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An Examination of Administrators' Knowledge of the Standards for Mathematical Practice - A Think Aloud

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AN EXAMINATION OF ADMINISTRATORS' KNOWLEDGE OF THE STANDARDS FOR MATHEMATICAL PRACTICE – A THINK ALOUD

by

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ABSTRACT

Administrators who observe mathematics teachers need to have knowledge and an understanding of mathematics teaching and learning to effectively evaluate teachers and how their instructional practices relate to student thinking. This research study was conducted to illustrate the importance of understanding the thought process of administrators as they make decisions about teacher effectiveness based on what they notice during observations of mathematics classrooms.

The purpose of this study was to examine what administrators attend to in the instructional environment and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice. A purposive sample of six administrators engaged in cognitive interviews, known as think alouds, while observing two mathematics classroom videos. This study was designed to explore how administrators' instructional leadership knowledge or skills influence what they notice during mathematics instruction.

There was evidence that administrators did notice aspects of the instructional environment pertaining to teachers, students, and, content. However, in this study it was found that administrators with an understanding of mathematics teaching and learning attended more to student's mathematical thinking during instruction. It was also found that there was an increase of the administrators' mathematical language and attention to student interactions with mathematics content when the administrators were presented with a tool describing the elements of a classroom engaged in the Standards for Mathematical Practice.

To my late mother Connie R. White-Miller, my late grandfather Charles “PePa” Gilmore, my grandmother Betty Gilmore and my sister Chara Miller.

I press toward the mark for the prize of the high calling of God in Christ Jesus Philippians 3:14 (KJV).

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
THE PROBLEM AND ITS CLARIFYING COMPONENTS

Introduction

The increasing interest in student achievement in mathematics has heightened the need for a more focused, coherent, and rigorous set of standards and attention to student thinking. Of particular importance and complexity are how administrators view, comprehend, and observe these key shifts in mathematics education and how they support their teachers with their implementation. There has been growing interest in teacher evaluations and how they relate to standardized assessments designed to measure this sought-after student achievement (Darling-Hammond, 2015; Fennell, 2011; Good & Dweck, 2006; Nolan & Francis, 1992). The development of the Common Core State Standards for Mathematics [CCSSM] (National Governors Association & Council of Chief State School [NGA & CCSSO], 2010), and within them the Standards for Mathematical Practice (SMPs), has led to the hope that administrators will collaborate with teachers concerning the expectations of how the mathematics standards should be implemented and how students are expected to interact with the content. The CCSSM has become a favorite topic for analysis regarding how teachers are teaching what some view as different ways of learning mathematics and how administrators will analyze the new assessments associated with the Common Core State Standards for Mathematics. The study of how students think about mathematics has become an important aspect of what it means to teach and learn mathematics. Also, of importance in the 20th century is how administrators influence teaching and learning mathematics (Achieve, 2013; Blasé &Blasé, 1999).

A central issue in mathematics education, policy, and educational leadership is how administrators view and support mathematics instruction. The relationship between the role of administrators and their overall involvement in schools has been extensively studied in recent years (Bolman & Deal, 2003; Council of Chief State School Officers [CCSS)], 2008; Hattie, 2012; Heck & Hallinger, 1999; Murphy, 1994; National Association of Elementary School Principals [NAESP], 2008; National Policy Board for Educational Administration [NPBEA], 2011; Owens & Valesky, 2011). Several studies have also been focused on administrators' influence on student achievement, the learning environment, classroom instruction, and teacher development (Brenninkmeyer & Spillane, 2004; Hallinger & Heck, 1998; Schoen, 2010). However, little attention has been devoted to the administrator's role in content areas, particularly in mathematics. Yet, a few investigations have been conducted that attempted to shift from general student achievement towards administrators' understanding of content and standards-based instruction (Hull, Balka & Miles, 2013; Nelson & Sassi, 2000; 2006; Schoen, 2010; Stein & Nelson, 2003).

The objective of this study was to bring awareness to the Standards for Mathematical Practice (SMPs) and their relationship to classroom observations. The aim of this study was to explore how administrators think and make decisions about mathematics instruction as it pertains to student thinking. In this study, I reported on the results obtained through cognitive interviews, known as think alouds, and classroom video observation. This study was designed to understand how administrators' instructional leadership knowledge or skills influence what they notice during mathematics instruction. For this study, instructional leadership knowledge involved an administrator's attention to classroom instruction, curriculum, and assessment of student learning (Florida Department of Education [FDOE], 2013; Matthews & Crow, 2003; Murphy, 1994; Nelson & Sassi, 2005; Schoen, 2010). In this paper, I argue that several decades of mathematics reform has led to little change in classrooms, and that administrators need an understanding of the SMPs to effectively observe, evaluate, and provide targeted feedback for mathematics teachers. In this study, it was posited that the lack of knowledge of the SMPs held by administrators might unknowingly undermine current mathematics education reform efforts. Administrators may make decisions about mathematics instruction and teacher effectiveness based on their interpretation of what they see and hear during classroom observations without a deep understanding of the relationship between curriculum reforms, leadership, and policy changes. The issue of unknowingly undermining curriculum and mathematics reforms has been addressed with classroom teachers. Before teachers can effectively implement a new curriculum or policy change, they must have knowledge of the design, an understanding of how it impacts students, and be supported through the learning process of mathematics (Ball & Cohen, 1996; Cohen, 1990, 1993). The same might be said about administrators with the implementation of the Common Core State Standards, Standards for Mathematical Practice.

Teacher Evaluations

In 2013, a newspaper article from a local school district reported that although 98% of the teachers scored highly on their formal classroom evaluations, student achievement scores had not increased (Postal, 2013). The disproportionality between teacher evaluations and student scores was alarming. Ideally, if teachers were implementing best practices during classroom instruction, those practices should have had an impact on student learning. So, it would seem that either the teacher evaluations were not measuring effective teaching or the measures of student achievement were not connected to what was being taught, or both. My study focused on what was being measured through teacher evaluations. A majority of K-12 schools in the United States have utilized a type of teacher evaluation system that is usually conducted by a principal, assistant principal, or district level administrator. Prior to CCSSM (2010), administrators were trained to use a variety of supervisory and management techniques that focused on teacher behaviors when evaluating and observing classrooms (Behar-Horenstein, 1995; Lavely, Berger, Blackman, Follman, & McCarthy, 1994; Peterson, Kromrey, Micceri, & Smith, 1987). This was the case for an observation instrument used widely across the state in which this research was conducted, which was developed in the 1980s and was still in use in 2010. This instrument included four domains of teacher behavior: instructional organization and development, presentation of subject matter, verbal and nonverbal communication, and management of student conduct (FDOE, 2010; Peterson et al., 1987). However, with new statewide policy changes and accountability, administrators have been required to take a more active role in observing both teacher and student behaviors that correlate to student achievement.

Two widely known evaluation models have been designed to work toward the goal of increasing teacher effectiveness as it relates to student achievement. The Marzano Teacher Evaluation Model, based upon a synthesis of educational research and theory over several decades, includes four domains and sub elements designed to inform teacher instructional practices (Marzano, 2012). Domain 1 focuses on classroom strategies and behaviors of the teacher and student; Domain 2 is connected to classroom strategies by focusing on planning and preparation of lesson materials; Domain 3 requires teachers to reflect on their teaching performance; and finally, Domain 4 focuses on teacher collegiality and professional behavior. The second model, the Framework for Teaching, developed by Danielson of the Danielson Group (2013) also includes four domains and sub elements geared towards teacher effectiveness and improvement. The domains within the framework include Domain 1 planning and preparation, Domain 2 classroom environment, Domain 3 instruction, and Domain 4 professional responsibilities. Both models take into consideration the complexity of teaching with a focus on student achievement. However, these models include a wide range of general components that could be used across curricular content areas (Danielson Group, 2013; Marzano, 2012).

Rationale for Administrator Inclusion

Several decades of mathematics education reforms have occurred without sufficient involvement of administrators in content specific conversations prior to 1980 (National Council of Teachers of Mathematics [NCTM], 1980, 2000). A portion of the educational leadership literature describes the various roles of administrators with a focus on organizational or managerial concerns towards whole school improvement. However, there has been a shift toward involving administrators, particularly principals, in mathematics curriculum and other subject areas. After several decades of failed reform efforts to increase student achievement in mathematics, the NCTM Board of Directors issued *An Agenda for Action: Recommendations for School Mathematics in the 1980s* (NCTM, 1980). This document emphasized problem solving in mathematics and described a beginning process of encouraging administrators to understand the importance of participating in mathematics conversations about classroom instruction. Several subsequent recommendations suggested that administrators participate in content conversations with teachers, observe mathematics instruction, and make decisions about curriculum in their schools (Lindquist, 1984; NCTM, 1980). In response to *An Agenda for Action,* NCTM released several documents that provided guidance about what teachers, supervisors, administrators, and policymakers should look for when evaluating, observing, or making decisions about mathematics instruction and curriculum (NCTM, 1989, 1991, 1995, 2000, 2014). In the midst of the NCTM documents being released, the No Child Left Behind Act (NCLB), a reauthorization of the Elementary and Secondary Education Act, was introduced in 2001 with the expectation that all students would be proficient in mathematics and reading by the year 2014 through increased accountability for states and school districts as indicated by annual assessments for Grades 3-8 (U.S. Department of Education, 2001). Though student achievement increased, the 2014 goal was not met. In response to NCLB, the CCSSM were developed to provide teachers, administrators, and policymakers with a clear direction and vision of what mathematics teaching and learning should like in the classroom (NGA & CCSSO, 2010). As the age of accountability has become more targeted towards mathematics and English language arts, administrators have become increasingly responsible for more detailed feedback and guidance for the teachers they evaluate and observe.

The Presence of Administrators in Mathematics

Administrators are in need of information regarding student interactions with mathematics to gain knowledge about the classrooms they observe. Administrators are responsible for all school operations including teacher and student outcomes (CCSSO, 2008; Fink & Resnick, 2001; Hallinger & Heck, 2002; NAESP, 2008; Nelson, 1998; Nelson & Sassi, 2000a, 2000b, 2005; NPBEA, 2011; Spillane, Reiser, & Reimer, 2002). Although it has been posited that teachers have a direct impact on student achievement of about 33%, principals have been determined to account for about 25% of a school's impact on student achievement, which accounts for an effect size of [d =. 39] (Achieve, 2013; Hattie, 2012). Administrators, according to these researchers, have the potential to increase or decrease student gains by 50% based on their comprehension of school operations, their knowledge of teacher effectiveness, and their understanding of how students learn mathematics (Achieve, 2013; Hattie, 2012). With a high impact factor, administrators require knowledge about teacher effectiveness beyond surface level best practices (Nelson & Sassi, 2000; Spillane, 2000).

The CCSSM, the latest reform in mathematics education at the time of the present study, mentioned that administrators, principals, and teachers should have an active voice in determining how the standards will be met within their districts and schools and also have a clear understanding of what knowledge and skills are needed for students to succeed (NGA & CCSSO, 2010). Within the CCSSM, the Standards for Mathematical Practice present a clear vision of how students should be engaging and interacting with mathematics during instruction to develop mathematical proficiency. Although the concept of mathematical proficiency is not a new topic (Ball, 2003; National Research Council, 2000, 2001), the introduction of the CCSSM brought more awareness to the students' role during instruction and the importance of their mathematical thinking as part of observations and evaluations. Due to this shift, administrators need to understand the connection between the mathematical content standards, the process of learning mathematics from the teachers' and students' perspectives, and how to evaluate teacher effectiveness when implementing the content and process standards (NCTM, 2014; NGA & CCSSO, 2010). In general, administrators require an understanding of a teacher's pedagogical content knowledge (Shulman 1986, 1987) and knowledge of content and students (Ball, Hill & Bass, 2005; Hill, Ball, & Schilling, 2008), which describes how teachers use best practices and a deep understanding of mathematics to focus on how students learn and think about mathematics.

Statement of the Problem

The instructional vision and an understanding of various standards guide administrators in making decisions about their schools (Hallinger & Heck, 2002; Katterfeld, 2013). Therefore, administrators require a level of content expertise to ensure that teachers are teaching at the level of academic rigor that supports student achievement (Neuman & Mohr, 2001; Rice & Islas, 2001; Schifter & Granofsky, 2012).

Administrators have been utilizing observation protocols that are not necessarily designed to focus on teacher content knowledge, pedagogical-content knowledge or students' demonstration of their mathematical thinking during instruction. The two main protocols focus on both teacher and student behaviors of general instructional practices and look for general evidence of how certain domains are met (Danielson Group 2013; Marzano, 2012). Consequently, it is important to understand how administrators' professional vision about mathematics instruction and their leadership content knowledge, i.e., how administrators use their knowledge of academic subjects to make decisions as instructional leaders, influence what they see in a classroom. The problem researched in this study concerned (a) the identification of what administrators attend to in the instructional environment and (b) the determination of their effectiveness in identifying and interpreting the Standards for Mathematical Practice (SMPs).

Purpose of the Study

The study was an outgrowth of the work of Nelson and Sassi (2000a, 2000b). These researchers posited that shifting the focus of classroom observations from what the teacher does to how students' understand and interact with the teachers' instructional practices would increase student achievement in mathematics. The purpose of this study was to understand what administrators attend to during instruction and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice.

Research Questions

The following research questions guided this study.

1. How do administrators' leadership profiles relate to what they notice in the instructional environment?
2. How does what the administrators notice in the instructional environment relate to their ability to identify students engaging in appropriate Standards for Mathematical Practice within an instructional environment?

Significance of the Study

This research study was conducted to illustrate the importance of understanding the thought process of administrators as they make decisions about teacher effectiveness based on what they notice during observations of mathematics classrooms. Administrators who observe mathematics teachers need to have knowledge and an understanding of the Common Core State Standards, Standards for Mathematical Practice to effectively evaluate teachers and how their instructional practices relate to student thinking. Incorporating the SMPs as a focus for this research study builds upon previous research that identified the importance of connecting instructional leadership to standards-based instruction (Darling-Hammond & Richardson, 2009; Davis, Darling-Hammond, LaPointe, & Meyerson, 2005;Nelson & Sassi, 2000a, 2000b; 2005; Spillane, 2000; Spillane, 2012; Stein & Nelson, 2003).

Summary

This chapter presented an introduction to the study, including a brief background of the teacher evaluation process as it pertains to the administrator's role followed by the need and importance of the administrator's presence and voice in mathematics instruction. Next, the statement of the problem and research questions, which guided the study were presented. Finally, the purpose and significance of the study were also shared. The central issues in mathematics education, policy, and educational leadership as they relate to the support of mathematics classroom instruction were also stated. As a reminder, the purpose of this study was to understand what administrators attend to during instruction and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice. The following chapter contains a review of mathematics education literature leading into the development of the Standards for Mathematical Practice, a review of the instructional leadership literature pertaining to administrator's involvement in mathematics, and the conceptual framework for the study.

CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

The purpose of this study was to understand what administrators attend to during instruction and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice. Also important was to understand how their knowledge of instructional leadership, content, and students influence their vision of mathematics instruction during classroom observations.

Administrators require a level of content expertise to ensure that teachers are teaching at a level of academic rigor that supports student achievement (Neuman & Mohr, 2001; Rice & Islas, 2001; Schifter & Granofsky, 2012). The CCSSM has shifted the way teachers teach and how students think about mathematics (NGA & CCSSO, 2010). Administrators need to understand this shift as they evaluate and observe mathematics classrooms. In this chapter, I discuss the various reforms that have occurred in mathematics education and how they led to the development of the CCSSM and the Standards for Mathematical Practice they contain. Next, I discuss the role of administrators through a review of the instructional leadership literature pertaining to administrators' involvement in mathematics, followed by the details of the conceptual framework. Finally, the research methods used to understand the intersection of content and instructional leadership are reviewed and critiqued, and think aloud research methods are presented as a means of reducing the limitations of previous research methods that have been used to explore the relationship between administrators and mathematics instruction.

Mathematics Education Reform

Content Background

Empirical research conducted to specifically address the Standards for Mathematical Practice in relation to educational leadership or instructional leadership was limited. Therefore, I included the preliminary search parameters to elicit related studies and articles. EBSCOHost was the primary database searched for this study using the following descriptors: SU (administrators OR principals OR assistant principals) AND SU (Standards for Mathematical Practice); SU (administrators OR principals OR assistant principals) AND SU (Common Core State Standards); SU (Principals AND classroom observations AND mathematics); SU (administrators AND mathematical practices AND classroom observations) SU (instructional leadership and the school principal AND mathematics AND Common Core State Standards). Other databases that were used in this research included Education Full Text, Proquest Dissertations and Theses-Full Text, and Google Scholar. I also included practitioner-based literature to support the rationale of having administrators focus on the Standards for Mathematical Practice.

Although this study sought to examine administrators' knowledge of the Standards for Mathematical Practice, reference to the history of the mathematics reforms provides insight into the shift toward a focused curriculum and the Common Core State Standards for Mathematics. Though the content standards of the Common Core have not been emphasized, it is important to understand that content and processes should not be separated when teaching and learning mathematics (NGA & CCSSO, 2010; Koestler, Felton, Bieda, & Otten, 2014; Seeley, 2014).

Mathematics education has undergone several reforms over the past 55 years. The 'New Math' of the 1960s and 1970s emphasized the use of language and properties, proof, and abstraction but failed to incorporate broader concepts of mathematics and failed to increase student achievement (Jones, 1970). In the late 1970s and early 1980s, arithmetic computation and rote memorization of algorithms and facts were emphasized in the Back to Basics movement. This quickly shifted to critical thinking by 1989 when the National Council of Teachers of Mathematics (NCTM) produced a document with 13 curriculum standards that placed reasoning at the center of learning mathematics (NCTM, 1989). During the 1990s, mathematics reform included an emphasis on teaching pedagogy with various learning theory approaches to help students understand mathematics, standards for teaching mathematics, and standards to assess mathematics (NCTM, 1991, 1995). As a sequel to its 1989 *Curriculum and Evaluation Standards* document, NCTM continued its focus on the quality of mathematics instruction and produced a document that described the standards and expectations for each grade level centered around five content strands (NCTM, 2000). The content strands (Number and Operations, Algebra, Geometry, Measurement, and Data Analysis and Probability), high-quality mathematics standards from various states, other work by NCTM served as a foundation for the Common Core State Standards for Mathematics (NCTM, 2012).

The Common Core State Standards for Mathematics was built on existing standards and research and emphasized the skills and knowledge that were thought to be necessary for college and career success (NGA & CCSSO, 2010). Over a decade of research in mathematics education in the United States and other countries has launched nation-wide attention to how mathematics instruction is delivered and valued in classrooms. The new standards address the connotation that curricula in the United States lacks depth by highlighting three key shifts within mathematics: focus, rigor, and coherence (NGA & CCSSO, 2010). The shift in focus of the new standards addressed the mile-wide, inch-deep curriculum by asking teachers to narrow and deepen what they teach; coherence refers to connecting learning across and within grade levels; and rigor is comprised of conceptual understanding, procedural skills and fluency, and application (Confrey, 2008; NGA & CCSSO, 2010; Schmidt, 2008). It was the hope of the writers of the CCSSM that these shifts would strengthen students' foundation in mathematics and prepare them to be productive citizens in society.

While building upon the National Council of Teachers of Mathematics' past work (NCTM, 1989, 1991,1995, 2000, 2006), and addressing avenues to prepare students to master the content through processes, proficiencies, and practices, the Common Core State Standards for Mathematics (CCSSM) have resulted in progress in narrowing the curriculum in Kindergarten through Grade 8 in 11 domain areas:

- Counting and Cardinality
- Operations & Algebraic Thinking
- Numbers & Operations in Base Ten
- Numbers & Operations – Fractions
- Measurement & Data
- Geometry
- The Number System
- Expressions & Equations
- Functions
- Statistics & Probability

The need for a clear definition of mathematical proficiency and what topics students should learn was necessary to determine what is commonly considered to be sufficient mathematics at each grade level for all students (NGA & CCSSO, 2010). With the new and more rigorous Common Core State Standards, students have been challenged to think more deeply about mathematics and how concepts relate to the real world (NGA & CCSSO, 2010).

Process Standards

In addition to developing the five content strands, NCTM presented five process standards (i.e., problem solving, reasoning and proof, communication, connections, and representation) that described the approach to understanding the content standards (NCTM, 2000). These process standards are discussed later in conjunction with the

Common Core State Standards, Standards for Mathematical Practice as they provide a foundation for the importance of developing mathematical proficiency within students. Building proficiency in students requires the use of real-world or classroom-based examples supported by research, which allow students to follow a natural progression of developing mathematical understanding (Clements & Sarama, 2014; Confrey, 2008; Cross, Wood, & Schweingruber, 2009; Lester, 2007; NRC, 2001). Teachers need to understand this progression and develop instructional task that promote mathematical growth (Clements & Sarama, 2004, 2009) and administrators need to support teachers and students in the process.

Thinking Mathematically

In 1980, NCTM published *An Agenda for Action,* a list of eight recommendations for school mathematics, suggesting problem solving be the focus of school mathematics (NCTM, 1980). Extending upon the notion that students must be able to think differently about mathematics content, particularly with problem solving, the process standards gained more attention. One example of this was seen in the emphasis placed on the importance of mathematical habits of mind, which illustrated the benefits of providing students with the tools they need to use and understand mathematics on their own (Cuoco, Goldenberg, & Mark, 1996). The National Council of Teachers of Mathematics, psychologists, mathematicians, and mathematics educators have conducted countless studies on what mathematics students should learn and on how they should learn it (Carpenter, Fennema, Franke, Levi, & Empson, 1999; Clements, Sarama, Spitler, &

Wolf, 2011; Confrey, Maloney, Nguyen, Mojica & Myers, 2009; NCTM, 1989, 1991,1995, 2000, 2006; National Research Council, 2000; 2001).

The 1980s recommendation to incorporate problem solving in school mathematics caused a shift toward understanding how students thought about mathematics. Researchers and mathematicians have worked together to identify critical areas of mathematics, what is needed for students to acquire such knowledge, and how to develop proficiency in mathematics. According to the National Research Council (2001) mathematical proficiency involves five strands that is needed for a person to be successful in learning mathematics: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Each "strand is interwoven and interdependent and has implications for how students acquire mathematical proficiency" (p. 5). Table 1 lists the mathematical proficiency strands and their definitions.

Table 1

Mathematical Proficiency: Strands and Definitions

Strands	Definitions
Conceptual understanding:	Knowing mathematics beyond isolated facts.
Procedural fluency:	Knowing when and how to use algorithms and basic computations.
Strategic competence:	Understanding the process of solving mathematical problems.
Adaptive reasoning:	The ability to think logically about mathematical situations.
Productive disposition:	The ability to use previously learned concepts to make sense of mathematical problems.

Source: Adapted from National Research Council (2001)

Conceptual understanding refers to a functional understanding of mathematical concepts and ideas where a student is able to represent the mathematics in different ways for different purposes (Bransford, Brown, & Cocking, 1999; NRC, 2001). For example, when adding fractional quantities such as $\frac{1}{4} + \frac{3}{5}$, students might use a picture or manipulatives to represent the sum (NRC, 2001). Procedural fluency supports conceptual understanding which allows students to engage in efficient and accurate computation without the use of other resources (NRC, 2001; Wearne & Hiebert, 1988). Strategic competence is similar to problem solving and problem formulation (NRC, 2001). Becoming strategically competent involves students understanding the problem as a whole by generating mathematical representations of the relevant information in a problem (Hagerty, Mayer, & Monk, 1995; NRC, 2001). For example, consider this two-step problem adapted from *Adding It Up* (NRC, 2001):

At BP, gas sells for $2.45 per gallon.

This is 5 cents less per gallon than gas at Shell.

How much does 5 gallons of gas cost at Shell?

Proficient students will not solely focus on the numbers but rather construct a "mental representation that maintains the structural relations among variables in the problem" (NRC, 2001, p. 125). Adaptive reasoning allows students to think logically about the process, determine if the appropriate calculations were performed, and build capacity to justify their process (Maher & Martino, 1996; NRC, 2001). An example of adaptive reasoning may include students' reasoning about negative numbers such as in the problem, $6 + (-7) = -1$, through the process of adding and removing items from a bag (NRC, 2001; Rasmussen & Marrongelle, 2006). The final strand of mathematical proficiency is productive disposition. Once students develop conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning, they will understand mathematics as a whole rather than a series of isolated concepts (NRC, 2001). The NRC (2001) implies that a productive disposition requires students to make sense of mathematics aside from rote memorization and persevere through problem solving as well as "the inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (p. 6). However, if students are not given the opportunity to develop these strands of mathematical proficiency, they will come to understand mathematics as a set of procedural tasks (NRC, 2001; Schoenfeld, 1989). Therefore, "mathematical proficiency cannot be characterized as simply present or absent" (NRC, 2001, p. 135). It is important to recognize that mathematical ideas can be understood in various ways and that students are not mathematically proficient if they only demonstrate one or two strands (NRC, 2001; Schoenfeld, 2007). The NRC (2001) stated that being proficient in mathematics is acquired over time and includes all five strands.

Mathematical Habits and Processes

Though mathematical proficiency takes time to develop, students enter classrooms with some level of mathematics knowledge before receiving official instruction (Carpenter et al., 1999; NRC, 2001). The ability to count is an example of a pre-knowledge skill that students use to aid them in reasoning and explaining addition, subtraction, multiplication, and division during mathematical activities (Carpenter, et al., 1999; NRC, 2001). The application or use of a skill in an activity is called practice. Ball (2003) defined mathematical practice as "mathematical activities in which mathematically proficient people engage as they structure and accomplish mathematical tasks" (p. 11), but then redefined the term as "mathematical know-how–what successful mathematicians and mathematics users *do*" (p. 29). However, the phrase mathematical practices have been used interchangeably with mathematical habits of mind and mathematical processes (Cuoco et al., 1996; Li, 2013; Lim & Seldon, 2009; Seldon & Seldon, 2005). Mathematical practices and mathematical habits of mind are built upon the foundation of the five strands of mathematical proficiency: adaptive reasoning, strategic competence, conceptual understanding, procedural fluency, and productive disposition (NRC, 2001). The concern among mathematics educators involves the discrepancy as to why some students become mathematically proficient while others do not (Ball, 2003; Cuoco et al., 1996; NRC, 2001). Focusing on mathematical practices leads to the investigation of the social and cognitive process through which students interact with mathematics (Ball, 2003; NRC, 2001; Silver & Kenney, 2000).

Mathematical practices provide an opportunity for all students, not just a select few, to be proficient in mathematics; especially in the 21st century, where societal needs require problem solving, reasoning, and logic to make decisions (Ball, 2003; NRC, 2001). These practices also "provide learning resources needed by teachers and students who are engaged in more ambitious curricula and who are working toward more-complex educational goals" (Ball, 2003, p. 35). In sum, the focus on mathematical practices provides an avenue for all students to become proficient in mathematics by making connections outside of the classroom, seeing the worth in learning mathematics, and building systems for teachers to create these opportunities for students (Ball, 2003; Cuoco et al., 1996; Lim & Seldon, 2009; Seldon & Seldon, 2005). Continuing to build upon the National Research Council report, *Adding It Up* (2001), and the RAND Mathematics Group (Ball, 2003), a collective group of researchers and mathematics educators collaborated to develop the Common Core version of mathematical practices, processes, and habits of mind known as the Standards for Mathematical Practice (SMPs).

Common Core State Standards, Standards for Mathematical Practice

At the time of this study, empirical research involving the Standards for Mathematical Practice was limited. Therefore, I included the preliminary search parameters to elicit related studies and articles. EBSCOHost was the primary database searched for this study using the following descriptors: SU (Common Core State Standards for Mathematical Practice AND mathematical practices OR Standards for Mathematical Practice), peer reviewed from 2010-2015, which yielded 96 results. Majority of these articles were practitioner-based articles (i.e., concepts or activities that have been used in classrooms by teachers or other researchers). I also conducted a preliminary search in Dissertations and Theses Full Text using the following descriptors: AB (Standards for Mathematical Practice AND Common Core State Standards AND Mathematics) from 2011- 2014, which yielded 24 results. Google Scholar was also used but produced similar results. Based on the results, practitioner-based articles were used in this review to illustrate how the SMPs are being incorporated during instruction and how this shift in instruction requires a new lens for administrators to attend more to how students engage in and interact with mathematics instruction. The following section provides an overview of the Standards for Mathematical Practice. This leads to specific examples of what each SMP could look like in the classroom. These examples are important as they describe specific behaviors of the students and teacher during instruction.

The SMPs are student-centered which suggests that the students are responsible for obtaining new knowledge (Froyd & Simpson, 2008; McCombs & Miller, 2006; NRC, 2000). The SMPs outline specific characteristics that educators should be familiar with and what educators should work towards cultivating in students to develop a "comprehension of mathematical concepts, operations, and relations; skills in carrying out procedures flexibly, accurately, efficiently, and appropriately; and have an habitual inclination to see mathematics as sensible, useful, and worthwhile" (NGA & CCSSO, 2010, p. 6).

