following trustworthiness techniques during the study: peer debriefing, triangulation, and member checks. Peer debriefing occurred at each stage of the study to allow for an unbiased review of the study to ensure credibility. A mathematics teacher fulfilled the role of peer debriefer. Triangulation occurred through the use of multiple sources of data: a survey, interviews, and a focus group. These provided insight and supported dependability of the study. Member checks occurred after the focus group interviews and the data had been analyzed. This allowed participants to ensure the data collected from them had been accurately interpreted by the researcher.

**Summary**

The researcher used Grounded Theory approach to analyze this study and to determine secondary mathematics teachers’ knowledge of their specific content standards and to determine areas where further research was needed in the study for understanding and implementation of the standards. A survey was used to establish a base-line of teacher knowledge and needs. Subsequently, eight Algebra I or Algebra II teachers were interviewed and participated in a focus group. Ethical considerations were used during the whole research process. The researcher determined themes from the results using open, axial, and selective coding.
CHAPTER IV: PRESENTATION OF THE FINDINGS

The study sought to determine secondary mathematics teachers’ knowledge regarding their standards and how these standards related to other mathematics courses. Additionally, the study sought to determine ways to help teachers interpret the standards and to develop standards-based curriculum. Algebra I and Algebra II were selected as the focus of the study because these relate to each other with overlapping standards and are a continuation of one another.

Research Questions

The study was conducted in three phases: an online survey, semi-structured interviews, and a focus group. The questions used in each stage of the study were constructed to aid in gathering data related to the three key questions of the study:

- What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?
- How are classroom practices influenced by changes in secondary mathematics standards?
- What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

Description of Participants

The participants in the survey were 31 secondary mathematics teachers from a single large school district in East Tennessee who voluntarily took the survey. The teachers who participated in the survey taught a wide variety of secondary mathematics topics. Three taught Response to Instruction and Intervention for mathematics (RTI), three taught 7th grade math, four
taught 8th grade math, 16 taught Algebra I, nine taught Geometry, 11 taught Algebra II, one taught Precalculus, three taught Calculus, three taught Bridge Math, one taught SAILS, three taught Probability and Statistics, one taught Applied Mathematical Concepts, and two taught ACT Prep Math. Several participants taught more than one subject area. Table 4.1 represents the subject areas taught by the participants.

Table 4.1
Subject Areas Taught by Survey Participants

<table>
<thead>
<tr>
<th>Subject Area Taught</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response to Instruction and Intervention</td>
<td>3</td>
</tr>
<tr>
<td>Math Grade 7</td>
<td>3</td>
</tr>
<tr>
<td>Math Grade 8</td>
<td>4</td>
</tr>
<tr>
<td>Algebra I</td>
<td>16</td>
</tr>
<tr>
<td>Geometry</td>
<td>9</td>
</tr>
<tr>
<td>Algebra II</td>
<td>11</td>
</tr>
<tr>
<td>Precalculus</td>
<td>1</td>
</tr>
<tr>
<td>Calculus</td>
<td>3</td>
</tr>
<tr>
<td>Bridge</td>
<td>3</td>
</tr>
<tr>
<td>Sails</td>
<td>1</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Applied Mathematical Concepts</td>
<td>1</td>
</tr>
<tr>
<td>ACT Prep Math</td>
<td>2</td>
</tr>
</tbody>
</table>

The experience levels of the teachers also varied. Three teachers had 0-5 years of experience (YOE), 10 had 6-10 YOE, eight had 11-20 YOE, and 10 had more than 20 years’ experience. Table 4.2 represents the total number of years of experience by the survey participants.

Table 4.2
Years of Experience by Survey Participants

<table>
<thead>
<tr>
<th>Years of Experience</th>
<th>Number of Participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td>3</td>
<td>9.7</td>
</tr>
<tr>
<td>6-10</td>
<td>10</td>
<td>32.25</td>
</tr>
<tr>
<td>11-20</td>
<td>8</td>
<td>25.8</td>
</tr>
<tr>
<td>20+</td>
<td>10</td>
<td>32.25</td>
</tr>
<tr>
<td>Totals (N=31)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There were eight participants for the semi-structured interviews who taught Algebra I or Algebra II. Seven of the interview participants comprised the focus group; teacher 7 was unable to take part in the focus group for personal reasons not related to the study. All participants in this portion of the study were female and taught at three different schools in the study district. School A contained grades 10-12, school B contained grades 7-9, and school C contained grades 9-12. School A and B are separately funded and administered schools operating in the same building that share common areas such as a cafeteria, gym, and library.

Teachers 1-3 and Teacher 8 teach exclusively in School B. Teacher 1 has taught mathematics for eight years and currently teaches 9th grade Algebra I Standard and Honors level and 9th grade Honors Geometry. She has been in this teaching assignment for five years. Teacher 2 has taught mathematics for nine years and currently teaches 9th grade Algebra I Standard. She has previously taught 9th grade Algebra I Skills and 8th grade Algebra I. She has been in her current teaching assignment for four years. Teacher 3 has been teaching for 36 years with 25 of that in mathematics. She teaches RTI math for middle grades, and 9th grade Algebra I and teaches 9th grade Standard Algebra I. She has been teaching in her current assignment for two years. Teacher 8 has been teaching mathematics for 14 years. She teaches math grade 8 for regular education and accelerated eighth grade from the Algebra I text. She has been in her current teaching assignment for six years.

Teachers 4 and 7 teach in both Schools A and B. Teacher 4 has been teaching for 25 years with over 20 of that in mathematics. She has taught Skills-level Algebra I for over 20 years. She is in her first year at her current teaching assignment and currently teaches Skills Geometry and Algebra I Skills. Teacher 7 has been teaching mathematics for 25 years. She
currently teaches standard level Algebra I and Algebra II. She has taught these classes for 20 years and has been in her current teaching assignment for six years.

Teachers 5 and 6 teach at School C. Teacher 5 has been teaching mathematics for 33 years. She currently teaches 9th grade Honors Algebra I and Geometry. She has been teaching Honors Algebra I for approximately 15 years and Honor Geometry for seven years. Teacher 6 has been teaching mathematics for 14 years. She currently teaches Algebra II Standard, Algebra II Honors, and Advanced Placement (AP) Calculus. She has been teaching Algebra II Standard for 12 years, Algebra II Honors for 10 years, and AP Calculus for six years.

**Education.** Teachers 2 and 4-7 all took a traditional approach to being certified to teach mathematics. They majored in mathematics and had formal secondary teaching training. Teachers 2 and 4 received their degrees in states outside of Tennessee, Illinois and Ohio respectively. Teacher 4 also has a Master’s degree in Special Education and Elementary Education from a Tennessee college or university. Teachers 5-7 all received their math degrees from Tennessee colleges or universities. Teacher 7 has a Master of Education and an Education Specialist.

Teachers 1, 3, and 8 took a non-traditional approach to becoming certified to teach secondary mathematics. Teacher 1 has an accounting degree and in Florida participated in an alternate certification program to become certified to teach and passed the math praxis to specifically teach mathematics. She now also has a Master of Education and an Education Specialist from Tennessee universities. Teacher 3 began as a math major, and after her freshman year, changed her major and became certified to teach vocational economics. Due to having eight hours of mathematics credits after her initial certification, she took some more lower level math classes and CLEP tests and received an add-on endorsement for mathematics. Teacher 8
took and passed both the middle school math and the Algebra I Praxis tests to become certified to teach secondary mathematics. She has a Bachelor of Science in Interdisciplinary Studies Grades 4-8, a Master of Education and Education Specialist in Curriculum and Instruction and is currently working on a Doctorate in Educational Leadership.

**Presentation of Results: Survey Questions and Responses**

The survey participants answered eight questions, the first four with a multiple select options and the second four with a Likert scale four choice options: (1) Strongly Disagree, (2) Disagree Somewhat, (3) Agree Somewhat, (4) Strongly Agree.

The participants were divided into three different groups for data analysis: group X, those who only teach Algebra I or Algebra II; group Y, those who teach Algebra I or Algebra II and at least one other subject; and group Z, those who do not teach Algebra I or Algebra II. Table 4.3 represents the survey participants divided into subgroups by subjects taught.

Table 4.3  
*Subgroup Participants*

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Number of Participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group X</td>
<td>7</td>
<td>22.6</td>
</tr>
<tr>
<td>Group Y</td>
<td>16</td>
<td>51.6</td>
</tr>
<tr>
<td>Group Z</td>
<td>8</td>
<td>25.8</td>
</tr>
</tbody>
</table>

**Question 1: Which of the Algebra standards do you feel are areas of strength to teach?**

Group X chose the following Algebra standards domains as the greatest strengths to teach: Reasoning with Equations and Inequalities and Arithmetic with Polynomials and Rational Expressions. Group Y selected Reasoning with Equations and Inequalities and Linear, Quadratic, and Exponential Models as the greatest strengths to teach. Group Z chose The Real Number System and Creating Equations as the greatest strengths to teach. For the entire group of survey participants, The Real Number System and Reasoning with Equations and Inequalities
were chosen as the greatest strengths to teach. Table 4.4 illustrates the data gathered from Question 1.

Table 4.4

*Question 1: Which of the Algebra standards do you feel are areas of strength to teach?*

<table>
<thead>
<tr>
<th>Standard Domains</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Real Number System</td>
<td>16</td>
</tr>
<tr>
<td>Seeing Structure in Expressions</td>
<td>13</td>
</tr>
<tr>
<td>Arithmetic with Polynomials and Rational Expressions</td>
<td>14</td>
</tr>
<tr>
<td>Reasoning with Equations and Inequalities</td>
<td>18</td>
</tr>
<tr>
<td>Interpreting Functions</td>
<td>12</td>
</tr>
<tr>
<td>Building Functions</td>
<td>8</td>
</tr>
<tr>
<td>Making Inferences and Justifying Conclusions</td>
<td>3</td>
</tr>
<tr>
<td>Quantities</td>
<td>2</td>
</tr>
<tr>
<td>The Complex Number System</td>
<td>6</td>
</tr>
<tr>
<td>Creating Equations</td>
<td>10</td>
</tr>
<tr>
<td>Linear, Quadratic, and Exponential Models</td>
<td>14</td>
</tr>
<tr>
<td>Trigonometric Functions</td>
<td>4</td>
</tr>
<tr>
<td>Interpreting Categorical and Quantitative Data</td>
<td>3</td>
</tr>
<tr>
<td>Conditional Probability and the Rules of Probability</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Standard Domains</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Real Number System</td>
<td>3</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Seeing Structure in Expressions</td>
<td>2</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Arithmetic with Polynomials and Rational Expressions</td>
<td>4</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Reasoning with Equations and Inequalities</td>
<td>5</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Interpreting Functions</td>
<td>2</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Building Functions</td>
<td>1</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Making Inferences and Justifying Conclusions</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Quantities</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>The Complex Number System</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Creating Equations</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Linear, Quadratic, and Exponential Models</td>
<td>2</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Trigonometric Functions</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Interpreting Categorical and Quantitative Data</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Conditional Probability and the Rules of Probability</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Question 2: Which of the Algebra standards do you feel are of greatest difficulty to teach?

Group X selected the following Algebra standards domains as the greatest challenge to teach: Interpreting Categorical and Quantitative Data, Building Functions, and Conditional Probability and the Rules of Probability. Group Y chose Making Inferences and Justifying Conclusions and Creating Equations as the greatest challenge to teach. Group Z selected Making Inferences and Justifying Conclusions and Interpreting Categorical and Quantitative Data as the greatest challenge to teach. For the entire group of survey participants, Making Inferences and Justifying Conclusions, Interpreting Categorical and Quantitative Data, and Conditional Probability and the Rules of Probability were the most challenging to teach. No teachers in any group chose The Real Number System as a challenging area to teach. Table 4.5 illustrates the data gathered from Question 2.

Table 4.5
Question 2: Which of the Algebra standards do you feel are of greatest difficulty to teach?