The culture of mathematics classrooms is expected to change with the implementation of the CCSSM and the Standards for Mathematical Practice (SMPs) they contain (Cobb, Stephan, & McClain, 2011). The CCSSM have provided a guideline for what teachers should teach and the progression documents (Achieve, 2013) serve as one supplemental resource that includes selected topics within the standards with examples of how a concept could be taught with depth. The CCSSM have not identified specific paths or guidelines as to how the Standards for Mathematical Practice (SMPs) should be implemented or observed as they relate to a specific subject area or content domain; however, it is important to note that they provide one perspective of doing mathematics (Koestler, Felton, Bieda, & Otten, 2013; Stephan, 2014).

As previously mentioned, the National Council of Teachers of Mathematics [NCTM] (2000) has described the five-process standards as ways of applying and understanding mathematics through knowledge, skills, and application at all grade levels. Problem solving allows students to think and reflect about their process in mathematics; reasoning and proof requires students to make conjectures and evaluate mathematical arguments; the communication process standard requires students to share ideas while being clear in their language (NCTM, 2000). Students who understand mathematics as it relates to other subjects illustrate the connections process standard, and representations involve students using graphs, symbols, or pictures to reflect their understanding of mathematics (NCTM, 2000). Though the SMPs are built upon the mathematical habits of mind, mathematical practices, and the NCTM (2000) process standards, for this study I highlight the relationship between the SMPs and the process standards (Koestler et al., 2013; Seeley, 2014). Therefore, in Table 2, each SMP is discussed in conjunction with the NCTM process standards. Table 2 provides one interpretation of how the SMPs relate to the NCTM process standards.

Table 2

Relating the Standards for Mathematical Practice to the Process Standards

Standards for Mathematical Practice (CCSSM)	Process Standards (NCTM)
SMP1 Make sense of problems and persevere in solving them.	Problem Solving
SMP2 Reason abstractly and quantitatively.	Reasoning and Proof
SMP3 Construct viable arguments and critique the reasoning of others.	Reasoning and Proof, Communication
SMP4 Model with mathematics.	Connections
SMP5 Use appropriate tools strategically.	Representation
SMP6 Attend to precision.	Communication
SMP7 Look for and make use of structure.	Connections and Representation
SMP8 Look for and express regularity in repeated reasoning.	Reasoning and Proof

Note. CCSSM = Common Core State Standards for Mathematics; NCTM = National Council of Teachers of Mathematics.
Source: NGA & CCSSO, 2010; Kanold, Fennell & Briars, 2012; NCTM, 2000; Seeley, 2014.

Summary of Mathematics Education

In this section a brief history of mathematical reforms since the 1960s was discussed along with the impact and contribution of the National Council of Teachers of Mathematics concerning the content and process standards. The evolution of the Standards for Mathematical Practice and the importance of understanding how students think about mathematics were presented. In the following section, I discuss instructional leadership through a representative sample of the literature, followed by a theoretical perspective of how administrators view mathematics instruction. I conclude this chapter with the conceptual framework.

Instructional Leadership Literature

The literature available for review, which was focused on administrators' understanding of mathematics knowledge and instruction during classroom observations, was limited; therefore, I included the preliminary search parameters to elicit related studies. EBSCOHost was the primary database searched for this study using the following descriptors: SU (administrators OR principals OR assistant principals) AND SU (mathematics AND teacher evaluation AND knowledge); SU (administrators OR principals OR assistant principals) AND SU knowledge level AND SU mathematics; Principals AND classroom observations AND mathematics; Principals evaluation AND knowledge level AND standards-based instruction; Nelson, Barbara AND principals; (Leadership AND content knowledge). Other databases that were used in this research included Education Full Text, Proquest Dissertations and Theses-Full Text, and Google Scholar.

In this section of the literature review, I review and critique the research and scholarship on administrators' interactions with mathematics instruction. Although studies in educational leadership have been conducted to examine principal leadership qualities, administrators' influence on school improvement, and how teachers perceive school-based leaders, these studies have not directly addressed administrators' lack of attention to students' mathematical behaviors or their cognition during classroom observations. As such, this literature review provides additional insight into the methodological limitations of the educational leadership literature and suggests think aloud protocols as a viable alternative (Ericsson & Simon, 1993; Someren, Barnard, & Sandberg, 1994). The analytical focus on administrators' leadership content knowledge and their background knowledge provides another insight (Nelson 1998, 2010; Nelson & Sassi, 2000a, 2000b). This study sought to analyze the influence of administrators' instructional leadership on what was noticed during mathematics instruction. In addition, although numerous researchers have identified the importance of administrators' content knowledge when observing mathematics classrooms, making decisions about curriculum, and their role in supporting mathematics teachers, they have not been successful in capturing administrators' cognition during these tasks (Hallinger & Heck, 2002; Katterfeld 2010; Nelson, 2010; Schoen, 2010; Spillane, 2000). I will address this issue by demonstrating Nelson's (2010) notion of understanding the intersection between leadership and content, which provides a conceptual framework for integrating the instructional leadership and mathematical aspects of classroom observations.

In this section, a representative sample of studies is presented which connects instructional leadership and mathematical approaches to observing classroom instruction followed by the presentation and explanation of the conceptual framework. A sample of earlier studies is also summarized and critiqued to show what is both known about administrators' relationships with mathematics instruction and what researchers have yet to address. Finally, the research methods that have been used to study administrators and their role in observing or interacting with mathematics are reviewed and critiqued, and think aloud research methods are presented as a means of addressing the limitations of earlier research methods.

Review of Instructional Leadership Literature in Mathematics

To understand administrators' roles as instructional leaders and their influence on student learning, I situated a representative sample of studies into three of the four categories developed by Stein and Spillane (2005) and extended by Stuart-Olsen (2010). The categories are Stein and Spillane's broad description of how leadership practices are connected to student achievement: linking educational practice and student outcome; mediational paradigms; learning in a social and interactive context; and research on the thinking processes of researchers and educational leaders. The category of mediational paradigms, which involves school mission, organizational structures, and the policy demands of administrators during their daily tasks (Hallinger & Heck, 2002; Katterfeld, 2013; Murphy, 1994) will not be discussed, as the present study focuses only on the leadership practices that directly relate to student achievement. Situating a representative sample of the educational leadership literature in these three categories provides a foundation for the importance of administrators having an understanding of curriculum and content and the rationale to include student thinking and learning into their focus during classroom observations.

Instructional Leaders' Influence on Learning Outcomes

Literature in the educational leadership field has demonstrated that administrators have either a direct or an indirect influence on student outcomes. Studies in this category have been conducted to examine how administrators influence student achievement. Dumay, Boonen and Van Damme (2013) conducted a six-year longitudinal study involving data from 1,915 students and questionnaires from 2,652 teachers from 85 primary schools to examine the influence of principal leadership and teacher collaboration on student learning, how principal leadership and teacher collaboration affects students' learning growth in mathematics, and finally, the influence of organizational variables on student learning over an extended period of time. The use of students' competencies in mathematics and teacher self-reported questionnaires was assessed at several different points in time. Although the direct effects were statistically insignificant over a longer period of time for students' learning growth in mathematics, Dumay et al. (2013) found that the indirect influence of principal leadership and teacher collaboration on students' learning growth in mathematics was significant. A result from the study indicated that principals who were more involved in supporting and working with their teachers experienced larger student growth in mathematics in their schools.

In another large-scale quantitative study, the Mid-continent Research for Education and Learning Center [McREL] (2003) conducted a meta-analysis to examine the effects of leadership practices on student achievement. Using a 30-year timeframe, McREL identified 21 specific leadership responsibilities significantly correlated with student achievement (Waters, Marzano, & McNulty, 2003; Marzano, Waters, &

McNulty, 2005). From 70 studies involving 2,894 schools, 14,000 teachers, and close to a million students, the McREL research team found that there was a relationship between leadership and student achievement with an effect size of [*d* = .25]. McREL explained the effect size with the following example: if two schools were ranked in the 50th percentile on a standardized, norm-referenced test and the principal of one school improved in the 21 key leadership responsibilities, that school would show an increase of 10 percentile points when compared to the other school. The results of both studies illustrated the impact administrators can have on student achievement and support the notion of exploring this impact through classroom observations.

Learning in a Social and Interactive Context

The second category of research was used to examine how administrators' interactions with their colleagues influence student learning and classroom instruction. Bartholomew, Melendez, Orta, and White (2005) concluded that assistant principals who had an active role in supporting mathematics teachers were more valuable to the principal. The yearlong project consisted of 25 elementary and middle school assistant principals who were challenged to understand the key concepts of mathematics; understand how pedagogical content knowledge was needed to incorporate the techniques of the district's mathematics programs; and strengthen their supervisory skills for the purpose of improving mathematics instruction. The assistant principals participated in mathematical activities similar to what students would do in the classroom, attended study groups, examined student work, and evaluated mathematics classroom videos.

Viewing the assistant principal as a 'connector' or liaison with an area of expertise created a different environment in the schools, resulting in a mathematics agenda that focused on student outcomes and how to support teachers in developing reasoning and communication skills in their students (Bartholomew et al., 2005). Creating a collaborative atmosphere among the teachers and the assistant principal allowed the structural barriers to be removed and developed a process for teachers to have a more active role in the decision-making process that affected mathematics learning at their schools (Bartholomew et al., 2005).

Higgins and Boone (2011) conducted a two-year exploratory case study with elementary school leaders who worked collaboratively with their teacher leaders in mathematics. At the conclusion of their study, these researchers found that the increase in student achievement resulted from administrators learning and working alongside their staff through professional development activities.

Cognitive Frames

The final category of cognitive frames permits the examination of the thought processes of administrators as they interact with faculty, make instructional decisions, and evaluate and provide feedback to teachers. Cognitive frames focus on the administrators' mental and intellectual perspectives of their actions (Stuart-Olsen, 2010). Literature on the thought processes of administrators as they engage in instructional tasks and decision-making has been limited. However, there have been studies and conceptual work explaining that administrators do have the knowledge needed to make general leadership decisions concerning overall school improvement, organizational matters, and budget operations, to name a few (Bolman & Deal, 2003; Hattie, 2012; Heck & Hallinger, 1999; Murphy, 1994; Owens & Valesky, 2011). Yet, it is not only important to be aware of administrators' knowledge. How administrators use this knowledge as instructional leaders to support teachers and students in academics is also important. Existing literature suggests that administrators are influenced by their knowledge of subject matter and instruction when making decisions to improve classroom instruction (Stuart-Olsen, 2010). Both qualitative and quantitative researchers have demonstrated the effects of content knowledge on administrators and their leadership practices (Katterfeld, 2011; Nelson, 2010; Nelson & Sassi, 2000a, 2000b; Schoen, 2010; Stuart-Olsen, 2010).

Although administrators' leadership practices are influenced by their knowledge of a specific content area, particularly mathematics, content knowledge in itself is not sufficient. Nelson and Sassi (2000a, 2000b) found that administrators who understood the intersection between leadership knowledge and mathematics content knowledge were able to provide relevant and specific feedback about students and classroom instruction to their teachers. However, the literature is still limited in contributing to the understanding of how administrators developed this knowledge and the cognitive frames that were involved in understanding the mathematics to provide such a high level of support.

I sought to add to the literature in this area by focusing on the thought processes of administrators as they observed and identified students engaged in the Standards for Mathematical Practice during instruction. The three categories (instructional leaders' influence on learning outcomes, learning in a social and interactive context, and cognitive frames) were used to demonstrate the importance of administrators and how they influence student achievement. However, the literature did not address how administrators make decisions about mathematics instruction based on what they saw students doing in classrooms.

This section of the literature review was written to provide insight in understanding administrators' roles and influences on teaching and learning through a representative sample of the instructional leadership literature. A foundation was set for the importance of administrators having an understanding of leadership and content knowledge and the rationale to examine student thinking and learning during classroom observations. The overview of the three categories presented leads into the conceptual framework for this study.

Conceptual Framework

The conceptual framework provided a rationale for the analysis of the data. For this study, I used the lens of knowledge of content and students, leadership content knowledge, and noticing. The Standards for Mathematical Practice are also presented to provide real-world and classroom-based examples of how the conceptual framework was used in the resulting analysis.

Knowledge of Content and Students

Knowledge of content and students is a small portion of what is needed for mathematics knowledge for teaching (Ball, et al. 2005, 2008; Hill, et al. 2008). To understand the significance of knowledge of content and students, it is important to briefly discuss its evolution beginning with Shulman's (1986, 1987) pedagogical knowledge. As a component of what is needed for general knowledge of instructional methods, pedagogical knowledge refers to the deep understanding of the processes and practices of teaching and learning such as lesson planning, classroom management, and the overall learning environment. Realizing that there is more to teaching than general practices, Shulman (1986) presented the notion of pedagogical content knowledge (PCK) which is the intersection of what a teacher needs to know and understand about their specific content and how to transfer or organize such knowledge for student comprehension. More specifically, PCK has been defined as "an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of the most frequently taught topics and lessons" (p. 9). For example, Hauslein, Good, and Cummins (1992) provided the example of the difference between a scientist and a science teacher. Although a scientist and a science teacher may have the same working knowledge of the content, the science teacher must be capable of presenting the information from a teaching perspective rather than a research perspective. The same pertains to the difference between a mathematician and a mathematics teacher. Continuing to build on the framework of Shulman and his colleagues, Ball and others have developed a content specific framework known as Mathematical Knowledge for Teaching (MKT) which occurs when students' mathematical content knowledge and pedagogical content knowledge are viewed simultaneously (Ball, Hill, & Bass, 2005; Hill, Rowan, & Ball, 2005). There are several components of the MKT framework.

The MKT framework is divided into two main categories of knowledge: subject matter knowledge (SMK) and pedagogical content knowledge (PCK). The subject matter knowledge components require knowledge of the content similar to Shulman's content knowledge but do not necessarily focus on the knowledge of students or teaching and are not discussed (Ball et al., 2005). The components of the PCK category relate more to the teaching and learning of mathematics. Knowledge of content and teaching (KCT) refers to how tasks are sequenced in a lesson or what ideas should be the focus of instruction (Hill et al., 2005). Knowledge of content and curriculum is similar to Shulman's curriculum content knowledge where teachers or educators use their knowledge of resources to help students connect with concepts through exploration and synthesizing information. The final section, which is a component of the conceptual framework, is Knowledge of content and students (KCS). Hill et al. (2005) defined KCS as "content knowledge intertwined with knowledge of how students think about, know, or learn this particular content" (p. 375). KCS is used when teachers attend to specific tasks or elements of a concept and combine that knowledge with a particular learning style or something specific about students that may help them understand what is being taught. Hill et al. (2005) provided the following example to illustrate this idea:

> In teaching students to add fractions, a teacher might be aware that students, who often have difficulty with the multiplicative nature of fractions, are likely to add the numerators and denominators of two fractions. Such knowledge might help her design instruction to address this likely issue. (p. 375)

Although KCS was developed through empirical research with teachers, it provides a framework that is relevant to the knowledge that should be a focus for administrators.

Leadership Content Knowledge

The next component of the conceptual framework for this study is also an extension of Shulman's (1986) PCK framework. Although researchers have explored teacher content knowledge and subject-matter knowledge (Ball et al., 2005; Hill & Ball, 2004; Hill et al., 2008; Hill et al., 2005; Hill, Schilling, & Ball, 2004), a relatively small number of them have studied the knowledge base needed for administrators to identity and support teachers' knowledge of content, pedagogy, and curriculum. Administrators are responsible for supporting teachers and students, and they bring a level of knowledge from their leadership training that influence how their support is implemented. Background information on leadership content knowledge is relevant to the discussion of an administrator's thought processes during observations of mathematics instruction. Stein and Nelson (2003) defined leadership content knowledge (LCK), as "the knowledge of academic subjects that is used by administrators when they function as instructional leaders" (p. 423). Nelson (2010) supported this by providing examples from both the teacher and principal's perspective in a study with 485 elementary and middle school principals in eight different states regarding two major components of leadership content knowledge: mathematics knowledge for teaching and beliefs about mathematics teaching and learning to determine how they observed mathematics classrooms. The mathematics content knowledge of the principals was measured using an assessment, which included items about numbers, operations, and functions (Hill, & Ball, 2004; Hill, Schilling, & Ball, 2004). The principals were categorized by their scores on the level of mathematics knowledge for teaching assessment and their beliefs about mathematics teaching and learning. The combination of the scores constituted each principal's LCK profile. Nelson and Sassi (2010) concluded that principals with a different LCK profile viewed instruction differently during classroom observations, evaluated mathematics classes differently, and their support for teachers varied.

The LCK profile for this study was developed based on administrators' perceptions of their instructional leadership and their beliefs about mathematics teaching and instruction. This profile was used to categorize the administrators based on what they noticed about mathematics teaching and learning. According to Nelson and Sassi (2010), administrators would benefit from going beyond their views of what a traditional mathematics classroom entails and focusing on how students understand the concepts. For example, Nelson and Sassi (2006) discussed that "many principals assume that if students know basic mathematical facts and can perform basic calculations, they understand mathematics" (p. 47). However, noting that students knew their mathematics facts was not sufficient. Principals had to ensure that knowing facts led to a deeper understanding of the content and were related to the learning goal of the lesson.

Principals could only make these judgments by looking for strategies that emphasized conceptual understanding, focusing on students' mathematical thinking, and learning to listen for students' thinking and how teachers are able to listen to their students to make instructional decisions (Nelson & Sassi, 2006). It is important to know that leadership content knowledge (LCK) in mathematics does not suggest that administrators become mathematics experts in order to effectively observe and evaluate teachers. Instead, LCK brings awareness to administrators about what they should hear and see from both the student and teachers and how those dialogues should be used to guide instruction (Nelson & Sassi, 2007).

Noticing

Several qualitative and quantitative studies resulted in suggestions that there is a positive relationship between student achievement and effective principal leadership. Qualitative case studies of high-performing schools have been conducted to explore leadership and student learning (Charles A. Dana Center, 1999; Maden, 2001; Scheurich, 1998) and quantitative studies have focused on the indirect effects of leadership on student achievement (Hallinger, Bickman, & Davis, 1996; Heck, 1992; 2000; Marks & Printy, 2003). The effect administrators have on student achievement has been found to be second only to the impact of instruction provided by the classroom teacher. Administrators influence student achievement through performing classroom observations, making instructional decisions, and providing feedback to their teachers. As instructional leaders, administrators are responsible for observing and evaluating teaching and learning through classroom observations (DiPaola & Hoy, 2008; Downey, Steffy, English, Frase, & Posten, 2004; Glickman, Gordon, & Ross-Gordon, 2004; Ing, 2009). Administrators often gather teacher performance and student achievement data from assessment results and what they notice during classroom observations. What an administrator notices provides information beyond pencil and paper or computer-based assessments. A compilation of various versions of the Merriam-Webster dictionaries and thesaurus (2015), and online vocabulary sources defined *noticing* as giving critical attention, appraisal, or evaluation to or the observation of, perception of, or attention to something that occurs in everyday life. Researchers have studied the construct of noticing extensively as it relates to teacher noticing, which involves where teachers look, what they see, and how they make sense of what they see (Berliner, 1994; Frederiksen, Sipusic, Sherin, & Wolf, 1998; Mason, 2002; Nguyen, 2000; Sherin, Jacobs & Phillip, 2011). Yet, research involving administrators has often been focused on leadership styles, principal relationships with their teachers during the observation process, administrators' influence on school climate, or the extent to which principals have improved school achievement (DiPaola & Hoy, 2008; Ing, 2009; Johnson, Uline, & Perez, 2011). For this study, attention was given to what administrators notice when they observe mathematics classrooms and an essential research study (Nelson & Sassi, 2000a) is discussed as the foundation for this section.

When administrators observe classrooms, they are prepared to look for certain practices and environmental items such as how the teacher addresses the students or if the learning goal is written on the board. Administrators' visions of instruction are influenced by what they notice in standards-based classrooms (Nelson & Sassi, 2000a). As researchers and participants in their own study, Nelson and Sassi (2000b) conducted a yearlong professional development seminar for school-based and district level administrators on the classroom observation process of elementary teachers during mathematics instruction. A self-selected group of 24 administrators from four districts in metropolitan Boston were invited to participate in the seminar. The seminar included two sessions of viewing and analyzing the same mathematics lesson video clip at different points during the professional development. During the initial viewing, attention to what the administrators noticed during the observation demonstrated what they considered to be important (Nelson & Sassi, 2000a). According to Nelson and Sassi (2000a, 2000b), though classroom practices such as wait time, questioning techniques, and student centers may be important in the teaching profession, they are not the only techniques or practices that administrators should target. Shifting the focus from what may be considered typical classroom practices that are summarized into checklists or other forms of observational categories requires a paradigm shift in how administrators observe standards-based instruction (Nelson & Sassi, 2000b). At the conclusion of the study, administrators shifted their attention to how students were exploring mathematical ideas and noticed how focusing on the learning process of students was interwoven with the pedagogical processes associated with teacher assessments (Nelson & Sassi, 2000b). Although the administrators in this study viewed the mathematics lesson via videotape, they realized the difficulty in separating content knowledge and pedagogical processes when making decisions about high quality instruction. Nelson and Sassi (2000b) illustrated the importance of administrators understanding the mathematical thought processes that occurred between teacher and students as they observed classrooms.

Relating noticing across disciplines provides additional support for exploring administrators' observation processes of classroom instruction more deeply. The term, *expert noticing*, emerged from a qualitative research study of 22 K-12 reading teachers and seven university faculty members while observing three videotaped literacy lessons (Ross & Gibson, 2010). Experts are defined as individuals who have a deep understanding of their subject matter, are able to formulate reasoned interpretations of events, and notice meaningful patterns that are not visible to others (NRC, 2000; Ross & Gibson, 2010). During each lesson observation, the participants were prompted to digitally record what they noticed throughout the lesson. Ross and Gibson noted, "Expert participants were able to attend to more detail in their noticing, in order to monitor, understand, and interpret" pivotal events in literacy (p. 186). Applying the construct of expert noticing to instructional leadership, Johnson et al. (2011) viewed principals as experts and explored what they noticed about classroom instruction in high-performing urban elementary, middle, and high schools. A total of 14 principals were purposefully selected and interviewed using a standardized open-ended protocol, which is a type of structured interview format. The researchers asked two primary questions: "Explain what you notice when you conducted classroom observations. What do you look for during formal or informal observations?" (p. 128). The principals attended to student engagement, learning, and understanding; classroom climate, tone, and atmosphere; and teacher actions. The principals in Johnson et al.'s study prioritized student engagement and learning and saw teacher actions as a byproduct of what occurred during classroom instruction. Experts' noticing requires individuals to have an understanding of the content that extends beyond subject-matter knowledge. Research involving administrators and what is noticed from their perspectives, particularly in mathematics, has been limited (Johnson et al., 2011). This model framed the focus of the study: there exists some relationship between leadership content knowledge and knowledge of content and students which influences what is noticed during classroom observations, in this case, what it means for students to engage in the Standards for Mathematical Practice.

Standards for Mathematical Practice

At the time of this current study, I used practitioner-based articles in relation to the NCTM (2000) process standards, as previously discussed, to provide examples of what each SMP might look like in a classroom. It is important to note that a few examples might have been dated prior to the development of the Standards for Mathematical Practice however, the idea of student thinking is aligned with the SMPs. Although each Standard for Mathematical Practice is discussed with specific examples, the focus within the literature has been from the teacher's perspective, teachers' classroom experiences, or from a researcher's observation of what has occurred during mathematics instruction (Bleiler, Baxter, Stephens, & Barlow, 2015; Lockwood & Weber, 2015; Pilgrim, 2014). To support this statement the following search criteria was used elicit related articles: EBSCOHost was the primary database searched for this study using the following descriptors: SU (Common Core State Standards for Mathematical

Practice AND mathematical practices OR Standards for Mathematical Practice), peer reviewed from 2010-2015. The SMPs focus on student engagement with mathematics instruction that is facilitated by the teacher. Therefore, it is important for an administrator to understand what students should be doing and saying during instruction and how teachers design lessons that encourage those opportunities. Each SMP is discussed in conjunction with the NCTM (2000) process standards as presented in Table 2.

Standard for Mathematical Practice (SMP) 1

Standard for Mathematical Practice 1, make sense of problems and persevere in solving them, is often viewed as the overarching SMP for the remaining seven practices (Koestler et al., 2013; Seeley, 2014). However, for this study, SMP1 is discussed as it relates to the problem solving standard. “Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution” (NGA & CCSSO, 2010, p. 6). NCTM (2000) described problem solving as “engaging in a task for which the solution methods is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings” (p. 52). Problem solving is deeply rooted in mathematics and has been researched extensively by researchers for decades from Dewey in the1930s to Polya in the 1940s to Stanic and Kilpatrick in 1980s (Lester, 2003; Schoen & Randall, 2003). Problem solving extends beyond teaching students keywords and phrases. Instead, students are engaged in discourse to make sense of the problem and the solution (Koestler et al., 2013; Seeley, 2014). Such problems may appear difficult to students. However, when given the opportunity to explore, think, and collaborate, students will often develop their own strategies to find the solution (Carpenter et al., 1999).

In Rigelman (2007), two elementary classrooms were observed with different approaches to problem solving. Both teachers offered students several learning opportunities, but the first teacher focused on one approach to the problem. By contrast, the second teacher permitted students to explore the relationship between the problems presented and allowed them to share the possibilities of how to arrive at the solution. Rigelman concluded that students are willing to persevere and make sense of solutions when teachers provide such opportunities. Fi and Degner (2012) incorporated the game of chess to teach rate of change in a high school mathematics class. They examined their teaching moves through the process and concluded that teaching through problem solving (TtPS) can be viewed as a pedagogy or philosophy within itself. The teachers concluded that involving students in SMP 1 and TtPS did not include inserting activities into a unit, but rather enabled focusing on the content where students were allowed to struggle productively and experience the complexity and beauty of mathematics (Fi & Degner, 2012).

Standard for Mathematical Practice (SMP) 2

Standard for Mathematical Practice 2, reason abstractly and quantitatively, relates to the reasoning and proof standard (Kanold et al., 2012; Seeley, 2014). “Mathematically proficient students make sense of quantities and their relationships in problem situations" (NGA & CCSSO, 2010, p. 6). Reasoning in this manner requires students to understand several approaches "of representing numbers [and the] relationships among numbers [and] understand meanings of operations and how they relate to one another" (NCTM, 2000, p. 32). Though reasoning appears to be an extended version of SMP 1, making sense, SMP 2 requires more than thinking abstractly. In SMP 2, students are required to decontextualize and contextualize problem situations where students move fluidly between translating a problem situation into a mathematical representation without context then determining if the mathematics makes sense within the original context (NGA & CCSSO, 2010; Seeley, 2014). Reasoning abstractly and quantitatively allows students to focus on the overall process and particular details of the problem simultaneously. This is a skill that has to be taught and developed.

Wenrick, Behrend and Mohs (2013) observed a primary classroom of 18 students during mathematics to focus on how the teacher integrated reasoning and proof within her lesson. The teacher presented a variety of problems to the class including true or false, open-ended, fill-in-the-blank, and comparison questions. Several students discussed their explanations to the true-false questions but others were not able to explain. The observers noticed that one student found a flaw in his argument as he returned to the original problem. Through this process, the student changed his response. The teacher did not tell the student whether he was correct or not, yet the student was able to use the information provided by his classmates to reconsider his answer (Wenrick et al., 2013).

Standard for Mathematical Practice (SMP) 3

Standard for Mathematical Practice 3, construct viable arguments and critique the reasoning of others, is connected to the reasoning and proof and communication process standards. "Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments" (NGA & CCSSO, 2010, p. 6). Although proofs are viewed as the logical heart of reasoning or the cornerstone of mathematical activity, students often have difficulty making arguments for themselves and tend to accept definitions or theorems as mathematical generalizations (Ball & Bass, 2003; NCTM, 2000, Seeley, 2014; Stylianides & Stylianides, 2009). Although other SMPs are connected to reasoning and proof, SMP 3 is connected to this process standard through students' abilities to verbalize or articulate their explanations through a variety of methods of mathematical proofs (Koestler et al., 2013; NCTM, 2000; NGA & CCSSO, 2010; Seeley, 2014). SMP 3 describes the activities or behaviors students are expected to engage in when constructing arguments and providing logical feedback to others. Relating to the adaptive reasoning strand of mathematical proficiency (NRC, 2001), SMP 3 involves students in moving through three phases of reasoning: empirical, preformal, and formal (Koestler et al., 2013; NRC, 2001; NCTM 2009; Seeley, 2014). In the empirical phase, students rely on explanations, examples, or theorems that have already been proven to be true (Koestler et al., 2013;NCTM, 2009; Stylianides & Stylianides, 2009). At the preformal level, students move from relying solely on what has been proven to viewing theorems or other definitions more generally to support their own intuitive explanations about what is occurring mathematically (Koestler et al., 2013;

NCTM, 2009; NRC, 2001). The formal phase pertains to students having their own understanding and the ability to convince others with their reasoning (Ball & Bass, 2003; Koestler et al., 2013; Stylianides & Stylianides, 2009).