<table>
<thead>
<tr>
<th>Standard Domains</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Real Number System</td>
<td>0</td>
</tr>
<tr>
<td>Seeing Structure in Expressions</td>
<td>4</td>
</tr>
<tr>
<td>Arithmetic with Polynomials and Rational Expressions</td>
<td>7</td>
</tr>
<tr>
<td>Reasoning with Equations and Inequalities</td>
<td>4</td>
</tr>
<tr>
<td>Interpreting Functions</td>
<td>5</td>
</tr>
<tr>
<td>Building Functions</td>
<td>5</td>
</tr>
<tr>
<td>Making Inferences and Justifying Conclusions</td>
<td>19</td>
</tr>
<tr>
<td>Quantities</td>
<td>1</td>
</tr>
<tr>
<td>The Complex Number System</td>
<td>2</td>
</tr>
<tr>
<td>Creating Equations</td>
<td>8</td>
</tr>
<tr>
<td>Linear, Quadratic, and Exponential Models</td>
<td>5</td>
</tr>
<tr>
<td>Trigonometric Functions</td>
<td>8</td>
</tr>
<tr>
<td>Interpreting Categorical and Quantitative Data</td>
<td>11</td>
</tr>
<tr>
<td>Conditional Probability and the Rules of Probability</td>
<td>11</td>
</tr>
<tr>
<td>Standard Domains</td>
<td>Group X</td>
</tr>
<tr>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>The Real Number System</td>
<td>0</td>
</tr>
<tr>
<td>Seeing Structure in Expressions</td>
<td>2</td>
</tr>
<tr>
<td>Arithmetic with Polynomials and Rational Expressions</td>
<td>1</td>
</tr>
<tr>
<td>Reasoning with Equations and Inequalities</td>
<td>0</td>
</tr>
<tr>
<td>Interpreting Functions</td>
<td>1</td>
</tr>
<tr>
<td>Building Functions</td>
<td>3</td>
</tr>
<tr>
<td>Making Inferences and Justifying Conclusions</td>
<td>2</td>
</tr>
<tr>
<td>Quantities</td>
<td>0</td>
</tr>
<tr>
<td>The Complex Number System</td>
<td>0</td>
</tr>
<tr>
<td>Creating Equations</td>
<td>2</td>
</tr>
<tr>
<td>Linear, Quadratic, and Exponential Models</td>
<td>1</td>
</tr>
<tr>
<td>Trigonometric Functions</td>
<td>1</td>
</tr>
<tr>
<td>Interpreting Categorical and Quantitative Data</td>
<td>4</td>
</tr>
<tr>
<td>Conditional Probability and the Rules of Probability</td>
<td>3</td>
</tr>
</tbody>
</table>

**Question 3: Which of the eight mathematical practices do you feel are the most challenging to implement in your classroom?**

Group X, those who only teach Algebra I or Algebra II, identified the following mathematical practices were the most challenging to implement in the classroom: make sense of problems and persevere in solving them and construct viable arguments and critiques the reasoning of others. Groups Y, those who teach Algebra I or Algebra II and at least one other subject, and group Z, those that do not teach Algebra I or Algebra II, both identified reason abstractly and quantitatively and critiques the reasoning of others were the most challenging mathematical practices to implement in the classroom. These two mathematical practices were also the most commonly chosen from all teachers in the survey. Table 4.6 illustrates the data gathered from Question 3.
Table 4.6

Question 3: Which of the eight mathematical practices do you feel are the most challenging to implement in your classroom?

<table>
<thead>
<tr>
<th>Mathematical Practices</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>make sense of problems and persevere in solving them</td>
<td>11</td>
</tr>
<tr>
<td>reason abstractly and quantitatively</td>
<td>16</td>
</tr>
<tr>
<td>construct viable arguments and critique the reasoning of others</td>
<td>15</td>
</tr>
<tr>
<td>model with mathematics</td>
<td>5</td>
</tr>
<tr>
<td>use appropriate tools strategically</td>
<td>3</td>
</tr>
<tr>
<td>attend to precision</td>
<td>6</td>
</tr>
<tr>
<td>look for and make use of structure</td>
<td>7</td>
</tr>
<tr>
<td>look for and express regularity in repeated reasoning</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mathematical Practices</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>make sense of problems and persevere in solving them</td>
<td>3</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>reason abstractly and quantitatively</td>
<td>2</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>construct viable arguments and critique the reasoning of others</td>
<td>3</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>model with mathematics</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>use appropriate tools strategically</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>attend to precision</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>look for and make use of structure</td>
<td>2</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>look for and express regularity in repeated reasoning</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Question 4: Which of the eight mathematical practices do you feel are the easiest to implement in your classroom?

Group X selected the following mathematical practices as the easiest to implement in the classroom: construct viable arguments and critiques the reasoning of others and use appropriate tools strategically. Groups Y chose model with mathematics and use appropriate tools strategically as the easiest mathematical practices to implement in the classroom. Group Z selected model with mathematics, use appropriate tools strategically, and attend to precision as the easiest mathematical practices to implement in the classroom. The survey group, as a whole, chose model with mathematics and use appropriate tools strategically as the easiest practices to implement in the classroom. Construct viable arguments and critique the reasoning of others was the only mathematical practice where teachers in a specific group noted it was both the
easiest and most challenging practice to implement in the classroom. This occurred with the group containing only Algebra I and Algebra II teachers. Table 4.7 illustrates the data gathered from Question 4.

Table 4.7

**Question 4:** Which of the eight mathematical practices do you feel are the easiest to implement in your classroom?

<table>
<thead>
<tr>
<th>Mathematical Practices</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>make sense of problems and persevere in solving them</td>
<td>11</td>
</tr>
<tr>
<td>reason abstractly and quantitatively</td>
<td>3</td>
</tr>
<tr>
<td>construct viable arguments and critique the reasoning of others</td>
<td>7</td>
</tr>
<tr>
<td>model with mathematics</td>
<td>15</td>
</tr>
<tr>
<td>use appropriate tools strategically</td>
<td>17</td>
</tr>
<tr>
<td>attend to precision</td>
<td>12</td>
</tr>
<tr>
<td>look for and make use of structure</td>
<td>8</td>
</tr>
<tr>
<td>look for and express regularity in repeated reasoning</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mathematical Practices</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>make sense of problems and persevere in solving them</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>reason abstractly and quantitatively</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>construct viable arguments and critique the reasoning of others</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>model with mathematics</td>
<td>3</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>use appropriate tools strategically</td>
<td>4</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>attend to precision</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>look for and make use of structure</td>
<td>1</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>look for and express regularity in repeated reasoning</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

**Question 5:** I am confident in implementing and teaching the content standards for the class (specific grade/subject/level) I teach.

All teachers who participated in the survey either agreed or strongly agreed that they were confident in implementing their own content standards. In group X, those that only teach Algebra I or Algebra II, 85.71% agreed, and 14.29% strongly agreed. In group Y, those who teach Algebra I or Algebra II and at least one other subject, 56.25% agreed, and 43.75% strongly agreed. In group Z, those that do not teach Algebra I or Algebra II, 37.5% agreed, and 62.5% strongly agreed. For all survey participants, 58.06% agreed, and 41.94% strongly agreed that for
their specific grade/subject/level they were confident in their abilities to implement the content standards. Table 4.8 illustrates the data gathered from Question 5.

Table 4.8

Table 4.8

Question 5: I am confident in implementing and teaching the content standards for the class (specific grade/subject/level) I teach.

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Number of Participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>18</td>
<td>58.06</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>13</td>
<td>41.94</td>
</tr>
<tr>
<td>Totals (N=31)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>6</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>1</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Question 6: I understand how my standards fit into the larger picture of secondary mathematics.

This question sought to determine teachers’ understanding of how their content standards fit into all secondary mathematics standards and had the highest percentage of disagreement of all of the four Likert scale type questions. Group X was the only group without disagreement; 71.43% agreed, and 28.57% strongly agreed that they understand how their standards fit into secondary mathematics. Group Y had 56.25% agreed, 37.5% strongly agreed, and 6.25% disagreed. Group Z had 50% agreed, 25% strongly agreed, 12.5% disagreed, and 12.5% strongly disagreed. For all survey participants, 58.06% agreed, 32.26% strongly agreed, 6.45% disagreed, and 3.23% strongly disagreed that they understand where their standards fit into secondary mathematics. Table 4.9 illustrates the data gathered from Question 6.
Table 4.9

**Question 6**: I understand how my standards fit into the larger picture of secondary mathematics.

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Number of Participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>1</td>
<td>3.23</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>2</td>
<td>6.45</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>18</td>
<td>58.06</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>10</td>
<td>32.26</td>
</tr>
<tr>
<td>Totals (N=31)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>5</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4.10 illustrates the data gathered from Question 7.

**Question 7**: The standards for my class affect how I teach the class.

This question elucidated how teachers view their teaching practices and how the standards for the class affect how the class is taught. In group X, those that only teach Algebra I or Algebra II, 57.14% agreed, 28.57% strongly agreed, and 14.29% disagreed that the standards affect the method used to teach. For group Y, those that teach Algebra I or Algebra II and at least one other subject, 68.75% agreed, 25% strongly agreed, and 6.25% disagreed. Group Z, those that do not teach Algebra I or Algebra II, had all agreement where 37.5% agreed, and 62.5% strongly agreed. For all survey participants, 58.06% agreed, 35.49% strongly agreed, and 6.45% disagreed that the standard they are teaching affect how they teach the course content.

Table 4.10

**Question 7**: The standards for my class affect how I teach the class.

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Number of Participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>2</td>
<td>6.45</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>18</td>
<td>58.06</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>11</td>
<td>35.49</td>
</tr>
<tr>
<td>Totals (N=31)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.10

*Question 7: The standards for my class affect how I teach the class.*

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>4</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Question 8: The level of class I teach affects how I teach the standards.**

The final survey question investigated how teachers perceive the level of the class being taught affecting how they teach the content standards. Group X had 57.14% agreed, 28.57% strongly agreed, and 14.29% disagreed. Group Y had 43.75% agreed, 50% strongly agreed, and 6.25% disagreed. Group Z again had only agreement where 12.5% agreed and 87.5% strongly agreed. For all survey participants 38.71% agreed, 54.84% strongly agreed, and 6.45% disagreed that the level of the class being taught affects how the teacher teaches the content standards. Table 4.11 illustrates the data gathered from Question 8.

Table 4.11

*Question 8: The level of class I teach affects how I teach the standards.*

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Number of Participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>2</td>
<td>6.45</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>12</td>
<td>38.71</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>17</td>
<td>54.84</td>
</tr>
<tr>
<td>Totals (N=31)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Likert Score</th>
<th>Group X</th>
<th>Group Y</th>
<th>Group Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Strongly Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2) Disagree</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(3) Agree</td>
<td>4</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>(4) Strongly Agree</td>
<td>2</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.12 displays a summary of all Likert responses from the survey.
Table 4.12
Percentages Summary of All Likert Responses

<table>
<thead>
<tr>
<th>Question</th>
<th>(1) SD</th>
<th>(2) D</th>
<th>(3) A</th>
<th>(4) SA</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) I am confident in implementing and teaching the content standards for the class (specific grade/subject/level) I teach.</td>
<td></td>
<td></td>
<td>58.06</td>
<td>41.94</td>
</tr>
<tr>
<td>(2) I understand how my standards fit into the larger picture of secondary mathematics.</td>
<td>3.23</td>
<td>6.45</td>
<td>58.06</td>
<td>32.26</td>
</tr>
<tr>
<td>(3) The standards for my class affect how I teach the class.</td>
<td>0</td>
<td>6.45</td>
<td>58.06</td>
<td>35.49</td>
</tr>
<tr>
<td>(4) The level of class I teach affects how I teach the standards.</td>
<td>0</td>
<td>6.45</td>
<td>38.71</td>
<td>54.84</td>
</tr>
</tbody>
</table>

Presentation of Results: Analysis of Teacher Interview Data

An 18-question interview guide was used to collect data from the eight teacher participants to better understand the teacher’s perception of the standards and implementation of the standards. The researcher divided the data by the three research questions for data analysis. After finalizing the preliminary phase of data collection, data were sorted through open, axial, and selective coding. Through the initial open and axial coding, themes developed to support the categories in presenting pertinent information to answer the research questions. Selective coding permitted the data to be separated into three categories which address the three research questions. The data analysis and coding process related back to Constructivism, which served as the theoretical framework of the study. The following research practices were employed: studying the context and setting of the participants, involving the researchers to collaborate with the participants, collecting meaning of context that were participant generated, interpreting the data, and creating an agenda for change (Dudovskiy, 2019). Peer debriefing occurred at each stage of the study to allow for an unbiased review of the study to ensure credibility. A mathematics teacher reviewed the data and verified the themes garnered. The peer debriefer
posed questions and added a different perspective to the analysis process. Member checks occurred at the end of the study. The interview and focus group participants were given the opportunity to read their transcripts and give further statements. The study results were divided into three categories with the themes that justify each. Tables 4.13, 4.14, and 4.15 illustrate the level of coding for the study.
Table 4.13

Coding Research Question 1: What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?

<table>
<thead>
<tr>
<th>Raw Data</th>
<th>Open Coding</th>
<th>Axial Coding</th>
<th>Selective Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>“make sure that they relate to everyday life”</td>
<td>Real-life problem solving</td>
<td>Mathematical practices relate to real life</td>
<td>Practices to increase teachers’ understanding of current standards</td>
</tr>
<tr>
<td>“relating them to the situations that the students are doing relating to real life problem solving”</td>
<td>Relate problems to everyday life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“slowed down my teaching to make sure everything is covered”</td>
<td>Look at all aspects of questions</td>
<td>Spend more time on material</td>
<td></td>
</tr>
<tr>
<td>“relating it more to where they can see connections”</td>
<td>Seeing and making connections</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“make sense of the problems and make sure that they relate to everyday life and reasoning skills”</td>
<td>Focus on understanding</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“Sometimes it’s harder to relate that to everyday life.”</td>
<td>Reasoning skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“They can get an answer but they do not understand what they have done and they can’t explain what they have done.”</td>
<td>Hard to relate to everyday life</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard skills to teach</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard to back up answers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.14

Coding Research Question 2: How are classroom practices influenced by changes in secondary mathematics standards?

<table>
<thead>
<tr>
<th>Raw Data</th>
<th>Open Coding</th>
<th>Axial Coding</th>
<th>Selective Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>“have a kid create something and explain it”</td>
<td>Problem solving</td>
<td>Expecting more out of students</td>
<td>Classroom practices influenced by changes in secondary mathematics</td>
</tr>
<tr>
<td>“getting them to reason and think critically”</td>
<td>Critical thinking</td>
<td>Teachers appreciate the new standards</td>
<td></td>
</tr>
<tr>
<td>“relating to real life problems solving”</td>
<td>Students create</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“they are easy to implement and flow well together”</td>
<td>Reasoning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“I think they relate to former standards and there a lot of correlation”</td>
<td>Relating standards to the real world</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“do some type of assessment to kinda see where the students are”</td>
<td>Standards flow well together</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“make sure that students have strong basics”</td>
<td>Standards correlate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“show how strong basics are needed”</td>
<td>Easy to implement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“working more on trying to fill the gaps”</td>
<td>Relate to former standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“being able to openly communicate”</td>
<td>Gaps in student learning</td>
<td>Pretest and retest</td>
<td></td>
</tr>
<tr>
<td>“search for new ways to teach”</td>
<td>Students at different levels</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pretest</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teach strong basics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fill in gaps</td>
<td>Improving teaching practices</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.15
Coding Research Question 3: What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

<table>
<thead>
<tr>
<th>Raw Data</th>
<th>Open Coding</th>
<th>Axial Coding</th>
<th>Selective Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>“allow us to collaborate and provide with different opportunities to continue learning”</td>
<td>Provide common planning time for teachers of same subject or grade level</td>
<td>Provide tools and resources necessary for teaching</td>
<td>Principal supports</td>
</tr>
<tr>
<td>“supplying teachers with the tools to teach kids like manipulatives”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“give the teachers ideas like how to implement the standards”</td>
<td>Gathering and sharing ideas with teachers</td>
<td>Providing aid in lesson planning and topic exploration</td>
<td>Teacher leader supports</td>
</tr>
<tr>
<td>“provide us with what we need”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“get ideas from teacher leaders”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“allow them to come into a classroom to observe them teaching”</td>
<td>Mentor program</td>
<td>Planning together</td>
<td>Supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards</td>
</tr>
<tr>
<td>“share best practices”</td>
<td>Classroom observations</td>
<td>Sharing ideas, plans,</td>
<td></td>
</tr>
<tr>
<td>“mentor or buddy that you are paired with”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“more beneficial when I hear from other math educators how they implemented in their classroom”</td>
<td>PD related to the standards and skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>“professional development that specifically focuses on relating Algebra I to real situations”</td>
<td>Time for collaboration with math teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Led by teachers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Relates to the classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Research Question 1: What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?

Standard Domains

The teachers were asked in which of the standard domains they considered themselves most proficient as a teacher. The responses were varied and plentiful. The teachers provided a list of standard domains in which they were proficient. Only one of the eight teachers picked a single standard domain. Table 4.16 illustrates the standard domains chosen by each teacher in the survey as the most proficient standard domain to teach.

Table 4.16
Interview Participants Most Proficient Standard Domains

<table>
<thead>
<tr>
<th>Standard Domains</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Real Number System</td>
<td>3</td>
</tr>
<tr>
<td>Seeing Structure in Expressions</td>
<td>2</td>
</tr>
<tr>
<td>Arithmetic with Polynomials and Rational Expressions</td>
<td>5</td>
</tr>
<tr>
<td>Reasoning with Equations and Inequalities</td>
<td>3</td>
</tr>
<tr>
<td>Interpreting Functions</td>
<td>2</td>
</tr>
<tr>
<td>Building Functions</td>
<td>6</td>
</tr>
<tr>
<td>Making Inferences and Justifying Conclusions</td>
<td>2</td>
</tr>
<tr>
<td>Quantities</td>
<td>0</td>
</tr>
<tr>
<td>The Complex Number System</td>
<td>0</td>
</tr>
<tr>
<td>Creating Equations</td>
<td>2</td>
</tr>
<tr>
<td>Linear, Quadratic, and Exponential Models</td>
<td>1</td>
</tr>
<tr>
<td>Trigonometric Functions</td>
<td>1</td>
</tr>
<tr>
<td>Interpreting Categorical and Quantitative Data</td>
<td>0</td>
</tr>
<tr>
<td>Conditional Probability and the Rules of Probability</td>
<td>1</td>
</tr>
</tbody>
</table>

The reasons the teachers provided for picking the standard domains were individualized to the teacher:

- Teacher 1 (Building Functions) chose the standard domain based on statistic results from end-of-course testing. This is an area where her students scored highest in the past.
- Teacher 2 (Seeing Structures in Expressions, Arithmetic with Polynomials and Rational Expressions, Making Inferences and Justifying Conclusions, Reasoning with Equations...
and Inequalities) taught different levels of Algebra I and stated that she had a good background on how to break down problems at different levels for student mastery to occur. She also indicated that different domains were best depending on the students.

- Teacher 3 (The Real Number System, Seeing Structure in Expressions, Arithmetic with Polynomials and Rational Expressions, Building Functions, Reasoning with Equations and Inequalities) shared she was proficient in most areas provided she had a book to consult.

- Teacher 4 (The Real Number System, Arithmetic with Polynomials and Rational Expressions, Reasoning with Equations and Inequalities) asserted that these standard domains provided the foundational skills for Algebra I and that they were easily related to everyday life.

- Teacher 5 (Arithmetic with Polynomials and Rational Expressions, Interpreting Functions, Building Functions, Creating Equations, Linear, Quadratic, and Exponential Models) asserted that much could be done with the standards when thinking in real-world situations and focusing on blended learning and using the Google Classroom platform; these standards allowed students to build or create functions.

- Teacher 6 (Building Functions, Making Inferences and Justifying Conclusions) chose these standard domains because she wanted her students to justify their answers in order to mathematically deepen their understanding by explaining why, and she stressed this was best accomplished in these domains.

- Teacher 7 (The Real Number System, Interpreting Functions, Building Functions, Trigonometric Functions, Conditional Probability and the Rules of Probability) chose these standard domains because they were the areas where she had the most experience.
Teacher 8 (The Real Number System, Building Functions, Creating Equations, Arithmetic with Polynomials and Rational Expressions) stated that these standard domains flowed the best from year to year and were easiest to make connections and to explain. She also identified these as the standards where she was the most comfortable.

The teachers were asked in which standard domains they were least confident in teaching. Table 4.17 illustrates the standard domains chosen by each teacher in the survey as the least confident standard domains to teach.

Table 4.17

<table>
<thead>
<tr>
<th>Interview Participants Least Confident Standard Domains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Domains</td>
</tr>
<tr>
<td>The Real Number System</td>
</tr>
<tr>
<td>Seeing Structure in Expressions</td>
</tr>
<tr>
<td>Arithmetic with Polynomials and Rational Expressions</td>
</tr>
<tr>
<td>Reasoning with Equations and Inequalities</td>
</tr>
<tr>
<td>Interpreting Functions</td>
</tr>
<tr>
<td>Building Functions</td>
</tr>
<tr>
<td>Making Inferences and Justifying Conclusions</td>
</tr>
<tr>
<td>Quantities</td>
</tr>
<tr>
<td>The Complex Number System</td>
</tr>
<tr>
<td>Creating Equations</td>
</tr>
<tr>
<td>Linear, Quadratic, and Exponential Models</td>
</tr>
<tr>
<td>Trigonometric Functions</td>
</tr>
<tr>
<td>Interpreting Categorical and Quantitative Data</td>
</tr>
<tr>
<td>Conditional Probability and the Rules of Probability</td>
</tr>
</tbody>
</table>

Irrespective of which standard domain was chosen, the primary reason teachers indicated that they selected the standard was because it was an area where their students struggle. For creating equations and building functions, the teacher stated that these standards were most difficult because they related to student’s background and foundational skills; if a student did not have a strong mathematics background, these standards were difficult. The teacher also noted that the wording of the problems could be confusing for students to understand and that students had difficulty creating from the problems. Trigonometric Functions and The Complex Number System...
System were found to be difficult because they are higher level skills that do not relate to everyday life. The teacher that chose Conditional Probability and the Rules of Probability did so because it is an area that she does not find to be challenging so it is not interesting to her. Previously she has not put a great deal of focus into this standard domain. Moving forward, her challenge is to completely overhaul her unit on probability and strives to make this unit better for her students. Regarding Reasoning with Equations and Inequalities, the teacher identified this as difficult because it requires application and reasoning not just numbers. She stated the same about Making Inferences and Justifying Conclusions. Another teacher stated that it is difficult to aid students in being able to “talk math” and draw their own conclusions from what they create when referencing Making Inferences and Justifying Conclusions. Interpreting Categorical and Quantitative Data were noted by teachers to be a problematic standard domain because it is an area that is hard to explain a specific process for the students, and students have difficulty reading and interpreting the data. The teacher who chose Linear, Quadratic, and Exponential Models as difficult stated because it is requires higher levels of Algebra and is hard for lower students.