Yackel and Cobb (1996) explored the conversations, routines, and activities in several second grade classrooms during mathematics instruction to interpret how students develop mathematically. The teachers were asked to change the way they taught by shifting from teacher-led discussions to posing questions and problems to the entire class. During the process, reoccurring themes or sociomathematical norms were developed across the classrooms when the teachers increased students' learning opportunities. Yackel and Cobb (1996) defined sociomathematical norms as "normative aspects of mathematics discussions specific to students' mathematical activity" (p. 461). After analyzing the student's activities, Yackel and Cobb noticed that students were engaged in mathematical conversation and discussions that moved beyond procedures. For example, some students "constructed increasingly sophisticated concepts of ten, partitioned and recomposed two-digit numbers flexibly, and developed ways of talking about their mental activity using the standard language of tens and ones" (Yackel & Cobb, 1996, p. 466). The change in teachers' instructional styles of engaging students in mathematical conversations and activities along with establishing sociomathematical norms increased students' mathematical argumentations and understanding of mathematics (Yackel & Cobb, 1996).

Stephan (2014) incorporated SMP 3 underlined with sociomathematical norms into one of her middle school classes where she focused on students being able to explain their thinking. During this process, Stephan realized that students had to be taught how to express themselves mathematically. Six strategies were established to assists students with explaining their thinking and critiquing the responses of their classmates:

> Strategy 1- state expectations before the first explanation occurs; strategy 2 – hold students accountable for explaining; strategy 3 – hold students accountable for asking questions; strategy 4 – hold students accountable for making sense of solutions; strategy 5 – hold students accountable to question what they do not understand; and strategy 6 – praise students for their participation and for providing informative feedback. (p. 538)

Stephan concluded that these strategies took time to develop and she had to provide her students with multiple opportunities before they automatically engaged in the process of explaining, justifying, and critiquing. Students often have difficulties in explaining their thinking, producing arguments and reasoning, and critiquing other explanations. Therefore, teachers need to incorporate activities that allow students to develop these skills (Ball & Bass, 2003; Koestler et al., 2013;Seeley, 2014; Stylianides & Stylianides, 2009, Yackel & Cobb, 1996).

<u>Standard for Mathematical Practice (SMP) 4</u>

Standard for Mathematical Practice 4, model with mathematics, is related to the connections process standard. "Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace" (NGA & CCSSO, 2010, p. 7). Pollack (2003) distinguished modeling from other forms of application in two ways. First, modeling gives explicit attention to the beginning of the problem, the process of solving the problem and the mathematical formulation needed to obtain a solution (Pollack, 2003). Second, the solution of the problem is obtained through the reconciliation between the mathematics and the real-world situation (Pollack, 2003; Seeley, 2014). Although modeling has attributes of the representation process standard, it moves beyond superficial ways of understanding mathematics by requiring students to investigate real-world problems through the lens of reformulation and non-trivial mathematics (Koestler et al., 2013). Students who are able to simplify real problems, identify mathematical models for or formulate the problem, solve the problem through computation, interpret the problem as it relates to the real-world problem, and validate their solutions are those engaged in mathematical modeling (Borromeo Ferri, 2013; Koestler et al., 2013; Schoenfeld, 2013; Seeley, 2014; Usiskin 2011).

The following examples of SMP 4 are dated prior to 2010. However, they depict characteristics of modeling with mathematics that are relevant. Lesh and Harel (2003) used quilting to teach scale factor and parts of a whole to middle school students. The students read about a quilting club who found it difficult to create templates using photographs to model what they saw in magazines. The students worked in groups measuring the picture and discussing its relationship to the actual size of a quilting pattern. Through several attempts, the students realized their measurements were not aligning to the template and identified other ways to measure and connect the shapes. The students compared their measurements to the model several times and discovered why the quilting club had difficulties in transferring magazine pictures to an actual template. This example is related to SMP 4 because the students "routinely interpret[ed] their mathematical results in the context of the situation and reflect[ed] on where the results [made] sense" (NGA & CCSSO, 2010, p. 7).

In a high school example, Brantlinger (2005) presented a discussion about the 1992 Rodney King riot to his class where he discussed how mathematics could be used to understand social justice, measurement and distance, and population density. In groups, the students were tasked with determining the number of liquor stores, community centers, and movie theaters within a three-mile radius of the South Central neighborhood in Los Angeles, as well as the average number of blocks it would take someone to reach either place. The final step of the problem was to compare the 1992 data to their neighborhoods. After a few calculations and estimations, one group had two different answers for the number of city blocks in the three-mile radius. One student suggested referring to the problem in context to determine which solution made sense. At the conclusion of the activity, the teacher discussed how the students used mathematics to understand social justice and other real-world, complex problems involving population density and distribution of resources (Brantlinger, 2005).

<u>Standard for Mathematical Practice (SMP) 5</u>

Standard for Mathematical Practice 5, use appropriate tools strategically, is connected to the representation process standard. "Mathematically proficient students consider the available tools when solving a mathematical problem" (NGA & CCSSO, 2010, p. 7). The representation process standard describes the importance of students being able to "select, apply, and translate among math representations to solve problems (NCTM, 2000, p. 67). In order for students to be able select appropriate tools and understand how to apply them, teachers must expose students to various items such as pencil and paper, concrete manipulatives, fingers, graphing calculators, and base-10 blocks (Koestler et al., 2013; NCTM, 2000). Although incorporating various tools in the classroom is important, SMP 5 emphasizes the importance of students being able to select these tools at the appropriate time for appropriate uses (NGA & CCSSO, 2010; Seeley, 2014). In terms of tools, careful consideration must be given to ensure that there is equity within classrooms ensuring that all students have the same opportunities and access when learning mathematics (NCTM, 2014; Seeley, 2014).

The following classroom examples are dated prior to the development of the Standards for Mathematical Practice and a year after its release to demonstrate similarities between the representation process standard regarding tools and SMP 5. Suh, Johnston, and Douds (2008) described their experiences using technology while working with elementary English Language Learners (ELL) and students with special needs in a mathematics classroom. The participating school was a Title I elementary school, and approximately 51% of its 600 students were Hispanic. Over 50% of the student population received free or reduced lunch, and 44% received a form or language services (Suh et al., 2008). In a third-grade class, the students were introduced to counting money using a SMART Board, which allowed them to touch and move representations of the coins across the screen. The students were able to see various representations of money, using life-like models of coins and comparing them to a virtual hundreds chart. At the end of the activity, the students were able to compare and make generalizations about counting coins (Suh et al., 2008). Although the students did not select their own tools for the task, they were engaged in using digital content to deepen their understanding of counting coins, which is similar to an attribute of SMP 5.

Trinter and Garofalo (2011) engaged high school pre-calculus students in four non-routine function tasks including algebraic and graphical representations of exponential, logarithmic, rational, and power functions. Only task one, "comparing the growth of exponential and power functions" will be discussed as an example of selecting an appropriate tool (Trinter & Garofalo, 2011, p. 509). The remaining three tasks followed similar procedures. In task one, the students were asked to solve an equation, which could not be solved by standard means or simple computation, algebraically. After the students struggled with the problem, the teachers discussed other methods to solving the problem such as applying the solver button on the graphing calculator or using the graphing functions. Screenshots of the functions were displayed during whole group discussion where the students compared the solutions with the different methods. The students discovered that each method produced the same results. Once the students understood the different methods of solving functions, they were allowed to select the method of their choice to find the solution to various equations. Through exploration, the teachers discovered that their students were able to "predict results, consider alternative methods, compare algebraic and graphical representations and solutions, and assess their solution methods and intuition" (Trinter & Garofalo, 2011, p. 513).

Standard for Mathematical Practice (SMP) 6

Standard for Mathematical Practice 6, attend to precision, is connected to the communication process standard. "Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning" (NGA & CCSSO, 2010, p. 7). As students learn more complex mathematical terms, definitions, and formulas, they are required to engage in discussions and critique mathematical arguments with precision and accuracy (Koestler et al., 2013). However, being precise extends beyond vocabulary. Students are also required to be precise in measurement and calculations. Seeley (2014) noted that "there's a thin line between being precise and focusing so intently on getting the right answer that a person becomes discouraged about dealing with any new mathematical idea or problem" (p. 313). Teachers are responsible for developing mathematical skills within students that allow them to be effective mathematics communicators who can articulate, reason, and critique the mathematical ideas of others (Koestler, 2013; NCTM, 2000; Seeley, 2014). Standard for Mathematical Practice 6 also addresses equity by providing consistent opportunities to learn through language support for students who may struggle with vocabulary or English as their second language (NCTM, 2014).

The following examples illustrate the importance of language and precision in an elementary and middle school classroom. Kinman (2010) discussed the outcomes of focusing on communication in writing and vocabulary with her fourth-grade mathematics class. A culture of explaining thought processes, defending solutions, listening to and participating in meaningful conversations, and writing was established before the focus shifted to accuracy of definitions and terms (Kinman, 2010). Once the students were familiar with the process, they had to share their thinking about subtraction, using correct terms such as minuend, subtrahend, and difference. The students also engaged in geometry activities where they learned the importance of using appropriate definitions when classifying shapes. Kinman concluded that focusing on communication and providing students with multiple opportunities to learn in her mathematics class clarified misconceptions and deepened her students' understanding of mathematics.

Standard for Mathematical Practice (SMP) 7

Standard for Mathematical Practice 7, look for and make use of structure, relates to both the connections and representation process standards. "Mathematically proficient students look closely to discern a pattern or structure. They can see complicated things as single objects or as being composed of several objects" (NGA & CCSSO, 2010, p. 8). Understanding patterns is viewed as an essential part of mathematical habits of mind as understanding mathematical structure or patterns allow students to build upon and generate new knowledge (Cuoco et al., 1996; Koestler et al., 2013; NRC, 2001; NCTM, 2000; Seeley, 2014). SMP 7 emphasizes the importance of students being able to make connections conceptually and abstractly to understand mathematical structures such as the commutative property, where adding the same numbers in different orders produces the same result (Koestler et al., 2013; NCTM, 2000; NRC, 2001; Seeley, 2014). Understanding the distributive property require students to "represent and analyze mathematical situations and structures using algebraic symbols" (NCTM, 2000, p. 37). Consider the following example from Koestler et al. (2013):

> Being able to express the distributive property using algebraic symbols (a (b + c) = ab + ac, where a, b, and c are real numbers) allows a student to not only recognize the distributive property when multiplying binominals, (e.g., $(x + 3)(x + 5) = x * x + 5x + 3x + 3 * 5$) but also see how decomposing numbers such as 26 into 2(12 + 1) is a situation where the distributive property applies. (p. 93)

Looking for and making use of structure has been linked to understanding algebra by addressing properties, generalizations, and reasoning (Carpenter, Franke, & Levi, 2003; Koestler et al., 2013; Russell, Schifter, & Bastable, 2011; NCTM, 2000; NGA Center & CCSSO, 2010). Carpenter et al. (2003) discussed the importance of making connections between arithmetic and algebraic thinking beginning at the elementary level. Russell et al. (2011) extended the notion of connecting number sense to algebra for middle school after analyzing several classroom activities involving operations, notations, and the number system. Students who have a deeper understanding of numbers and operations arithmetically and algebraically make sense of problems and concepts by moving beyond procedures and rules (NGA Center & CCSSO, 2010; Russell et al., 2011; Seeley, 2014).

Standard for Mathematical Practice (SMP) 8

Standard for Mathematical Practice 8, look for and express regularity in repeated reasoning, is connected to the reasoning and proof process standard. "Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. As they work to solve a problem, [they] maintain oversight of the process, while attending to the details" (NGA & CCSSO, 2010, p. 8). As students are engaged in SMP 8, they are required to use both procedural fluency and conceptual understanding when solving problems or exploring mathematical ideas (Koestler et al., 2014; NCTM, 2000; NGA & CCSSO; 2010 NRC, 2001). As students work through procedural problems such as computing, calculating, or following an algorithm, they should be challenged to "look for patterns, consider generalities and limitations, and make connections across past and present bouts of reasoning" (Koestler et al., 2013, p. 106). SMP 8 relates to the reasoning and proof process standard through generalization, whereby students are required to move beyond general mathematical relationships to generalizing arguments (Ellis, 2011; Koestler et al, 2013; NCTM, 2000; NGA & CCSSO, 2010; Seeley, 2014).

Ellis (2011) documented six middle school students as they participated in generalization activities over a three-week unit on quadratic growth functions. The study illustrated the importance of students' being able to generalize, as this leads to focusing on mathematical relationships and students' being able to justify and clarify their work. Beigie (2011) described how using geometric counting strengthened her middle school students' algebraic thinking by connecting concrete and pictorial geometric representations to algebraic manipulatives. The students worked in groups using cubes and prisms to identity the number patterns of the cubes' surface area and polyhedrons to identify the pattern and relationship between the number of faces, vertices, and edges

(Beigie, 2011). The students were able to make generalizations and write algebraic expressions for a cube with *n* dimensions and *n*-sided polygons by noticing the repeated calculations of the geometric measurements (Beigie, 2011; NGA & CCSSO, 2010).

Although the Standards for Mathematical Practice have been presented separately, it is important to note that they are often paired based on overlapping attributes. The authors of the Common Core did not explicitly state which practices should be paired together or with which content standard. School districts, administrators, and teachers are expected to have those conversations amongst each other to determine which practices provide the best opportunity for students to develop mathematical proficiency.

Findings from Earlier Studies

Classroom Observations

Classroom observations provide data for administrators to make decisions about classroom instruction. There are a variety of policies and protocols describing what administrators should look for, how often they should visit classrooms, and how they should use these data to support teachers and students (FDOE, 2013; Grant et al., 2006; NCTM, 2007). In order for administrators to effectively support mathematics teachers, they must view the classroom through a more content- and student-centered lens (Nelson & Sassi, 1998, 2000a, 2000b, 2005). Classroom observations provide information that is crucial to improving teaching and learning (Good & Dweck, 2006). Classroom observations may include formal and informal observations and classroom walkthroughs, which are brief impromptu visits. Most administrators use checklists with predetermined "look-fors" describing teacher questioning techniques, teacher moves, and the classroom environment, which also includes ensuring that equity is present during instruction (Danielson, 2013a; Gewrtz, 2005; Marzano, 2012; NCTM, 2014).

There is a general process for classroom observations, which includes a pre-observation conference, the actual observation, and a post-observation conference. The observation process allows administrators to acquire as much data about the learning environment as possible. The pre-conference provides evidence about how teachers designed lessons and their understanding of instruction and student expectations. Administrators should meet with teachers to discuss the goals of the lesson and what mathematical ideas will emerge from the lesson. The post-conference provides teachers with the opportunity to reflect on the strengths and weaknesses of the lesson. During this time, administrators often provide feedback to the teachers to improve instruction. The feedback data are obtained from the classroom observations, which were the focus of this study. The classroom observation requires administrators to make decisions about teacher effectiveness and classroom instruction. Administrators need to go beyond assessing surface level features of the classroom such as classroom management or physical features of the classroom environment (Good & Dweck, 2006; Nelson & Sassi, 1998, 2000, 2005; Schoen, 2010). The emphasis should be on what students are learning and whether or not students are being active participants in developing their mathematical proficiency.