**Mathematical Practices**

The mathematical practices have impacted most of the teachers’ approach to teaching. Some expressed that the practices aid them in relating situations to real and everyday life. Teachers find themselves spending more time on the material as they scrutinize all aspects of a concept as they work on reasoning skills, making sense of problems, seeking connections, and focusing on understanding. The teachers stated that the practices make them think more about students’ prior knowledge and make them more aware of what is expected moving forward for the students. Two of the teachers indicated that the addition of the mathematical practices to the
curriculum did not have a profound impact on their teaching. One proclaimed this because the practices fall into her personal philosophy of teaching mathematics and she has been teaching by this approach her entire career. The other stated this because she believed that without examining the practices, she did not know all of them.

The teachers were asked which of the mathematical practices were the most difficult to implement with the standards. The mathematical practice, reason abstractly and quantitatively was chosen the most. Teachers identified this mathematical practice because it is hard to relate to everyday life, and it is a hard skill to teach students. One teacher chose, the mathematical practice, attend to precision as a difficult practice to implement because it is relevant to every math problem, and it can be difficult for students to understand how important it is to the process for students to understand and be precise. Another teacher asserted that it depends on the day and group of students which practice is the most difficult to implement and that for her current students, using tools strategically was currently the practice that was most difficult to implement. Another teacher noted that in addition to reason abstractly and quantitatively, construct viable arguments and critique the reasoning of others was a problem practice because it could be difficult to teach students to how to support their answers mathematically. Finally, one teacher did not have a specific practice that was difficult to implement, but stated instead that focusing on the practices slows down the teaching to ensure that all standards are taught. Table 4.18 illustrates the mathematics practices chosen by the teachers as most difficult to implement with the standards.
Table 4.18
*Most difficult to implement mathematical practices*

<table>
<thead>
<tr>
<th>Mathematical Practices</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>make sense of problems and persevere in solving them</td>
<td>0</td>
</tr>
<tr>
<td>reason abstractly and quantitatively</td>
<td>3</td>
</tr>
<tr>
<td>construct viable arguments and critique the reasoning of others</td>
<td>1</td>
</tr>
<tr>
<td>model with mathematics</td>
<td>0</td>
</tr>
<tr>
<td>use appropriate tools strategically</td>
<td>1</td>
</tr>
<tr>
<td>attend to precision</td>
<td>1</td>
</tr>
<tr>
<td>look for and make use of structure</td>
<td>0</td>
</tr>
<tr>
<td>look for and express regularity in repeated reasoning</td>
<td>0</td>
</tr>
</tbody>
</table>

**Research Question 2: How are classroom practices influenced by changes in secondary mathematics standards?**

During the interview, the teachers were asked how they felt about the shift in the content standards. In general, the teachers like the new standards. They stated that the standards flow well together, have a strong correlation, are easy to implement, and relate to the former content standards. The teachers also like how the new standards raise the expectations as they increase the academic rigor. The new standards do so through a focus on concepts, by moving topics to different mathematics courses and moving several former Algebra II concepts to the Algebra I curriculum. This requires students to obtain a greater understanding of mathematics through the use of mathematical practices. Some other comments teachers made on the standards were that they are necessary in order to compete with others in the workforce and that they make teaching more consistent for everyone.

When faced with the question of how the shift in the standards affected the teaching of a course, the teachers’ answers varied, but focused generally on student expectations. They responded with comments that indicate show more is expected from the students with the new standards, which have more rigorous content. Currently, students are expected to problem solve using critical thinking skills; creating, finding relationships between related the mathematics
content; employing higher order thinking skills; using reasoning; understanding their thinking; and applying the standards to the real world. Additionally, when teachers were asked how courses that come academically before their course affect their teaching practices, they stated that it encouraged them to teach content more in-depth and required them to spend more time studying topics as they were moved from one grade level to another.

Pretesting and retesting were the two primary themes that emerged. Some of the teachers gave some form of assessment at the beginning of their class to gauge students’ knowledge of content learned in previous classes. The previous knowledge determines where teachers could begin teaching their class. After determining previous student knowledge, teachers begin reteaching content that is necessary for the current class standards. Teachers must reteach concepts and skills forgotten due to the gap in time between courses or cover content standards previous classes did not teach that were supposed to be included. Teachers noted that teachers of prior mathematics courses should develop the following skills: working independently, creating and explaining mathematics rather than simply following solution steps, developing a deeper understanding of mathematics, and using more real-world applications.

When asked to consider math courses that follow the current course, three main themes emerged: teaching strong basics, communicating with future teachers, and moving forward. The teachers stated it was important to give their students a strong foundation of mathematics in their classes so these students have the skills needed as they move on to more advanced mathematics classes. They also believed that communication with the teachers of courses after theirs was of great importance. Communication would manifest in the form of feedback for the teachers on what areas are strengths and weaknesses of their students, so that teaching of the content could be improved. Discussions between teachers should also center on where the focus of teaching
should be due to the importance of topics. The teachers in the study who teach the advanced
students declared their focus should be on challenging students to develop higher level thinking
and making connections between concepts. They also wanted to teach concepts keeping in mind
how the topic would look in future courses like Calculus; thinking of slope as rate of change
(Teacher 5).

The swift implementation of the standards created gaps in student learning. The major
theme for how this affected student learning identified by the teachers was that the students
struggle. Reasons given for the struggle were the missing standards that students have from
content moving from one course to another and having to fill the holes in student learning.
Additionally, two teachers stated that the students have improved at doing the math due to the
overlap, and the gaps are lessening. Another teacher reported similar gaps in 9th grade Algebra I
students to the gaps that existed prior to the implementation of the new standards. Another
teacher asserted that the new standards resulted in a wider gap in students’ knowledge and
demonstrated ability in the classroom.

The gaps in student learning required teachers to move teaching at a slower pace due to
reteaching material and spending extra time covering material that is no longer part of a course’s
content standards. The teachers also discussed how they must spend time learning new
vocabulary with the new standards and relearning material that has moved from higher level
courses to lower level courses. Finally, the teachers stated that the new standards led to more
differentiation and use of technology in the classroom.

Teachers were asked to think about their own teaching practices and what changes they
needed to make in order to be a more effective teacher of the content standards. Teachers
expressed that they could always improve. Teachers wanted to find ways to fill gaps of students
more effectively, advance students, and improve teaching practices. In filling gaps, teachers wanted to focus on lessening the gap between achievement groups in understanding and finding techniques to more quickly identify where students have learning gaps. To advance students’ knowledge of mathematics, the teachers discussed using differentiation to reach students with different abilities and levels and working with students on talking about the math to gain a deeper understanding of mathematics. The teachers discussed a variety of techniques that could be used to improve teaching: incorporating technology with a blended learning structure, making content relevant to students, improving questioning techniques, doing more active listening to students to discover where they feel they need help, and searching for new and different ways to teach the teachers expressed the need to be open to change.

Research Question 3: What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

Principal Support

Two themes emerged from the interview question on how principals can provide support for teachers in implementing the new standards. First, they can provide teachers with some sort of common planning time during the school work week to enable collaboration with those who teach the same subject matter or grade level. Second, they can provide tools and resources necessary for teaching: manipulatives, technology, and books. Some other supports principals could provide include the following: assigning a common storage for teaching materials, attending departmental meetings, conducting evaluations with fidelity, checking lesson plans, clarifying expectations, providing professional development opportunities, leveling class enrollments, and placing transfer students appropriately. One teacher stated that principals do
not really provide support for implementing the standards; she just wants to be allowed to do her job.

Teacher Leader Support

Teacher leaders could provide teachers with support in implementing the new standards. The interviewed teachers noted three main themes regarding how teacher leaders could be useful. They could gather ideas and share them with teachers. These ideas should relate to best practices, successes and failures to provide learning opportunities, real-world application, and modeling teaching practices. Teacher leaders could aid teachers in lesson planning and topic exploration. Finally, they could provide support by answering questions or finding answers to questions and obtaining resources needed, such as technology. One teacher believed it was important for teacher leaders to approach teachers in a non-judgmental manner.

Supporting New Teachers

New teachers to the profession have much to learn concerning both the job in general and the subject matter being taught. There are several ways that veteran teachers could aid in implementing the content standards. Each novice teacher should have a mentor teacher as a guide. Teachers advised this needs to be more than a one-time meeting and suggested a regularly scheduled program would be most effective. Classroom observations would be another way to aid new teachers. The new teacher could both observe veteran teachers to see how they teach specific content and manage a classroom. Veteran teachers, in return, could also observe and provide feedback on what they believe are strengths and weaknesses in teaching. Spending time planning together would be beneficial for any teacher, but especially new teachers. Planning time could include sharing ideas about teaching strategies, lesson planning, and sharing what types of lessons were effective. One teacher expressed that team teaching, where two or
more teachers would focus on their strengths could be an effective method for helping both new and veteran teachers.

**Professional Development**

The teachers in the study participated in a variety of professional developments offered by the state, district, individual schools, and those not associated with school. The professional developments offered by the state related to the new standards implementation, testing changes, and ways to teach the using the mathematical practices. The professional developments offered by the school district included technology instruction with Google educational apps, including Google classroom and blended learning. The district also offered several training sessions by a former mathematics teacher addressing different subject and grade levels of mathematics. The sessions focused on application of the mathematical practices as related to the standards for the class, techniques and methods for teaching, and class activities relevant to specific subjects or grade. At the school level, the professional developments offered were in the form of Professional Learning Communities (PLC) formed by subject department or grade level. One PLC focused on the individual strengths and weaknesses of the teacher teaching the standards. A few of the teachers have participated in professional developments outside of formal educational settings, including webinars and a national mathematics conference.

Three themes emerged regarding the attributes of professional development that were most helpful to the teachers in implementing the standards. Collaboration was essential: teachers desired interactive time to discuss mathematics with fellow teachers. Professional developments that related to the standards, the mathematical practices, and mathematics skills were found to be helpful. Finally, teachers believed professional development opportunities that were teacher led and specifically related to the classroom and teaching practices were more useful than those with
a mass group instructed without classroom application. Some teachers also found those professional developments that related to using technology in the classroom to be of most aid in teaching and implementing the standards.

Professional development is an ongoing process. Moving forward, the teachers from the study specified topics or attributes that are needed in future professional development offerings. First, they would like to have time to go out from their classrooms and observe teaching from other mathematics teachers who effectively implement the standards. This would help them gain insight on teaching techniques and ideas. Teachers would also like time to meet with teachers across grade levels and even school levels to discuss vertical alignment of the standards and areas of focus for each class. The main issue was time; teachers need time scheduled into their work schedule to collaborate, observe, and plan. Other requests teachers had for future professional developments were those that related real-world application problems and having problems aligned to the standards from the state.

The teachers exhibited professional development in several ways in their classrooms. Some discussed using it to drive lesson planning by structuring their lessons around the practices. One teacher noted that she writes the wording from the practices in her lesson so that she will use the terminology during her lessons. Others spoke of using different or new techniques or activities learned through professional development. Some specific techniques mentioned were differentiated instruction and blended learning with the inclusion of technology where students create rather than just doing book work. One teacher stated that she shares her professional development experiences with her students to show them that she is trying to improve as a teacher; “I want them to understand that learning is an ongoing process” (Bob 6).
Final Thoughts

The teachers were asked what advice they would offer to educational leaders regarding the implementation of standards in mathematics. The major theme was that change in standards needs to be a more gradual process. Implementation should occur over time with work on a small set of standards or grade levels at a time, not all at once. Teachers also requested that leaders need to gain feedback from educators because decisions most closely affect them. Specific feedback should focus on how the implementation affected learning. One teacher asserted that the state and leaders needed to be more prepared and have a clear plan about the implementation. Another teacher wanted more direct feedback from the implementers with standards aligned to the practice tests and specific questions written for each standard. Finally, one teacher stated that more than one path should be available. Not all students are going to end up in the same place after secondary schooling ends.

The teachers in the study detailed some specific thoughts and requests. One teacher wanted more communication between state leadership and teachers and for the standards to be implemented in a slower timeframe in the future. Another teacher wished that the end-of-course test would better mirror the standards because there seemed to be a disconnect between the test and the standards. One teacher wanted feedback on how the implementation of the new standards impacts ACT scores and questioned whether the standards were making a difference with student outcomes and the process of learning. Another teacher noted that teaching is always a learning process and that students get better as teachers improve.

Presentation of Results: Analysis of Focus Group Data

The focus group was conducted in two parts. The first part was a continuation of the semi-structured interviews questioning the participants further regarding implementation of the
standards and best practices. The group began with a discussion of ways colleagues could provide aid to better implement the standards. The teachers stated that discussion between teachers can be a rich learning tool. When teachers meet with colleagues, they discuss the standards, pacing of class content, when and where different standards should be taught in the flow of a class, testing, and making sure that the standards are being covered thoroughly on tests. Another component of this discussion was the downfall of teachers being unique in a school; they are the only one who teaches their specific course or level of class. This emphasized how important collaboration is for teachers. One teacher detailed how she had to reach out to those who do not teach the exact same level in order to gain feedback and improve teaching. The teachers also discussed seeking out more veteran teachers in the subject matter to help understand what is required of the standards. Interpretation was also discussed. Through discussion with colleagues’ one can see how others view the language and ideas can be discussed. Colleagues were the avenue through which teamwork could be achieved.

Teachers’ needs were also debated. The discussion began with a major thought from the semi-structured portion of the study, time for collaboration. Teachers never have enough time. Teachers wanted support from administration to have a regularly scheduled time to meet and collaborate. Without a preplanned time, life interfered and collaboration time would be lost. Real-world application was noted which led to the second phase of the focus group. The teachers want resources provided by the test and standards’ writers with problems aligned to the standards. They expressed that they need to discuss the standards with other teachers and talk about the difficult language and what is required by each standard. A veteran teacher, who has immersed herself in the standards for several years, stated that this could be useful for new teachers or those who are not comfortable with the content standards. The discussion focused on
language of end-of-course tests and other high stakes tests, such as the ACT. The teachers discussed the importance of using the databases of questions provided by the district and state that should contain questions similar to those on the end-of-course tests. One teacher emphasized that these questions need to be used as more than review and should be a part of daily class life and the language used in testing and teaching concepts.

The teachers were of two different mindsets regarding their best teaching practices. The first group stated that their strength in teaching was in the presentation of the material; breaking content into steps with a procedure; employing the technique of I-do, you-do, we-do; and modeling the mathematics for their students. The second group was at the opposite end of the spectrum with their strengths in having the students work through the math, giving them time for productive struggle, applying the math to the real-world, and verbally explaining the math. In both circumstances, the teachers voiced that their best practices came in the explanation of the material in multiple ways where the students partaking of the lessons were the focus of how the material was presented. In relationship to the standards, the teachers stated that the best practices needed to revolve around real-world application with differentiated instruction and presentation methods. Teachers stated that students need to do in order to learn.

The focus group shifted to a professional development activity. The teachers, prior to the focus group, investigated the standards. Each teacher was given six different standards to create or choose a problem that fit the standard to bring to the focus group for discussion. They were asked to focus on finding questions that were either real-world application or used the language of testing. During the activity, they discussed the language of the standards and what was required of the students from a testing standpoint. The teachers talked about the language of the questions provided by the state and district as testing type questions. The testing questions
shifted from rote memorization step-by-step questions to word problems. The teachers discussed how the questions were about making connections between the math and the real world. Students were asked to apply the math in situations. Teachers talked about the structure of questions, specific notation used, and the level of difficulty of the tested material. Teachers gave examples of the language: where does the line …, when is the cost the same…, which of the following is the best example…, words are of great importance. During the activity, several questions were altered to increase the rigor of what was asked or to change the language to resemble testing language. Through the questions, students were asked to interpret what the question is asking, instead of procedural math. The teachers expressed that the activity produced a tool that would be beneficial for teachers in understanding the content standards, and those that teach Geometry and Algebra II, in addition, to Algebra I, wished for the same to occur for those courses. The questions from the activity are attached in Appendix D.

Findings

Research Question One: Best practices to increase secondary mathematics teachers’ understanding of teaching current standards

Secondary mathematics teachers can increase their understanding of teaching the current standards in three ways. First, they can identify the standard domains that are strengths in their teaching practices. This includes understanding the underlying reasons that support why these areas are personal strengths. This was an area that did not have commonalities between the teachers in the study as it pertained to each individual teacher’s background and style of teaching. Second, teachers can recognize the standard domains that are challenging to implement. Though the domains were not the same, there were three common factors that teachers stated as the reason behind the selections: the domains were areas where students
struggle with the content, they require students to recall mathematics that was previously taught, and students were required to interpret the meaning of the mathematics. Finally, teachers can increase their understanding of teaching the current standards by incorporating the mathematical practices. Teachers find themselves spending more time on the material as they scrutinize all aspects of a concept as they work on reasoning skills, making sense of problems, seeking connections, and focusing on understanding. Regarding the, mathematical practices, the challenges come in the application of the mathematics.

**Research Question Two: Classroom practices influenced by changes in secondary mathematics standards**

The teachers in the study appreciated the new standards. They indicated that the standards have encouraged them to change their expectations of their students. At present, students are expected to problem solve using critical thinking skills, creating, finding relationships between related the mathematics content, employing higher order thinking skills, using reasoning, understanding their thinking, and applying the standards to the real world.

The shift in the standards prompted numerous changes to the curriculum of many courses. Pretesting students to determine their previous knowledge and spending time reteaching concepts or introducing missed concepts that have been moved to previous courses has impacted teachers in teaching their own standards. The standards work together and move across course levels. This required teachers to ensure they provided students with strong foundational skills and focus on communicating with of various courses to ensure that all content is being taught proficiently and that students are ready for the content of the next class. The teachers stated that discussion between teachers can be a rich learning tool.
Teaching practices are never perfect and can always be improved. The new standards brought increased rigor to the content and the mathematical practices with real-world application and interpreting the mathematics. The teachers discussed a variety of techniques that could be used to improve teaching: incorporating technology with a blended learning structure, make content relevant to students, improve questioning techniques, doing more active listening to students to discover where they feel they need help, and search for new and different ways to teach. The teachers expressed the need to be open to change.

**Research Question Three: Supports needed by secondary mathematics teachers to effectively implement the secondary mathematics standards**

Supports come from both individuals and professional development. Teachers stated that principals can be of the greatest support by providing regularly scheduled time during the workday for collaboration and planning among peers and providing resources that are necessary for implementing the standards. Teachers indicated that supports from teacher leaders should come in the form of teaching aids: lesson planning, mathematics modeling, and answering questions about teaching. Supports for new teachers should come in the form of mentoring by one or more veterans where all aspects of the job are explored. Professional development can also be a great support in implementing the standards. The teachers indicated three areas that are most useful: those that are led by classroom teachers; those that relate to the standards, the mathematical practices, and mathematics skills; and those that provided time for teachers to collaborate with other mathematics teachers. They also noted that support could be provided by the state in the form of practice test questions that are aligned directly with the standards.
Summary

Chapter Four provides an analysis of the data gathered in the survey, semi-structured interviews, and the focus group. The purpose of this study was to determine secondary mathematics teachers’ knowledge regarding their standards, how these standards related to other classes, and to determine ways to help teachers interpret the standards and to develop curriculum that would be standards-based. The participants for the study were mathematics teachers in an East Tennessee school district. Analysis of the data gathered transpired to assist in answering the following research questions:

- What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?
- How are classroom practices influenced by changes in secondary mathematics standards?
- What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

The data sources were analyzed, and common themes emerged. For the first research question, three themes emerged: the mathematical practices relate the standards to real life situations, teachers are spending more time on each concept, and the standards and mathematical practices vary in degree of difficulty to implement for each individual teacher. For the second research question, four themes emerged: teachers are expecting more from their students academically, the teachers appreciate the new standards, teachers are spending more time pretesting and reteaching material, and teachers are finding ways to improve their teaching practices. For the third research question, the data are divided into two subcategories: supports from leaders and supports from professional development. Supports from leaders produced three themes: common planning time, time to collaborate and share, and providing resources and support.
Supports from professional development produced four themes: activities should relate to the standards, teachers should have time during activities to collaborate with other math teachers, activities should be led by teachers, and activities should relate to the classroom. The study culminated with a focus group where the teachers participated in a professional development activity and created a question for each Algebra I standard.
CHAPTER V: FINDINGS, IMPLICATIONS, AND RECOMMENDATIONS

Mathematics standards in Tennessee experienced a dramatic overhaul with the adoption of the Common Core Standards in 2010, which were to be fully implemented by the 2013-2014 school year (Common Core State Standards Initiative, 2018). Common Core Standards prompted a move from traditional practices of mathematics to leading students to develop a deeper conceptual understanding of the content. Educators created the standards from the best of mathematics standards from across the U.S., with the primary goal of making mathematics standards across the country more coherent and focused (Roberts, 2015).

The purpose of this qualitative study was to determine secondary mathematics teachers’ knowledge regarding their standards and how these standards related to other courses. Additionally, the study sought to determine ways to help teachers interpret the standards and to develop curriculum that is standards-based. The researcher chose Algebra I and Algebra II as the focus of the study because these relate to each other with overlapping standards and are a continuation of one another. To inform the study, the researcher used an online survey, semi-structured interviews, and a focus group. A total of 31 secondary mathematics teachers voluntarily participated in the survey portion of the study. Eight of the Algebra I and Algebra II teachers, from the survey, participated in the semi-structured interviews and focus group. One teacher was unable to participate in the focus group due to conflicts unrelated to the study. Purposeful sampling based on varying years of experience and those who taught different levels of the classes: skills, standard, and honors, determined the chosen teachers. The analysis of the data from this study supplied a greater understanding of teachers’ knowledge of the secondary
mathematics standards and the supports necessary to better implement them. This qualitative study focused upon the examination of the following research questions:

1. What are best practices in increasing secondary mathematics teachers’ understanding of teaching current standards?
2. How are classroom practices influenced by changes in secondary mathematics standards?
3. What are the supports needed by secondary mathematics teachers to effectively implement secondary mathematics standards?

**Findings**

All study participants teach secondary mathematics and were from a single, large school district in East Tennessee. A comprehensive analysis of data gathered from an online survey, semi-structured interviews, and a focus group provided answers for the research questions of this qualitative study, and also provided triangulation. To improve the credibility of the study, triangulation, member checks, and peer debriefing were incorporated during the research process. The following is a summary of the findings related to the research questions and themes that emerged from the data.

**Research Question One: Best practices to increase secondary mathematics teachers’ understanding of teaching current standards**

Tennessee mathematics standards were divided into four parts: content standards, clusters, domains, and conceptual categories (“Tennessee Math Standards,” 2018, p. 5). For high school courses, there are five conceptual categories: number and quantity, algebra, functions, geometry, and statistics and probability (“Tennessee Math Standards,” 2018, p. 4). The conceptual categories are further detailed into domains or categories of standards. The standards
are accompanied by eight mathematical practices that students should exhibit while performing mathematical tasks.

During the survey, teachers indicated strengths and challenges in both the standard domains and the mathematical practices. Teachers identified the standard domains, The Real Number System and Reasoning with Equations and Inequalities, as their greatest strengths to teach. Teachers chose the mathematical practices, model with mathematics and use appropriately tools strategically, as the easiest mathematical practices to implement in the classroom. Teachers indicated that the standard domains, Making Inferences and Justifying Conclusions, Interpreting Categorical and Quantitative Data, and Conditional Probability and the Rules of Probability, were the most challenging to teach. The mathematical practices that were most frequently chosen as most challenging to implement were the mathematical practices, reason abstractly and quantitatively, and critiques the reasoning of others.

The survey also gathered data assessing teachers’ confidence with the content standards of the courses they teach and all of secondary mathematics. All teachers surveyed indicated that they either agreed, 58.06%, or strongly agreed, 41.94% that they were confident in implementing and teaching content standard for their classes. When relating standards to secondary mathematics as a whole, the majority of teachers agreed, 58.06%, or strongly agreed 32.26%, that they understood how their standards fit with all secondary mathematics standards. There was some disagreement on this question, with 6.45% disagreeing and 3.23% strongly disagreeing about understanding how their content standards relate to secondary mathematics.