A number of representative studies were important to consider in relation to the potential findings of this study. These studies focused on administrators' leadership content knowledge and the administrators' understanding of mathematical knowledge and how the use of observation protocols or testing instruments dictated the focus during the evaluation of mathematics instruction. Nelson and Sassi (2000b) found that administrators recognized the importance of focusing on students as they learned mathematics and not solely on the external factors of a classroom or the teacher. The checklist approach or other forms of evaluation tools used by the administrators and other school leaders allowed them to make the connection between pedagogy and content while using their leadership content knowledge to make valid decisions about high quality instruction. During a six-month pilot study, Burch and Spillane (2003) found that elementary principals saw reading and mathematics as a priority but had views about classroom instruction that differed from the new reform strategies that were introduced. For example, many of the principals connected mathematics learning to formal training and routines in class instead of emphasizing the importance of teacher autonomy. The study "illustrated that instructional leadership in elementary schools is mediated by subject matter" (Burch & Spillane, 2003, p. 528). The findings from the study conducted by Burch and Spillane supported the notion of administrators, particularly at the elementary level, having a clear role and expertise in standards-based instruction and mathematics reform.

From a collection of case studies, Nelson (2010) found that various levels of leadership content knowledge (LCK) affected administrators' evaluation of mathematics instruction. Administrators' understanding of mathematics and their LCK determined the type of feedback they provided to teachers during the post-observation conference and the type of support they provided to their teachers. For example, one principal who had a high LCK score, meaning that she viewed mathematics learning as being comprised of sense-making, paid close attention to how students solved and discussed the mathematics problems that were presented in class. The principal focused on specific situations where students demonstrated an understanding, or lack thereof, during an equivalent decimal activity. During the post-observation conference, the principal was able to ask the teacher about "the mathematical ideas [that] had been central to the lesson" (p. 47). The principal was able to provide specific content-related feedback to the teacher. In a contrasting example, Nelson discussed a principal with a lower LCK score, who believed that students learn mathematics by emulating the teacher through procedures and practice. During his classroom observations, the principal focused on general instructional strategies that were based on a predetermined observation form. The form described information about the lesson objective, the course standard, Bloom's taxonomy, and high yield strategies to name a few. The principal did not address how students were thinking about mathematics. The post-observation conference focused on pedagogical processes and prompted the principal to ask the teacher a series of reflective questions about the lesson. The principal was not able to provide guidance specific to the mathematics instruction or to target specific areas of improvement relative to mathematics teaching and learning.

Connecting the importance of administrators' LCK, professional vision, and expectation to a different subject area, Stuart-Olsen (2010) studied principal practices in writing. Stuart-Olsen found "the greater the leadership content knowledge, the more aspects of instruction the principal attended to, moving beyond surface features of instruction to underlying pedagogy and assessment" (p. 74). For example, a principal with high LCK was able to describe the connections between reading and writing, understood how children learn to write, was able to identify the developmental stages of writing, and had extensive experience teaching writing (Stuart-Olsen, 2010). Having an understanding of writing content knowledge allowed principals to provide direct and relevant feedback to their teachers. As an overall finding related to the importance of this study, Stein and Nelson (2003) suggested that administrators need a solid understanding of a specific content area, which included the teaching and learning processes.

Review of Research Methods

A majority of the studies or conceptual articles have focused on what the Standards for Mathematical Practice might look like during instruction, which is important for administrators. Administrators have an important role in student achievement, particularly in mathematics. Researchers have shown that administrators with a higher level of understanding mathematics instruction view and support mathematics teaching and learning differently (Nelson, 1998; Spillane, 2000). Cobb, McClain, Lamberg and Dean (2003) noted that there is often a discrepancy between mathematics leaders and school principals based on their view of mathematics.

Principals viewed mathematics as routine, whereas mathematics leaders viewed mathematics instruction as complex and involved students in reasoning (Cobb et al., 2003). Such schism occurs when administrators do not have a sufficient level of understanding of mathematics instruction and pedagogy to support their teachers (Cobb et al., 2003; Schoen, 2010). Several studies have been focused on administrators' lack of deep content knowledge through observing classroom videos and through mathematics assessments, beliefs surveys, and other instruments that measured frequencies of teacher behaviors and interactions with students during mathematics classrooms (Nelson, 1998; 2010; Nelson & Sassi, 2000b; Schoen, 2010). This section describes a variety of research methods that have been used to examine and explore administrators' content knowledge and their views of instruction.

Nelson and Sassi (2000b) used naturalistic inquiry to study school and district administrators via classroom observations and teacher supervision over a period of one year. The study included 24 administrators who were shown videotapes of mathematics classrooms at two different times and who were then asked to evaluate what they saw. Nelson and Sassi concluded that the administrators focused too much on the teacher's pedagogical process rather than how the students interacted with the content and the quality of the instruction. Burch and Spillane (2003) interviewed and observed 15 elementary school administrators and 15 curriculum coordinators from eight urban elementary schools during a six-month pilot study in Chicago where they determined that instructional leaders who interacted directly with teachers about classroom instruction required more school-based expertise in mathematics. Torff and Sessions (2005) examined the perceptions of 242 secondary principals concerning teacher ineffectiveness. The survey was developed through an examination of 20 teachers' guides created by administrators at different schools that were used to observe and evaluate teachers. Five categories emerged from the guides, content knowledge, lesson-planning skills, lesson-implementation, ability to establish rapport with students, and classroom-management skills. The most perceived causes of teacher ineffectiveness were lack of pedagogical knowledge, teacher-student interaction, and classroom management. However, lack of content knowledge was the least frequently perceived cause. The study addressed how administrators focused their attention on the intersection of process and content when evaluating teachers instead of focusing solely on pedagogical practices (Torff & Sessions, 2005).

Reed, Goldsmith, and Nelson (2006) conducted a large-scale mixed methods study with approximately 500 elementary and middle school principals and approximately 800 teachers exploring how mathematics content knowledge affected administrators' views of mathematics teaching and learning. Using a Likert scale survey, data were collected to determine how principals' knowledge of mathematics influenced their classroom observations, interactions with teachers, and their judgment of what they considered to be high quality instruction. By examining the data from both teacher and principal surveys, Reed et al. (2006) concluded that many of the principals were not comfortable with mathematics and observed mathematics classes less frequently than other subjects. Reed et al. (2006) stated that additional research was needed to further understand the relationship between mathematics content knowledge and administrators' views and judgment of mathematics instruction during classroom observations.

In a study that focused primarily on the relationship between elementary principals' mathematical content knowledge and their expertise in classroom observations, Schoen (2010) used a mixed-methods approach to examine 78 principals' perceptions of mathematics instruction. The participants were assessed using the Patterns, Functions, and Algebra scale for measuring mathematics knowledge for teaching (Hill et al., 2008; Hill & Ball, 2004), they completed a series of surveys for demographics, watched three classroom videos of mathematics instruction, and recorded their interpretations of the video on an open-ended form. The principals also participated in professional development workshops. There were several findings in Schoen's study that led to the decision to not measure the content knowledge of administrators in the present study. First, Schoen concluded that the elementary principals appeared to have the same level of content knowledge in mathematics as elementary school teachers. Next, there was no relationship between the principals' mathematics knowledge and their observation expertise. Finally, Schoen found that the principals had high levels of agreement among the classroom videos that highlighted students working in groups, discourse between students and teachers, and teachers circulating throughout the classroom to name a few. Yet, the principals were inconsistent in describing details pertaining to the mathematics during instruction when the "central mathematical ideas [were] not explicit or stated in the learning goal" (p. 124). This could be related to limited content knowledge.

According to Nelson and Sassi (2006), most research involving school leadership and supervision of teachers has focused solely on pedagogical practices with little to no attention on how such practices relate to subject-matter content and standards-based instruction. A variety of research methods were used to explore and examine administrators' perceptions of classroom instruction and their understanding of pedagogy and mathematics content. However, the methods used did not address how administrators made decisions about instruction during classroom observations or why administrators were not comfortable with making decisions about mathematics. Although researchers have addressed the need for administrators to develop a deeper understanding of mathematics content, the methods for these studies did not provide the opportunity for administrators to examine students' mathematical thinking nor did the methods allow administrators to verbalize their thought processes. Schoen (2010) suggested the use of a think aloud as another layer of data collection to "yield more detailed information about [administrator's] interpretations of mathematics instruction" (p. 63).

Think Aloud Protocol Analysis to Study Classroom Observations

To overcome the limitations of methods used in psychology research, the think aloud verbal protocols were used in a systematic way to document administrators' thinking to understand as they observed mathematics classrooms (Ericsson & Simon, 1993). Overcoming prior research limitations, while maintaining a methodical way to document administrators' thinking, was important to understanding how administrators' knowledge of instructional leadership, content, and students influence what they notice while observing classroom videos. Think aloud protocols enable administrators to share their thoughts while engaged in watching the classroom videos of mathematics lessons (Ericsson & Simon, 1993). With this technique, administrators share their thought processes, leaving less room for researcher bias than with the use of only surveys and assessments (Ericsson & Simon, 1998). Examining the administrators' cognition provides insight into how administrators make decisions concerning teacher observations. Think aloud research methods may not be familiar to all educational researchers; however, these methods have been used in psychology and many related fields for decades (de Groot, 1965; Duncker, 1945; Newell, Shaw, & Simon, 1958; Newell & Simon, 1956).

Summary

In this chapter, mathematics education reforms were discussed along with the process leading to the development of the Common Core State Standards, Standards for Mathematical Practice. This was followed by a selected review of research on instructional leadership in mathematics education. Next, the conceptual framework undergirding this study was presented, explained, and supported to show how the data were analyzed. The conceptual framework consisted of the theory of leadership content knowledge and the concepts of noticing and knowledge of content and students. The results of several studies were shared to show both what is known about the process of administrators observing content instruction and what researchers have not yet been able to address. Finally, the research methods used to understand the intersection of content and instructional leadership were reviewed and critiqued, and think aloud research methods were introduced as a means of reducing the limitations of earlier methods. The think aloud protocol and methodology will be discussed in further detail in the following chapter which details the research methods and procedures used to conduct the study.

CHAPTER 3
METHODOLOGY

Introduction

This chapter contains a description of the participants, research design, instruments, and the data collection and analysis procedures. The purpose of this study was to understand what administrators attend to during instruction and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice. The primary research methods for this study were qualitative where data were collected using think aloud protocol analysis [Appendix A] (Ericsson & Simon, 1993) through video and audio recordings and observational notes using Audio Note. Additional qualitative and quantitative data were collected using the Leadership Profile Survey [LPS] (Appendix B) and the Standards for Mathematical Practice Identification Tool [SMPIT] (Appendix E). The LPS was adapted from the Thinking About Mathematics Instruction Leadership Content Knowledge Elementary and Middle School Principals' Survey [TMI Survey] (Educational Development Center, 2006) and the Florida Principal Leadership Standards (FDOE, 2013, 2015). Responses to the LPS provided professional and academic background information for each participant, the participant's views about mathematics instruction, and the participant's knowledge level of instructional leadership. The LPS was used to aid in determining a purposive sample using maximum variation or heterogeneity sampling (Patton, 2015). The Standards for Mathematical Practice Identification Tool (SMPIT) included examples of student and teacher actions related to each SMP (ASCD, 2012; Fennell, 2011; NGA & CCSSO,

2010) as a way of supporting administrators to connect to what they observed in the SMPs. These data aided in the preliminary categorization of participants and analysis of data across the sample (Creswell, 2007). To ensure that the research questions were answered, individual case study techniques (Creswell, 2007; Stake, 1995) were used to compile a profile of the participants and categorize them based on their views of mathematics-in-use. The profile and categorizations included data from the Leadership Profile Survey, the think aloud protocol, and the Standards for Mathematical Practice Identification Tool.

Research Questions

The following research questions guided this study.

1. How do administrators' leadership profiles relate to what they notice in the instructional environment?
2. How does what the administrators notice in the instructional environment relate to their ability to identify students engaging in appropriate Standards for Mathematical Practice within an instructional environment?

Rationale for Research Design

The think aloud design of this current research study (Ericsson & Simon, 1993) is unique to the education leadership field but the concept of thinking aloud has been addressed as a suggested reading and critical thinking strategy for teacher effectiveness (Klinger, Vaughn, & Schumm 1998; McTighe & Lyman, 1988; Norris, 1985, Wilson &

Berne, 1999) and is familiar to mathematics educators in the arena of problem solving (Schoenfeld, 1985, 1987). To understand the think aloud protocol method used in this study, systems theory, from program evaluation research, was used. The purpose and methods for this study assumed a systems perspective (Patton, 2015) in that instructional leadership and subject matter content cannot be separated when understanding and evaluating the dynamics of a mathematics classroom. A systems perspective involves "understanding real-world interconnections and interrelationships, viewing things as whole entities embedded in context and still larger wholes" (Patton, 2015, p. 140). When observing and evaluating classrooms, the instructional leadership knowledge of an administrator cannot isolate pedagogical knowledge from content knowledge, as a classroom is a whole system where "function and meaning of the parts are lost when separated from the whole" (Patton, 2015, p. 140). This systems thinking is consistent with the perspective of administrators and their views of mathematics classrooms and is concerned with the interrelationship between what administrators notice in a mathematics classroom and the mathematical behaviors of students (Patton, 2015).

In turn, this dynamic systems perspective (Patton, 2015) led to the use of a think aloud protocol as it could capture administrators' cognition about the process of observing classrooms in a consistent manner and enable valid inferences to be made compared to data collected using content assessments, belief surveys, professional development, or other behavioral observations without a think aloud protocol. The verbal protocol provides a systematic and methodical way to document administrators' mental decision-making process as they analyze classroom videos without my making inferences as in some research designs (Ericsson & Simon, 1993). This approach provided a direct expression of administrators' thinking without interrupting their focus on the task at hand (Ericsson & Simon, 1993, 1998).

Population and Sample

Prior to recruiting participants, I selected a targeted sample range of participants for the individual case studies and developed a set of initial criteria. I selected a sample range of six to 15 administrators and aspiring administrators based upon the reported experience of several qualitative researchers and those who have conducted research using think aloud methods (Creswell, 2007; Crittenden, 2014; Ericsson & Simon, 1998; Hayes & Wood, 2011; Keller, 2008; Patton, 2015; Stake, 1995; Willis, 2004). The wide sample range of participants for the study allowed me to obtain variability among the participants with the intent of also providing a variety of perspectives when observing mathematics instruction. The initial criteria was based on selected information from the Leadership Profile Survey, such as comfort with mathematics, classroom teaching experience, administrative experience, response to the classroom reflection scenario within the LPS, and knowledge of the Common Core State Standards, Standards for Mathematical Practice. Table 3 provides a ranked list of selection criteria based on the type of participant I expected to obtain for this research study. This initial criterion was also developed to ensure that I would obtain as many participants as possible with a wide range of experiences.

Table 3

Initial Participant Criteria

First Choice	Second Choice	Third Choice
Mathematics Background	Science or comparable background	Other background
High comfort with mathematics	Comfort with mathematics	Not comfortable with mathematics
Classroom teacher (middle/high)	Classroom teacher (any level)	Classroom teacher (any level)
Administrator with advanced leadership certification	Administrative experience with minimal certification	Aspiring administrator (may have certification)
High knowledge of instructional leadership skills	Knowledge of instructional leadership skills	Minimal knowledge of instructional leadership skills
Experience observing classrooms (at least 6 – 8, 9 -12)	Experience Observing Classrooms (at least 3 – 5)	Knowledge of classroom observation process
Knowledge and understanding of the CCSSM and SMPs	Knowledge of the CCSSM and SMPs	Knowledge of the CCSSM but no knowledge of the SMPs
Responded to classroom reflection scenarios	Responded to classroom reflection scenarios	Responded to classroom reflection scenarios

The population from which the sample was drawn was from a doctoral program at a university in Florida, because sampling from this program allowed access to a sample with varying levels of educational leadership and classroom teaching experiences. The students within the doctoral program were employees in various K-12 public and private school districts in Florida. Within the program, there were principals, assistant principals, school district level administrators, aspiring administrators, and classroom teachers with leadership responsibilities who possessed a range of experiences in public schools. The selection criteria ensured that the research questions could be answered. With UCF Institutional Review Board (IRB) approval, I provided access to the Leadership Profile Survey, to all students within the doctoral program by way of email.

The sample of participants was selected using the purposeful sampling strategy of maximum variation (Patton, 2015). From the population, 18 students completed the LPS through Qualtrics. Eight participants were eliminated based on incomplete responses within the Leadership Profile Survey. For example, a majority of the students were eliminated as a result of failure to respond to the classroom reflection scenarios within the LPS. This elimination provided a participant subgroup of 10. Using the initial criteria in Table 3, I ranked the remaining 10 participants by first, second, and third choice. After comparing the initial criteria to the LPS responses, I decided to use the students from the first and second choice categories because they had experience with conducting classroom observations. This process led to a sample of six participants. These six participants were selected as individual case studies to provide variation on identifying the Standards for Mathematical Practice and to provide unique perspectives about issues of central importance to the purpose of the research (Patton, 2015; Stake, 1995). The six participants included one assistant principal, one former principal, and four district level administrators. The data from these six participants were analyzed using individual case study techniques (Creswell, 2007, Stake, 1995), which is described later in this chapter and discussed in detail in Chapter 4.

Instruments and Materials

Data were collected using a variety of instruments and materials: the Leadership Profile Survey, the think aloud protocol, classroom videos, the Standards for Mathematical Practice Identification Tool, and the Standards for Mathematical Practice Rater Form. Each instrument is described in the following paragraphs.

Leadership Profile Survey (LPS)

Administrators and school leaders must possess a variety of abilities and skills necessary to perform their duties in a high-performing and effective manner (FDOE, 2015). The Leadership Profile Survey (Appendix B) was developed using two sources: the Florida Principal Leadership Standards (FPLS) and the TMI Survey (EDC, 2006; FDOE, 2013, 2015). To develop the leadership portion of the profile, I selected and adapted one of four domains of effective leadership from the FPLS: domain 2, Instructional Leadership. The Instructional Leadership domain consists of 3 of 10 standards: instructional plan implementation, faculty development, and learning environment, with descriptors to define each standard and domain. To determine the administrators' perceptions regarding their knowledge of instructional leadership, I adapted nine of the 17 descriptors of the standards listed under the Instructional Leadership domain as individual questions on a Likert Scale embedded within the LPS. The instructional leadership literature review pertaining to classroom instruction and student achievement that was presented in chapter 2, along with the targeted sample selection for the study provided a rationale for the focus on Domain 2 of the FPLS. A professor in Educational Leadership at the University of Central Florida also reviewed the descriptors to verify which standards were appropriate for the study. The perception of the ability to identify the administrator's knowledge level of each descriptor was developed using a scale ranging from 1 (very low knowledge) to 5 (very high knowledge). The words of each descriptor were modified from the FPLS to match the language of the main question stem: "Please select the rating that best represents your level of knowledge. . . ". The instructional leadership standards were used as a self-assessment of the administrators' instructional leadership abilities and as a component of their individual case study leadership profiles.

A majority of the LPS was adapted from the TMI Survey (EDC, 2006), which was developed by Nelson as part of a research project funded by the National Science Foundation. Nelson also introduced the concept of leadership content knowledge (LCK) and has completed extensive research with LCK in mathematics. The original purpose of the TMI Survey was to investigate elementary and middle school principals' leadership content knowledge for mathematics in the hopes of gathering information to improve professional development for administrators through the use of pre- and post-surveys, classroom reflections, and solving mathematics problems. For this study, I incorporated and adapted the following sections: (a) comfort with mathematics; (b) part 2 section A classroom reflection; (c) part 2 Section B1 Learning Mathematics; and (d) part 2 section B 2 Strategies for Teaching Mathematics. Several attempts were made to contact the developers of the TMI Survey through email and by phone; however, no response was obtained. All components of the TMI Survey are listed as public use with the exception of the mathematics content questions, which were not used in this study. The validity and reliability of each component of the TMI Survey and research project was addressed through the grant project by using the survey with a sample of 21 principals from New York, Massachusetts, and other parts of New England who participated in cognitive interviews (EDC, 2006). The cognitive interviews of the principals in the TMI study were used to determine if the principals were interpreting the items on the survey as the researchers intended the items to be used. The developers of the TMI Survey found that the principals were consistent with the overall perspective on teaching and learning (EDC, 2006). The coding scheme was developed for the open response portion of the survey, the classroom reflection scenarios, to ensure reliability. The group of researchers and senior staff members from the Thinking About Mathematics Instruction project used two rounds of ratings to reach a consensus. This coding scheme was used during the analysis of the LPS for categorization purposes for the individual case studies and will be discussed in Chapter 4.

Classroom Videos

I selected videos from Inside Mathematics (2014), a public resource that includes tools for educators, classroom videos, Common Core resources, problems of the month, and performance tasks. Inside Mathematics was developed as an extension of the Noyce Foundation's Silicon Valley Mathematics Initiative. The Inside Mathematics classroom videos explore actual classrooms involved in mathematics learning by real teachers. According to Inside Mathematics, the classroom videos, or public lessons have been extensively field-tested in multiple settings where teachers and other mathematics educators provided feedback. The lessons were then refined to serve as virtual learning tools to improve mathematics teaching. The Common Core section within Inside Mathematics has devoted resources to both the content standards and the Standards for Mathematical Practice (SMPs). Each SMP is represented with a general explanation of how it was implemented, followed by a lesson description, and complete classroom video lesson. The alignment of the classroom videos to the Standards for Mathematical Practice was developed in collaboration between the Silicon Valley Mathematics Initiative and the Charles A. Dana Center at the University of Texas Austin (Inside Mathematics, 2014). It is important to note that some videos were dated prior to the development of the CCSSM in 2010; however, they share similar characteristics to the descriptions of the SMPs.

As a previous middle school mathematics teacher and high school mathematics instructional coach, I have been trained to observe teachers and students during mathematics instruction to provide support and informal feedback to improve the learning environment. During my time as an instructional coach, my former principal allowed me to conduct informal observations of the mathematics teachers and work closely with the district and state mathematics specialists as they conducted formal classroom walk-throughs and observations. I have also observed classrooms in multiple counties due to my work with undergraduate and graduate student interns as an Intern Coordinator. These experiences have provided me with a broader perspective on mathematics classroom instruction as opposed to only drawing on my experience as a former classroom teacher. Therefore, I initially reviewed a sample of the videos across practices and grade levels to ensure that the classrooms were similar to the classrooms that the participants might observe or evaluate. I then searched for elementary and middle school videos that claimed to have multiple practices represented in a single clip. Through this process, two classroom videos were selected. A few SMPs overlapped between the two videos that were selected. It was important to select videos that represented multiple SMPs to provide multiple opportunities for the administrators to select the same SMPs. However, it was possible that an administrator might have selected an SMP that was not a focus of either lesson. Public-use videos were selected for ease of replication and to provide a standardized view of instruction to limit the variability of actual classroom observations.

In video 1, *Multiple Representations of Numeric Patterning,* Mr. Dickinson led a number talk with his $5^{th}/6^{th}$ grade class on an input/output table, asking what is the rule. A number talk is defined as brief conversations among students to help them develop computational fluency (Parrish, 2010). Mr. Dickinson also gave attention to multiple ways of representing the rule $3x - 3$. For example, he discussed how "three *x* minus three" would be the same as "*x* times three minus three". According to Inside Mathematics (2014), the SMPs that were evident in this video clip were: SMP 1 – make sense of problems and persevere in solving them; SMP 3 – construct viable arguments and critique the reasoning of others; SMP 6 – attend to precision; SMP 7 – look for and makes use of structure; and SMP 8 – look for and express regularity in repeated reasoning.

In video 2, *Algebraic Equations, Inequalities, & Properties*, Mr. Disston led a lesson highlighting the importance of using mathematical vocabulary such as commutative property and coefficient, with his 7th grade class. He also helped students to make connections between equations, inequalities, and expressions. According to Inside Mathematics (2014), the SMPs that were evident in this video clip were: SMP 1 – make sense of problems and persevere in solving them; SMP 3 – construct viable arguments and critique the reasoning of others; and SMP 6 – attend to precision.

Classroom Video and Standards for Mathematical Practice Rater Protocols and Forms

Prior to data collection, a panel of professionals with mathematics teaching, administrative experience, or both, was used to confirm or refute the existence of the SMPs that were listed as being evident in the classroom videos by Inside Mathematics (2014). The panel consisted of five individuals: an assistant professor of mathematics education from a college in Florida; an assistant professor of elementary mathematics education from a university in Florida; an instructor of statistics from a private university in Florida who received a doctoral degree in mathematics education; a central officer administrator of an independent school district in Texas; and a mathematics education doctoral candidate who was former district level mathematics coach. Each member was emailed two documents. The first document, the classroom video rating protocol (Appendix C) provided detailed instructions about how to rate the selected classroom videos. The second document, the Standards for Mathematical Practice rater form (Appendix D) included "look fors" from the student and teacher actions. The Standards for Mathematical Practice rater form was adapted from several sources: the CCSSM Standards for Mathematical Practice (NGA & CCSSO, 2010), the ASCD Professional Development Institute (2012), and the Elementary Mathematics Specialists & Teacher Leaders Project (Fennel, 2011). This form is similar to the SMPs Identification Tool used by the administrators in this study. However, the SMPs rater form used by the panel provided detailed information regarding student and teacher actions and allowed the panel members to justify their selection of each SMP. The panel was given two weeks to complete the rating forms. Only three panel members returned the rating forms by email, the assistant professor of mathematics education, the assistant professor of elementary mathematics education and the mathematics education doctoral candidate. Across the panel, either one or all members confirmed each SMP identified by Inside Mathematics for both videos. Table 4 provides the SMPs that were identified by the panel members and Inside Mathematics (2014).

Table 4

Standards for Mathematical Practice (SMPs) Identified in Classroom Videos

	SMPs Identified	
Rating Sources	Video 1 (Mr. Dickinson)	Video 2 (Mr. Disston)
"Inside Mathematics" (2014)	1, 3, 6, 7, 8	1, 3, 6
Assistant Professor Mathematics Education	1, 3, 6	1, 3, 6
Assistant Professor Elementary Mathematics Education	3, 6	1, 3, 6
Mathematics Education Doctoral Candidate	3, 6, 7, 8	3, 6, 7

The panel members provided their rationale for selecting each Standard for Mathematical Practice for each classroom video. For video 1, Mr. Dickinson's (the assistant professor of mathematics education) class was the only one to select SMP 1--make sense of problems and persevere in solving them, as the "students analyzed the relationship between the quantities in the table to determine the appropriate equation to match the rule". All three-panel members selected SMP 3--construct viable arguments and critique the reasoning of others. The assistant professor of mathematics education noted several indications of this SMP.

The students used their knowledge of table to develop an equation rule. As students provided their solutions, their classmates clarified and/or disproved their reasoning. They suggested ways of improving upon their classmates' solution.

Students also asked questions of other students. As students shared freely, it was evident that there was a safe a collaborative learning environment. The teacher provided opportunities for students to listen to one another; he also prompted them to discuss their oppositions in small group. The assistant professor of elementary mathematics education noticed two instances where Mr. Dickinson modeled SMP 3, stating to students:

> "I see some silent disagreement around the room. Does anyone care to make a comment about that?"
>
> "Why is this (3x – 3) more right than this (x3 – 3)? Turn to your partner and have a conversation."

The mathematics education doctoral candidate indicated evidence of SMP 3 by stating "students were able to discuss the pattern and expression/equation for the pattern both as whole class and in small groups once a discrepancy came up." In addition to SMP 3, the panel members also selected SMP 6--attend to precision. The assistant professor of mathematics education noted, "As students shared their solutions, the teacher asked questions in a way to get them to clarify their solutions." The assistant professor of elementary mathematics education stated, " I believe the discussion concerning the difference between 3x and x3 was about convention and precision." The mathematics education doctoral candidate did not provide additional comments for SMP 6 but indicated evidence using the rating form by selecting the student actions of communicating precisely using clear definitions and providing carefully formulated explanations. The doctoral candidate also selected the teacher action of asking probing questions. One panel member identified Standards for Mathematical Practice 7 and 8. For SMP 7--look for and make use of structure, the doctoral candidate stated:

> This is the main focus of the lesson. Students were describing the expression/equation that can be used to generalize a specific table of x's and y's. The teacher facilitated discussions and allowed for the discussion of multiple answers and forms of answers. Then the students discussed different forms of answers in pairs discussing if one or both were correct and why.

This panel member also selected SMP 8--look for and express regularity in repeated reasoning where "students were finding general forms for a pattern of number pairs."

For video 2 which was used in Mr. Disston's class, the panel members confirmed evidence of SMPs 1, 3, 6, and 7. SMP 1 was selected by both assistant professors. The assistant professor of mathematics education indicated,

> Students were given a group of expressions and equations to sort based on their commonalities. . . . They had to analyze the information given from each given statement. Groups sorted the expressions and equations differently. The teacher prompted students to explain and justify their ways of reasoning about the groups. While students were explaining and justifying, the teacher was probing them to get them to think about their own thinking.