Secondary mathematics teachers were capable of increasing their understanding of teaching the current standards in three ways. First, they identified the standard domains that are strengths in their teaching practices and the underlying reasons that support why these areas are
personal strengths. This was an area that did not have commonalities between the teachers in the study as it pertained to each individual teacher’s background and style of teaching. How a teacher understands and interprets the standards, how these standards are implemented in a classroom, and what effect they have on student learning and understanding are the foundation of education in a classroom (NCTM Research Committee, 2013).

Additionally, teachers recognized the standard domains that are challenging to implement. Though the domains were not the same, teachers noted three common factors for these selections: areas where students in their classes struggle with the content, the domains require students to recall mathematics that was previously taught, and students were required to interpret the mathematics. The teachers’ perceptions relate to the research as application and problem-solving concepts are woven throughout the mathematics standards from Kindergarten through secondary classes, building in complexity (“Tennessee Math Standards,” 2018).

Finally, teachers increased their understanding of teaching the current standards by incorporating the mathematical practices. Teachers find themselves spending more time on the material as they scrutinize all aspects of a concept as they work on reasoning skills, make sense of problems, seek connections, and focus on understanding. Application of mathematics presents the greatest challenges in teaching mathematical practices. In order to teach mathematics in a deeper way, it must be taught with conceptual understanding as the main focus as opposed to isolated concepts (Stigler & Hiebert, 1999).

Research Question Two: Classroom practices influenced by changes in secondary mathematics standards

Teaching practices, though they may follow certain trends, are unique to each educator. The methods used to teach mathematics should change. The “why” is vastly important in
mathematical knowledge, but often missing. Many view mathematics as just the “how.” Teachers need to know the “why” and “how” in order to sufficiently teach it to others (Brahier, Leinwand, & Huinker, 2014). Educators need to challenge students in math classes to fully engage students in mathematical reasoning.

The teachers in the study appreciated the new standards, and indicated that the standards have encouraged them to change their expectations of their students’ performance. At present, students are expected to problem-solve using critical thinking skills, creating, finding relationships between items related to the mathematics content, employing higher order thinking skills, using reasoning, understanding their thinking, and applying the standards to the real world.

The shift in the standards fostered numerous changes to the curriculum of many courses. Pretesting students to determine their previous knowledge and spending time reteaching concepts or introducing missed concepts that have been moved to previous courses have influenced teachers in teaching their course standards. It is crucial for teachers to be able to recognize and understand where students are in their mathematical thinking and aid students in refining and further developing these skills (Bartell, Wager, Edwards, Battey, Foote, & Spencer, 2017). The standards work together and move across course levels. This required teachers to ensure they taught strong basics and communicate with teachers of various mathematics courses to confirm that all content is being taught proficiently and that students are ready for the content of the next course in the sequence. The teachers stated that discussion between teachers was a rich learning tool. Data gathered from all portions of the study indicated that the courses that precede and follow have an effect on the way teachers approach the teaching of their course.
The teachers were of two different mindsets when asked to identify their best teaching practices. The first group stated that their strength in teaching was in the presentation of the material; breaking content into steps with a procedure; employing the technique of I-do, you-do, we-do; and modeling the mathematics for their students. Conversely, the second group identified their strengths as having the students work through the math; giving them time for productive struggle; applying the math to the real-world; and verbally explaining the math. The mindset of the second group of teachers aligns with the research on Common Core Standards. One key component of the Common Core mathematics standards was that students did not merely perform mathematics operations to solve a problem; they had to construct a solving method and justify the method used to show a deeper understanding of the content (Common Core State Standards Initiative, 2018). In both circumstances, the teachers voiced that their best practices were evidenced the explanation of the material in multiple ways and by being responsive to the needs of the students in the class. In relationship to the standards, the teachers stated that the best practices need to revolve around real-world application with differentiated instruction and presentation methods. Teachers asserted that students need to do in order to learn.

Teaching practices are never perfect and can always be improved. The new standards brought increased rigor to the content and the mathematical practices with real-world application and interpreting the mathematics. The teachers discussed a variety of techniques that could be used to improve teaching: incorporating technology with a blended learning structure, making content relevant to students, improving questioning techniques, listening more actively to students to discover where these students need help, and searching for new and different ways to teach; the teachers expressed the need to be open to change.
Research Question Three: Supports needed by secondary mathematics teachers to effectively implement the secondary mathematics standards

Study groups are an approach for a collaborative, teacher-centered professional development (Arbaugh, 2003). The research on the effectiveness of study groups in secondary mathematics defined a study group as a group of educators who meet on a set schedule for the purpose of supporting each other through the collaborative process in order to develop professionally and make their teaching practices better.

Supports come from both individuals and professional development. Teachers stated that principals were the greatest support by providing regularly scheduled time during the workday for collaboration and planning among peers and providing resources that are necessary for implementing the standards. Teachers wanted support from administration to have a regularly scheduled time to meet and collaborate. Collaboration promotes positive change, allowing educators to observe methods that others have found to work and then adapt to meet their own needs in their educational context (Fullan, 2011). Teachers indicated that supports from teacher leaders should be evidenced by teaching aids: lesson planning, mathematics modeling, and answering questions about teaching. Supports for new teachers should come in the form of mentoring by one or more veteran teachers where all aspects of the job are explored.

Teachers must have proper training in order to effectively teach (Owens, & Valesky, 2015). Professional development is an important part of the educational process. Professional development was another great support for teachers in implementing the standards. The teachers indicated three areas that are most useful: those that are led by classroom teachers; those that relate to specific mathematics standards; the mathematical practices, and mathematics skills; and those that provided time for teachers to collaborate with other mathematics teachers. Teachers
also noted that support could be provided by the state in the form of practice test questions that are aligned directly with the standards.

**Conclusions of the Findings**

The findings in this qualitative study led to a deeper understanding of the implementation of secondary mathematics standards in Algebra I and Algebra II. The data analysis and coding process related back to constructivism, which served as the theoretical framework of the study. The following research practices were employed: studying the context and setting of the participants, involving the researchers to collaborate with the participants, collecting meaning of context that were participant-generated, interpreting the data, and creating an agenda for change (Dudovskiy, 2019). The researcher collected various types of information from the participants in the study to gather data about teacher experiences as related to the standards. During the focus group portion of the study, the researcher interacted with the participants, facilitating the professional development activity, and gained a deeper understanding of the standards and how they were implemented.

Research shows that students are expected to develop mathematical practices of solving problems, make connections, understand multiple representations, communicate personal algorithms, and justify reasoning (Roberts, 2015). The first research question supported these findings and three themes emerged: the mathematical practices relate the standards to real life situations, teachers are spending more time on each concept, and the standards and mathematical practices vary in degree of difficulty to implement for each individual teacher.

For the second research question, four themes emerged: teachers are expecting more from their students academically; the teachers appreciate the new standards; teachers are spending more time pretesting and reteaching material; and teachers are finding ways to improve their teaching practices. Research on the standards evidenced an expectation for teachers to create
more adventurous and ambitious teaching styles, presenting a more challenging approach to problem solving and encouraging students to develop unique solution paths (Stigler, & Hiebert, 1999).

Teachers are often isolated in their daily professional lives and are not given the opportunity to collaborate in a way that is useful (Stigler, & Hiebert, 1999). The third research question generated data on supports from both leaders and professional development. Supports from leaders produced three themes: common planning time, time to collaborate and share, and providing resources and support. Supports from professional development produced four themes: activities should relate to the standards, teachers should have time during activities to collaborate with other math teachers, activities should be led by teachers, and activities should relate to the classroom. Research presented collaboration as an important part of professional learning communities and confirmed that it should be geared toward school improvement, distinctly identifying what students should learn from the standards and how to relate it in the classroom (DuFour, 2004).

Though the research questions were separate, and themes emerged from each, the themes weave the questions together. Understanding of the standards begins with professional development on the standards and collaboration with peers about the standards and teaching practices. Teaching practices change and evolve through collaboration with peers on lesson planning and modeling of the mathematics. Teachers are better able to implement standards when they understand what the content entails, and they learn from others. Teachers should always be learning and improving their teaching practices.

**Limitations/Delimitations**

This study was limited to secondary mathematics teachers of Algebra I and Algebra II in a single, large school district in rural East Tennessee. This reduced the number of interview
responses and the pool of focus group participants. The researcher expected that all research participants would be honest in answering questions on the survey, during interviews, and in the focus group, but this could not be verified. The opinion nature of some questions during the study and the group mentality of the focus group both influenced the research findings. The rural setting and demographic make-up of the participants are unique, making the results of the study distinctive. To increase the generalizability of the study, it should be duplicated in different settings.

Delimitations for this study were the school selecting where the researcher conducted the study and the sample population. Participants were chosen based on their teaching assignments in Algebra I and Algebra II. The researcher used quota and purposive sampling techniques for this study. Quota sampling determined the number of participants, and purposive sampling was utilized because the researcher needed teachers that met certain criteria (teaching Algebra I and Algebra II) (Ary, Jacobs, & Sorensen, 2010, pp. 156-157, 428-429).

**Recommendations for Future Research**

This study focused on secondary mathematics teachers and implementing the standards in Algebra I and Algebra II in one school district in East Tennessee. A similar qualitative study could be expanded to multiple districts or all districts in the state to normalize the data. The study should also be expanded or modified to incorporate all secondary mathematics subject areas or a different singular subject. The teachers in the study related some specific thoughts and requests for future research. One teacher noted a disconnect between the standards and the state test. Quantitative research should be conducted on the correlation between state-created tests and the standards. Another teacher wanted feedback on how the implementation of the new standards affects ACT scores and questioned whether the standards were making a difference with student outcomes and the process of learning. A quantitative study should be conducted on
the correlation between state test scores, student achievement in courses, and ACT scores. A qualitative study should be conducted between the standards implemented through processes of learning and ACT scores. Another teacher was interested in implementing the standards using different types of classroom; flipped and traditional. A qualitative study should be conducted on implementing the standards in a flipped classroom and a traditional classroom.

**Summary**

The purpose of this qualitative study was to determine secondary mathematics teachers’ knowledge regarding their standards and how these standards related to other classes. Additionally, the study sought to determine ways to help teachers interpret the standards and to develop curriculum that will be standards-based. The teachers in the study indicated that collaboration was a key component to both understanding the standards better and finding ways to better implement the standards in their courses. Additionally, teachers found that the increased rigor of the new standards led to a need for different teaching methods, drawing students to a deeper understanding of the mathematics, and application of the mathematics to the real world.
References


National Council of Teachers of Mathematics (n.d.). *Executive summary focus in high school mathematics: Reasoning and sense making.* Retrieved from
https://www.nctm.org/uploadedFiles/Standards_and_Positions/Focus_in_High_School Mathematics/FHSM_Executive_Summary.pdf


Appendices
Appendix A

Survey
A Study in Standards Implementation for Algebra I and Algebra II

Teacher Survey (Google Form)

Subject Area Taught (select all that apply)

☐  Math 7th
☐  Math 8th
☐  Algebra I
☐  Geometry
☐  Algebra II
☐  Precalculus
☐  Calculus
☐  Bridge
☐  SAILS
☐  Probability and Statistics
☐  Other ______________

If you teach Algebra I or Algebra II, what levels (skills, standard, honors)
______________________________________________ ex: Algebra I – standard

Years of Experience Teaching Mathematics:

0-5 years   6-10 years   10-20 years   more than 20 years’ experience

1. Which of the Algebra standards do you feel are areas of strength to teach?

☐  The Real Number System
☐  Seeing Structure in Expressions
☐  Arithmetic with Polynomials and Rational Expressions
☐  Reasoning with Equations and Inequalities
☐  Interpreting Functions
☐  Building Functions
☐  Making Inferences and Justifying Conclusions
☐  Quantities
☐  The Complex Number System
☐  Creating Equations
☐  Linear, Quadratic, and Exponential Models
2. Which of the Algebra standards do you feel are of greatest difficulty to teach?

- The Real Number System
- Seeing Structure in Expressions
- Arithmetic with Polynomials and Rational Expressions
- Reasoning with Equations and Inequalities
- Interpreting Functions
- Building Functions
- Making Inferences and Justifying Conclusions
- Quantities
- The Complex Number System
- Creating Equations
- Linear, Quadratic, and Exponential Models
- Trigonometric Functions
- Interpreting Categorical and Quantitative Data
- Conditional Probability and the Rules of Probability

3. Which of the eight mathematical practices do you feel are the most challenging to implement in your classroom?

- make sense of problems and persevere in solving them
- reason abstractly and quantitatively
- construct viable arguments and critique the reasoning of others
- model with mathematics
- use appropriate tools strategically
- attend to precision
- look for and make use of structure
- look for and express regularity in repeated reasoning
4. Which of the eight mathematical practices do you feel are the easiest to implement in your classroom?

☐ make sense of problems and persevere in solving them
☐ reason abstractly and quantitatively
☐ construct viable arguments and critique the reasoning of others
☐ model with mathematics
☐ use appropriate tools strategically
☐ attend to precision
☐ look for and make use of structure
☐ look for and express regularity in repeated reasoning

Below are a number of statements regarding mathematics standards and implementation of the standards. For the following statements, teachers will be asked to select one of the following responses: (1) Strongly Disagree, (2) Disagree Somewhat, (3) Agree Somewhat, (4) Strongly Agree.

5. I am confident in implementing and teaching the content standards for the class (specific grade/subject/level) I teach.
6. I understand how my standards fit into the larger picture of secondary mathematics.
7. The standards for my class affect how I teach the class.
8. The level of class I teach affects how I teach the standards.
Appendix B

Interview Guide
A Study in Standards Implementation for Algebra I and Algebra II

Core Subject Teacher Interview Protocol

Date and Time of Interview:

Location of Interview:

Name of Participant:

Participant Pseudonym:

To ensure confidentiality remind the participant, he or she has the right to decline questions and/or the right to stop the interview at any time.

Interview Questions:

1. How long have you been teaching? Teaching mathematics?

2. Which mathematics classes are you currently teaching? What level of the class? How long have you been teaching in that class and level?

3. What path did you take to become certified to teach secondary mathematics?

4. Tennessee is now several years in the shift to its new mathematics standards. How do you feel about the shift in standards?

5. How has this shift affected the way you teach your class? Can you give me an example?

6. Here is a list of math standards that comprise the Algebra I and Algebra II. In which standard do you consider yourself as most proficient as a teacher? Why did you select this one?

   - The Real Number System
   - Seeing Structure in Expressions
   - Arithmetic with Polynomials and Rational Expressions
   - Reasoning with Equations and Inequalities
• Interpreting Functions
• Building Functions
• Making Inferences and Justifying Conclusions
• Quantities
• The Complex Number System
• Creating Equations
• Linear, Quadratic, and Exponential Models
• Trigonometric Functions
• Interpreting Categorical and Quantitative Data
• Conditional Probability and the Rules of Probability

7. In which of these standards do you feel least competent as a teacher? Why did you select this one? Do your students also struggle with this standard?

8. Attention to mathematics practices is also a change for many mathematics teachers. How has this attention changed your approach to instruction?

9. In what ways do the classes that come before your class affect how you teach your class?

10. In what ways do the classes that come after your class affect how you teach your class?

11. Thinking about professional development opportunities provided by the state, district, and your school, what professional development activities have you attended? Which have been most helpful in implementing the standards? How is your professional development demonstrated in your classroom?

12. The implementation of the new standards was not a gradual process. It was implemented for all grades at one time. How did the holes in student learning affect the implementation? Your teaching? Student learning?
13. If you had a magic wand, at this point in the implementation, what additional professional development could your district provide to make you a more effective teacher of the content standards?

14. As a mathematics teacher, when you think about yourself and your instruction, what changes do you still need to make to improve your effectiveness as a teacher?

15. How can principals support teachers in implementing the new mathematics standards?

16. How can teacher leaders support teachers in implementing the new mathematics standards?

17. How can teachers support one another, especially new teachers to the profession, in this shift?

18. If you were to give advice to educational leaders on implementing new standards, what advice would you give?
Appendix C

Focus Group Guide
A Study in Standards Implementation for Algebra I and Algebra II

Focus Group Interview Guide

1. How have your colleagues aided you in the development of the standards?

2. What do you feel like you need in order to teach your standards? What would help you?

3. What do you feel is your best teaching practice? What do you feel you do the best?

4. What are best practices for positively implementing the content standards?
Appendix D

Professional Development Guide
Quantities:

A1.N.Q.A.1

A shuttle is shot in the air at an initial velocity of 11600 km per hour. If 1000 m is equal to 1 km, then what is the shuttle’s speed, in m per s, during take-off? *Round your answer to the nearest tenth.

A1.N.Q.A.2

Jason is installing tile flooring in his kitchen and needs to find certain measurements.

<table>
<thead>
<tr>
<th>Measurement 1</th>
<th>The area of the kitchen.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 2</td>
<td>The length of the kitchen.</td>
</tr>
<tr>
<td>Measurement 3</td>
<td>The height of the kitchen ceiling.</td>
</tr>
<tr>
<td>Measurement 4</td>
<td>The volume of the kitchen.</td>
</tr>
</tbody>
</table>

Which measurement(s) could have the unit \( \text{ft}^2 \)?

A. Measurement 1 only  
B. Measurement 2 only  
C. Measurements 1 and 4  
D. Measurements 2 and 3

A1.N.Q.A.3

Rachel was pouring milk into an 8-inch tall cylindrical container. She used the formula \( V = \pi r^2 h \) to calculate the cylinder’s volume which Rachel found to be 650 cubic inches of liquid. What would be the most accurate measurement for the radius of the container of milk?

A. 3 inches  
B. 6 inches  
C. 9 inches  
D. 12 inches

Seeing Structure in Expressions


“For example, recognize \( 53^2 - 47^2 \) as a difference of squares and see an opportunity to rewrite it in the easier-to-evaluate from of \( (53 + 47)(53 - 47) \). See an opportunity to rewrite \( a^2 + 9a + 14 \) as \( (a + 7)(a + 2) \)” (“Tennessee Math Standards,” 2018, p. 88).
A1.A.SSe.A.1b.

“For example, the growth of bacteria can be modeled by either \( f(t) = 3^{t+2} \) or \( g(t) = 9(3^t) \) because the expression \( 3^{t+2} \) can be rewritten as \( (3^t)(3^2) = 9(3^t) \)” (“Tennessee Math Standards,” 2018, p. 88).

A1.A.SSE.A.2

“For example, recognize \( 53^2 - 47^2 \) as a difference of squares and see an opportunity to rewrite it in the easier-to-evaluate from of \( (53 + 47)(53 - 47) \). See an opportunity to rewrite \( a^2 + 9a + 14 \) as \( (a + 7)(a + 2) \)” (“Tennessee Math Standards,” 2018, p. 88).

The height of one diver above the water during a dive can be modeled by the equation \( h = -2(4t + 4)(t - 5) \), where \( h \) is height in feet and \( t \) is time in seconds. Find the time it takes for the diver to reach the water.

A baseball is thrown from a height of 8 feet. If the person throws the baseball at a velocity of 25 feet per second, what will be the maximum height of the baseball? How long will it take the baseball to hit the ground?

A1.A.SSE.B.3c.
Rewrite the expression \( 4^{x+3} \) three different ways

Arithmetic with Polynomials and Rational Expressions

A1.A.APR.A.1
Simplify the expression
\[
(3x^4 + 9x^3 - 7x^2 - 4) - (-12x^4 + 8x^2 + 4x + 8)
\]

A1.A.APR.B.2
Find the zeros of the polynomial \( x^2 + 5x + 6 \) and sketch a graph of the polynomial.

Creating Equations

A1.A.CED.A.1
A veterinarian is changing the diets of two animals, Spot and Cuddles. Spot currently consumes 1300 Calories per day. That number will increase by 100 Calories each day. Cuddles currently consumes 2830 Calories a day. That number will decrease by 200 Calories each day. The patterns will continue until both animals are consuming the same number of Calories each day. In how many days will that be? How many Calories will each animal be consuming each day then?
A1.A.CED.A.2
Represent Real-World Situation: A restaurant needs to plan seating for a party of 170 people. Large tables seat 8 people and small tables seat 6. Let x represent the number of large tables and y represent the number of small tables. An expression like the total number of people you can seat using A large tables and B small tables is called a linear combination. For instance, 150 people could be seated using 10 large tables and 15 small tables. Use that expression to write an equation in standard form that models all the different combinations of tables the restaurant could use. Then identify at least one possible combination of tables other than (10, 15).

A1.A.CED.A.3
Sam will buy tea and lemonade for his co-workers. Each cup of tea costs $2.25 and each cup of lemonade costs $1.75. If he pays a total of $13.75 for 7 cups, how many of each did he buy?

A1.A.CED.A.4
Rearrange the formula $P = 2l + 2w$ solve for $w$.

Reasoning with Equations and Inequalities
A1.A.REI.A.1

<table>
<thead>
<tr>
<th>Step</th>
<th>Equation</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$8x - 2(x + 1) = 10$</td>
<td>Given</td>
</tr>
<tr>
<td>2</td>
<td>$8x - 2x - 2 = 10$</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>$6x - 2 = 10$</td>
<td>?</td>
</tr>
<tr>
<td>4</td>
<td>$6x = 12$</td>
<td>?</td>
</tr>
<tr>
<td>5</td>
<td>$x = 2$</td>
<td>?</td>
</tr>
</tbody>
</table>

A1.A.REI.B.2
$10x - 3 < 7x + 6$ What is the largest integer value that makes this inequality true?

Using Completing the Square method, which equation is equivalent to $x^2 - 8x - 43 = 0$

A. $(x - 4)^2 = 59$
B. $(x + 4)^2 = 59$
C. $(x - 8)^2 = 59$
D. $(x + 8)^2 = 59$

Solve the quadratic equation, $7x^2 - 3x - 5 = 0$
Which method is the best way to find the solutions, and why?
A1.A.REI.C.4

At the state fair, 3 bags of mini donuts and 4 turkey legs cost $22.50. For $15.75, you can buy 1 bag of mini donuts and 3 turkey legs. Write AND solve a system of equations to find the cost of 1 bag of mini donuts and 1 turkey leg.

A1.A.REI.D.5

Which coordinates would be found on the graph of the line $y = -4x + 1$. Select ALL that apply. Then, graph the equation.

$(-2, 9)$  $(-1, 4)$  $(0, 0)$  $(1, -3)$  $(2, 7)$

A1.A.REI.D.6

Solve the system of equations.

$f(x) = -x + 7$ and $g(x)$ is graphed below:

A1.A.REI.D.7

Graph the system of inequalities and find the area of the shape of the region bounded by the inequalities.

$y < -\frac{2}{3}x + 10$

$y \geq 4$

$y < \frac{1}{3}x + 4$
Interpreting Functions

A1.F.IF.A.1

The relation represents the number of video games sold and the price for the corresponding number of video games.

<table>
<thead>
<tr>
<th>number of video games sold</th>
<th>price ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>$45</td>
</tr>
<tr>
<td>5</td>
<td>$77</td>
</tr>
<tr>
<td>6</td>
<td>$92</td>
</tr>
<tr>
<td>8</td>
<td>$124</td>
</tr>
</tbody>
</table>

A1.F.IF.A.2

Bob is printing a report for school. There are 200 sheets of paper in the printer, and the number of sheets of paper left after t minutes of printing is given by the function \( p(t) = -6t + 200 \).

a. How many minutes would it take the printer to use all 200 sheets of paper? Show your work.
b. What is a reasonable domain for this situation? Explain.
c. What is a reasonable range of this situation? Explain.
A1.F.IF.B.3

Eric starts from the school and bikes home. The table shows the relationship between the minutes spent biking and the distance, in miles, left to cover.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Distance left to cover (miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>90</td>
<td>0</td>
</tr>
</tbody>
</table>

Which statement is correct?
A. The x intercept is 12 and it represents the initial distance, in miles, between Eric’s home and school.
B. The x intercept is 12, and it represents the distance, in miles, Eric bikes each minute.
C. The y intercept is 12, and it represents the initial distance, in miles, between Eric’s home and the school.
D. The y intercepts is 12, and it represents the distance, in miles, Eric bikes each minute.

F.IF.B.4

Fleet Feet is having a sale on athletic shoes. The cost as a function of the number of additional pairs of shoes purchased is modeled by $C(p) = 4p^2 + 60$, where C represents the total cost and p the total number of additional pairs of shoes purchased.

Which values for the domain make sense in the context of the problem?
A. All real numbers
B. Integers
C. Rational numbers
D. Whole numbers
F.IF.B.5
The table shows the relationship between time traveled in seconds and distance in feet for a skier skiing down a hill.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Distance (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>4</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
</tr>
</tbody>
</table>

What is the average rate of change between 2 and 4 seconds?

Given the equation $y = x^2 + 4x - 5$,

a. find the equation for the axis of symmetry,

b. find the coordinates of the vertex of the parabola, and

c. graph the equation plotting points for the vertex, intercepts, and any maxima or minima.

Graph the following equation:

$$f(x) = \begin{cases} 
-2x + 3, & x < 0 \\
\frac{1}{3}x + 6, & x \geq 0 
\end{cases}$$

$x^2 + 6x - 27 = 0$ Solve the equation by factoring, completing the square, and graphing. Show how the results relate.
A1.F.IF.C.8
Consider the functions \( f(x) \) and \( g(x) \).

\[ f(x) = \quad g(x) = -2x + 6 \]

<table>
<thead>
<tr>
<th>( x )</th>
<th>( f(x) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-10</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>

Which function has the smaller y-intercept?
A. \( f(x) \)
B. \( g(x) \)
C. \( f(x) \) and \( g(x) \) have equal y-intercepts.
D. The y-intercepts of the equations cannot be determined from the given information?

**Building Functions**


The table shows the cost of a cell phone plan based on the number of text messages.

<table>
<thead>
<tr>
<th>Number of Text Messages (t)</th>
<th>Cost (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>$37</td>
</tr>
<tr>
<td>150</td>
<td>$62</td>
</tr>
<tr>
<td>200</td>
<td>$87</td>
</tr>
<tr>
<td>250</td>
<td>$112</td>
</tr>
</tbody>
</table>

Which function represents the cost of a cell phone plan when \( t \) number of text messages are sent?
A. \( c(t) = 0.5t + 2 \)
B. \( c(t) = 0.5t - 37 \)
C. \( c(t) = 37 + 0.5(t - 100) \)
D. \( c(t) = 0.5 + 62(t - 100) \)

A1.F.BF.B.2

The function \( g(x) \) is a vertical translation up 4 units from \( f(x) \). What is the relationship between the two functions?
A. \( g(x) = f(x) - 4 \)
B. \( g(x) = f(x) + 4 \)
C. \( g(x) = f(x - 4) \)
D. \( g(x) = f(x + 4) \)
Linear, Quadratic, and Exponential Models


Put an x in the column that best describes the type of change resulting from each scenario.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Grows at a Constant Rate</th>
<th>Grows by Equal Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>the value of a cell phone decreasing at a rate of 8% each year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the value of an investment that doubles every 2 years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the volume of water in a swimming pool when 18 gallons of water are pumped into the pool every 20 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A1.F.LE.A.1b.

A construction site has a large pile of sand measuring 20 cubic yards. Every 50 minutes the construction crew takes 0.5 yd$^3$ of sand from the pile to mix concrete. Which of the following statements describes the scenario?

A. The function is exponential because the amount of sand in the pile is decreasing by a constant percentage.
B. The function is exponential because the amount of sand in the pile is increasing by a constant percentage.
C. The function is linear because the amount of sand in the pile is decreasing at a constant rate.
D. The function is linear because the amount of sand in the pile is increasing at a constant rate.
A1.F.LE.A.1c.

A sample of 50 bacteria was placed in a dish at 8 am. Scientists monitored the sample hourly to see how fast it was growing as shown in the table.

<table>
<thead>
<tr>
<th>Time</th>
<th>8 am</th>
<th>9 am</th>
<th>10 am</th>
<th>11 am</th>
<th>12 pm</th>
<th>1 pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>#Bacteria</td>
<td>50</td>
<td>85</td>
<td>135</td>
<td>208</td>
<td>333</td>
<td>527</td>
</tr>
</tbody>
</table>

If x represents the number of hours since 8 am and y is the population, which equation best represents the growth of the bacteria?
a. \( y=500(0.6)^x \)  
b. \( y=50(1.6)^x \)  
c. \( y=50+30x \)  
d. \( y=50+95x \)

A1.F.LE.A.2

1. The population of Sevier County in 2000 was 71,701. The population in 2017 was 97,638. Assume the population has grown linearly since 2000. Write a function to model the population between 2000-2017.
2. The population of Sevier County is growing at a rate of 1.07%. In 2000, the population was 71,701. Write a function to model the county’s population.

A1.F.LE.A.3

Consider the functions shown in the table below.

<table>
<thead>
<tr>
<th>x</th>
<th>( f(x) )</th>
<th>x</th>
<th>( g(x) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>-1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>0</td>
<td>3</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>15</td>
<td>7</td>
<td>128</td>
</tr>
</tbody>
</table>

For \( x \geq 0 \), which function grows at a faster rate as \( x \) increases and why?

A. \( f(x) \) grows at a faster rate because it is linear, while \( g(x) \) is exponential  
B. \( f(x) \) grows at a faster rate because it is quadratic, while \( g(x) \) is exponential  
C. \( g(x) \) grows at a faster rate because it is exponential, while \( f(x) \) is linear  
D. \( g(x) \) grows at a faster rate because it is exponential, while \( f(x) \) is quadratic
A1.F.LE.B.4
“The total cost of an electrician who charges 35 dollars for a house call and 50 dollars per hour
would be expressed as the function $y = 50x + 35$. If the rate were raised to 65 dollars per hour,
describe how the function would change” (“Tennessee Math Standards,” 2018, p. 94).

The population of a city in Tennessee is modeled by the function $P(t) = 25,460(1.035)^t$ where
t is time in years. What is the growth rate of the population?

Interpreting Categorical and Quantitative Data


A math teacher wanted to determine if there was a statistical difference between the heights of
her students in two math classes Algebra II and Precalculus. She recorded the heights (in inches)
in the tables below:

Heights of Algebra II students (in inches)

| 64 | 65 | 71 | 72 | 66 |
| 64 | 60 | 71 | 62 | 75 |
| 71 | 72 | 69 | 75 | 68 |
| 72 | 74 | 70 | 69 | 63 |
| 71 | 67 | 74 | 64 | 67 |

Heights of Precalculus Students (in inches)

| 69 | 64 | 69 | 66 | 67 |
| 68 | 65 | 73 | 64 | 69 |
| 67 | 63 | 67 | 66 | 72 |
| 66 | 66 | 65 | 72 | 67 |
| 65 | 72 | 66 | 73 | 71 |

1. Draw the following for the sets of data:
   a. Dot Plot
   b. Histogram
   c. Stem – and – Leaf Plot
   d. Box – and – Whisker Plot

2. Find the following statistical data for the situation:
   a. Mean
   b. Median
   c. Mode
   d. Interquartile Range
   e. Standard Deviation

3. Interpret and compare the different types of data found in part 2. Include information about
   possible outliers.

Allergy medicine can have a drowsy side effect. A study is conducted to determine the amount of drug in the blood after a certain period of time goes by. The data is shown in the table.

<table>
<thead>
<tr>
<th>Time (hours)</th>
<th>Amount of drug left in the blood (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>475</td>
</tr>
<tr>
<td>2</td>
<td>450</td>
</tr>
<tr>
<td>3</td>
<td>425</td>
</tr>
<tr>
<td>4</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>375</td>
</tr>
<tr>
<td>6</td>
<td>350</td>
</tr>
<tr>
<td>7</td>
<td>325</td>
</tr>
</tbody>
</table>

a. Draw a scatter plot of the data.
b. Describe the correlation shown by the data.
c. Find the correlation coefficient and the line of best fit.
d. Predict what will happen after 15 hours.

A1.S.ID.C.5

A headband manufacturer is interested in finding the linear relationship between the number of headbands purchased at one time and the cost per headband. The following data was obtained:

<table>
<thead>
<tr>
<th>x: Number of headbands purchased (in hundreds)</th>
<th>1</th>
<th>5</th>
<th>12</th>
<th>20</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>y: Cost per headband (in cents)</td>
<td>80</td>
<td>75</td>
<td>63</td>
<td>50</td>
<td>40</td>
</tr>
</tbody>
</table>

The correlation coefficient between x and y is $r = -0.99$. Which of the following conclusions is correct?

A. The linear relationship between x and y is weak, and y decreases when x increases.
B. The linear relationship between x and y is strong, and y decreases when x increases.
C. The linear relationship between x and y is strong, and y increases when x increases.
D. The relationship between x and y is not linear.
A1.S.ID.C.6

Find the correlation coefficient of linear fit for the following data and interpret what it means in the situation given.
A car’s miles per hour (mph) is being compared to the car’s miles per gallon (mpg)

<table>
<thead>
<tr>
<th>mph</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
<th>65</th>
<th>70</th>
</tr>
</thead>
<tbody>
<tr>
<td>mpg</td>
<td>34.0</td>
<td>33.6</td>
<td>32.4</td>
<td>31.9</td>
<td>30.5</td>
<td>29.4</td>
<td>28.3</td>
<td>26.8</td>
<td>26.2</td>
</tr>
</tbody>
</table>

A1.S.ID.C.7

Which pair best represents a causation relationship?
A. a child’s age and clothing size
B. the number of ice cream cones and the number of sunglasses sold
C. the temperature at a football game and the number of hot drinks sold
D. the number of people attending a movie and the length of the movie
Appendix E

Informed Consent
Informed Consent

**Title:** A Study in Standards Implementation for Algebra I and Algebra II

Dear Research Participants,

Please read the consent form carefully before deciding to participate in the study. The research has been approved by Carson-Newman’s Institutional Board (IRB).

**Purpose of the Study:** This study is to determine what secondary mathematics teachers know about their standards and how they relate to the other classes. The study is also to determine ways to help teachers interpret the standards and to develop curriculum that will be standards based.

**What you will be asked to do:** You will be asked to participate in an interview and a focus group centered on standards implementation in Algebra I and Algebra II.

**Time Required:** 3-5 hours

**Risks and Benefits:** You will be exposed to minimal to no risk throughout the duration of the research study.

**Confidentiality:** The interviews will be audio-recorded and the focus group will be video-recorded. The transcriptions, field note, recordings, and any other related materials will be secured on a password protected computer and stored in a locked filing cabinet. The name of participants and affiliated schools will not be shared. The participants will be assigned a pseudonym to remain anonymous. Each participant will have full access to the final reports prior to publication.

**Participation and Right to Withdraw:** Participation in the study is voluntary. You have the right to withdraw from the study at any time.

**Questions about the study:** If you have any questions regarding this study, please contact the researcher, Sarah Anderson.

Agreement: I have read and agree to the research procedures described above. I voluntarily agree to participate in the research study and have been given a copy of the informed consent form.

Participant Signature: ___________________________ Date: ______________

Participant (print name): ___________________________