The assistant professor of elementary mathematics education selected the student action of analyzing information from the rating form and the teacher action of providing opportunities for students to solve problems that have multiple solutions. All panel members selected SMP 3. The assistant professor of mathematics education provided a detailed explanation as to why SMP 3 was identified. First, the assistant professor indicated, "students used information about each statement to group them. They made mention of the commutative, associative, and distributive properties, when grouping them." Second, the assistant professor noted, "Students communicated and defended their reasoning freely. This indicated a safe and collaborative learning environment." The assistant professor's third reason for identifying SMP 3 involved the way students were asking questions of each other and suggesting other ways to group the expressions, equations, and inequalities. Finally, the assistant professor of mathematics education indicated, "The teacher did not state the correct answer, instead continued to ask questions to engage students in metacognition. While asking questions, this allowed students to listen to one another, discuss alternatives to grouping, and defend why."

The assistant professor of elementary mathematics education selected several items from the student and teacher actions from the video rating form but provided specific examples for two of them when selecting SMP 3 for video 2. The elementary mathematics education assistant professor noted, "A student put forth a conjecture, and Mr. Disston verified the conjecture across all examples," and when the teacher asked questions "Mr. Disston asked, 'What do you think of this grouping? Do these belong together?' ". The doctoral candidate also provided evidence for selecting SMP 3 for Mr. Disston's class where "students were grouping what the teacher called 'symbol strings' that have things in common and the students came up and grouped some of them and then provided an argument as to why." The doctoral candidate also noted that students were encouraged to discuss their groups as a group and mentioned, "This seems to be a useful way to begin or review vocabulary and general understanding of equations, expressions, properties, and inequalities."

For SMP 6, panel members provided additional comments to support their selection of this practice. The assistant professor of mathematics education stated, "As students shared their solutions, the teacher asked questions in a way to get them to clarify their solutions. When specific vocabulary was mentioned, he required them to elaborate on their definitions to ensure students attended to precision." The elementary mathematics education assistant professor noted, "Mr. Disston provided vocabulary in context and kept insisting that students use correct vocabulary in their discussion." The doctoral candidate also commented on the use of vocabulary words during the discussion and how the teacher encouraged students to clarify what they meant whenever they made a statement. Finally, the doctoral candidate was the only panel member to select SMP 7 for video 2 and mentioned, "The pattern finding and discussions encouraged through this grouping activity allowed students to explore different expressions, equations, and inequalities." The doctoral candidate also noted, "The comparing, and contrasting of these seemed to help students understand both vocabulary and possibly their later uses".

Standards for Mathematical Practice Identification Form

The Standards for Mathematical Practice Identification Tool (Appendix E) asked each participant in the research study to select the practice(s) of focus for each classroom video in the SMPs follow-up interview, which was conducted after the think aloud protocol. This form was adapted from the SMPs rater form (Appendix D) that was used by the panel members. The Standards for Mathematics Identification Tool included a list of the Standards for Mathematical Practice with student and teacher actions, which served as general descriptions or examples of each SMP. To minimize the length of the form I only included the student and teacher actions that were more closely aligned to the Common Core State Standards, Standards for Mathematical Practice descriptions (NGA & CCSSO, 2010). I also used a majority of the student and teacher actions that were selected by the panel members using the SMPs rater form. These descriptions were also used to provide a general overview that was in general language and to eliminate guessing an SMP without supporting evidence. A section for additional comments was included to provide written feedback that could have been provided to the teachers in the videos; however, I elected to have each participant talk out loud rather than record this feedback in writing to continue with the natural flow of verbalization.

Pilot Study

One administrator participated in a pilot study on April 29, 20015 to ensure validity with the think aloud protocol (Appendix A), the Leadership Profile Survey, (Appendix B), and the Standards for Mathematical Practice Identification Tool (Appendix E). To avoid contaminating the sample, the participant mirrored the targeted sample of participants for the actual research study. The participant was previously a district mathematics specialist with the School Transformation Office in a central Florida school district and at the time of the pilot study was an administrative dean with observation responsibilities at a middle school in central Florida. The participant was also an aspiring principal who was pursuing an Educational Leadership doctorate. The participant completed the Leadership Profile Survey through Qualtrics, engaged in the think aloud protocol, and participated in a follow-up interview using the SMPs Identification form. In addition to myself, a faculty member who also serves as a lecturer and program coordinator for the Masters in Teacher Leadership program from the University of Central Florida was present as I conducted the think aloud protocol and follow-up interview to assist with logistics and provide feedback on my questioning and prompting during the study. After the pilot study, a few adjustments were made. First, the think aloud protocol was adjusted by shortening the instructions. Second, a sample one-minute video clip of a person thinking out loud was added for the actual research study. The sample video involved a person thinking aloud as they watched people's behaviors at a busy intersection. The change was needed, as the administrator in the pilot study was confused about the think aloud process, even after reading through the directions. Finally, I included a brief description of the lesson (Inside Mathematics, 2014) for each video in a PowerPoint presentation (Appendix K) to compensate for the absence of the lesson objectives or standards that an administrator might have seen when entering a classroom. This change was necessary as the administrator stated the difficulty in keeping track of the lesson descriptions during the SMPs follow-up interview.

Data Collection

Approval was received from the University of Central Florida Institutional Review Board (IRB) to conduct the study prior to all recruitment activities and data collection (Appendix F). To maximize the recruitment process for the LPS, an addendum to the IRB (Appendix G) was submitted to allow the faculty members to email the consent forms to all current and aspiring administrators enrolled in a doctoral program at a university in Florida. An email was sent to the faculty members to seek permission to visit their classes to recruit participants (Appendix H). As a result of the email, I was able to visit three classes and the consent forms were distributed to all current and aspiring administrators enrolled in a doctoral program at a university in Florida. The survey consent form was also emailed to master's level students who were considered aspiring administrators. However, the data gathered from this group were not analyzed for use in the present study.

The data collection process of the current research study is discussed in three phases. Phase I consisted of the Leadership Profile Survey. Phase II involved completion of the think aloud protocol. Phase III was the SMPs follow-up interview using the SMPs Identification Tool. It is important to understand that phase III was conducted immediately following phase II of the research study.

Phase 1: Leadership Profile Survey (LPS)

After gaining IRB approval for the study, I emailed the six participants to confirm their willingness to participate in phase II. I then scheduled mutually convenient times to begin the think aloud protocol. As stated in the consent form, the LPS, an online survey, was slated to take about 30 minutes to complete; yet, there were a variety of time stamps listed in Qualtrics. The times ranged from 20 minutes to 2 hours. Later, I learned that a few participants completed the LPS while at work and were dealing with work related issues as they answered questions. The window for the LPS remained open until the conclusion of the study to collect additional data for future research studies. However, the participants were not allowed to change their responses. Selected information from the LPS was used to determine how the participants would be described as individual case studies. This process is described in the data analysis section of this chapter and discussed in detail in chapter 4.

Phase II: Think Aloud Data

Over the course of two weeks beginning May 24, 2015, I scheduled a time and location to begin phase II of the study with each of the six participants. A standard script (Appendix A) was used to explain the purpose of the study and the procedure for the think aloud protocol. Following the process of Ericsson and Simon (1993), I emphasized the importance of constant verbalization about participants' thinking without the need to explain their thinking. Participants described their thought processes without the need for validation about what they were thinking. I was positioned either behind or off to the side of the participants so as not to distract them with subconscious nonverbal cues. Prior to the think aloud protocol, an example of the think aloud process was demonstrated through a sample one-minute video clip of a nonrelated activity to emphasize the difference between thinking aloud and explaining what occurred. A few participants asked clarifying questions, but I was careful not to provide any leading information about what I was expecting them to say.

The think aloud protocol involved participants verbalizing their thoughts as thoughts entered their minds during a problem solving process and while constantly being prompted to talk if necessary (Ericsson & Simon, 1993; Someren, Barnard, & Sandberg, 1994). The think aloud protocol was considered to be an appropriate method to gather verbal data about what participants attended to in the instructional environment when observing the SMPs, because the participants' thought processes would not be interrupted by my probing or asking clarifying questions during the task. The intent of having the participants talk out loud during the video observation was to not interfere with their thought processes (Ericsson & Simon, 1993; Someren et al., 1994).

I estimated that the think aloud process would require approximately 30-45 minutes for each individual, but the entire process ranged between 20-33 minutes per individual. The participants viewed two 3-8-minute video clips from Inside Mathematics (2014) on the computer with headphones in a mutually agreed upon location. Each location was quiet, with limited external distractions and each participant was seated in a comfortable chair with a bottle of water if needed (Someren et al., 1994). I reminded the participants of the video recording component prior to the think aloud protocol, which was used to capture non-verbal gestures and as an additional layer of data collection to capture the verbal data.

It is important to note that because I worked within the participants' schedules, each participant performed the think aloud protocol in different locations. Creswell (2007) stated that descriptive and reflective notes be written immediately following an observation. I followed this process by using Audio Note on my iPad or computer, which allowed me to make notes in a document while simultaneously audio recording the participant. I also completed my reflections after each session. I was also able to replay the recording at the exact moment where I typed a note.

Each participant was given a description of the video lesson in a PowerPoint presentation (Appendix K) to mimic the preconference portion of the observation process or to compensate for not being able to see the lesson objective during an informal walkthrough. The PowerPoint included a title page, the sample video clip, descriptions of both lessons (Inside Mathematics, 2014), and hyperlinks to the videos for organizational purposes only. I used the lesson descriptions from Inside Mathematics (2014) but eliminated the sentences that provided clues to which SMP(s) were targeted. Both video- and audio-recordings were collected using high quality materials with several back up files and a master list of the type of information that was gathered. All files were saved on my password protected external hard drive and laptop. After the second video clip, each participant participated in phase III, a follow-up interview using the SMPs Identification Tool (Appendix E).

Phase III: Standards for Mathematical Practice Follow-up Interview

Immediately following the second video observation, each participant participated in the Standards for Mathematical Practice follow-up interview. This was accomplished by asking the participants to identify which SMP(s) were the focus in each lesson. I asked each participant to think aloud as they went through the process of selecting the SMP(s) of each lesson. It is important to note that the participants were not allowed to re-watch either video clip. However, they were allowed to reread the lesson descriptions if needed. After the SMPs follow-up interview, each participant was asked to describe the feedback they would provide to the teacher and to include any additional information about the videos if applicable. Given that one element of instructional leadership is to provide feedback to teachers, the question was relevant to the study (CCSSO, 2008; NAESP, 2008; NCTM, 2007; NPBEA, 2011).

Data Analysis Procedures

The six participants were analyzed as individual case studies techniques, which followed Ericsson and Simon (1993), Creswell (2007), and Stake's (1995) models of data analysis. The data used in this analysis were the results from the Leadership Profile Survey, the think aloud protocol, and the SMPs follow-up interview. I describe the data analysis procedures as follows: transcriptions and preliminary coding, coding of the think aloud protocols and SMPs follow-up interview data, and development of the individual leadership profiles.

Transcriptions and Preliminary Coding

To minimize researcher bias I began the transcription process after the last think aloud protocol. The audio recordings of the think aloud protocol and SMPs follow-up interview were transcribed. Verbatim transcriptions included all participant statements, vocal sounds, and utterances. The video recordings were consulted to clarify any unintelligible or inaudible phrases. Standard US spelling was used throughout even when the participant used informal words or phrases (e.g. gotta). The natural flow of speech was transcribed as spoken including pauses and incomplete sentences. I used ellipses (i.e., ". . .") to indicate the pauses. Punctuation was included if the participant spoke in complete sentences. Transcriptions were completed in a Word document with the pseudonym of the participant and the completion date of the think aloud protocol listed in the header. The observation notes were saved in Audio Note, which allowed me to replay, the audio recording while reading my notes simultaneously. I made notes whenever a participant mentioned anything pertaining to students, the teachers, made hand gestures, or laughed when there were long pauses in between talking out loud.

Ericsson and Simon (1993) discussed a process from the initial observation of raw data to encoded form in the case of verbal data. The process begins with unedited audio-recordings followed by written transcriptions that have eliminated a series of long unexplained pauses and other monotonous data. Thus, in the present study, after the data was preprocessed, it was reviewed by segments, which were then encoded using my conceptual framework giving attention to student interactions, teacher instructional behaviors, and leadership phrases. Ericsson and Simon (1993) stated that the theoretical model "is often achieved by first determining the coding categories a priori, then having human judges make the coding assessments" (p. 5). For this study, each segment was encoded independently to translate the participant's thoughts, ideas, or questions into words. Ericsson and Simon described this kind of analysis as giving meaning to participants' verbalizations. However, this might limit the full meaning of the verbalization. In addition to what I coded, a professor of Educational Leadership at the University of Central Florida provided clarification regarding additional themes that included what I considered leadership terminology. This clarification resulted in a new theme that emerged from the data, which is discussed in chapter 4.

Think Aloud and SMPs Follow-up Interview Coding

In qualitative research, the early stages are mostly inductive as the researcher begins to interact with the data. During this stage, the transcriptions were read several times. Based on the preliminary coding, I used content analysis to search for reoccurring words or phrases used by the participants that related to instructional leadership, mathematics content, and student and teacher behaviors to reveal patterns or themes (Creswell, 2007; Stake, 1995). This process revealed several themes, which were: attention to students, attention to teacher, and use of instructional leadership language. As suggested by Creswell (2007), the research questions were set aside to attend to the individual perspectives of each case. Descriptive codes were used to introduce the thought processes of each case to the readers as it related to the profiles of each case. Next, themes were established for each case through codes that were created directly from the language of the participants. This was challenging in that "for more important episodes or passages of text, we must take more time, looking at them over again and again, reflecting, triangulating, being skeptical about first impressions and simple meanings" (Stake, 1995, p. 78). Although the research questions were not of primary interest in attending to individual perspectives, the themes were constructed from the thematic codes based on the answers to the research questions (Creswell, 2007). To interpret these themes, I used a single instance, direct interpretation, and drew meaning from the example without over analyzing the phrase, establishing smaller categories (Creswell, 2007; Stake, 1995). The transcriptions within these themes were compared to the views of mathematics-in-use from the LPS, which are described as part of the individual case study leadership profile.

Development of Individual Leadership Profiles

After the transcriptions were completed, I built profiles of each case. A thick description of each case (Creswell, 2007) was developed using various components of the Leadership Profile Survey. These components included the academic background, teaching and administrative experiences, mathematics background, comfort with mathematics, knowledge level of the instructional leadership standards, and responses to the classroom scenario. The responses to the classroom scenarios were used to interpret how the participants viewed mathematics-in-use. Each participant read a fourth grade scenario about a division lesson and provided their thoughts regarding teaching and learning mathematics. The participants had to reflect on what the teacher was doing, determine if the strategies used were effective or not, describe the mathematical ideas of the scenario, and explain what students can learn from the lesson. The participant's responses were analyzed using the following process:

1. I read all of the responses for each case one at a time.
2. Using the TMI Mathematics-in-Use coding scheme (EDC, 2006), I analyzed each response case by case. For example, there were a total of five questions about the classroom scenario. I analyzed the first response for each case, followed by the second response, until all five responses were analyzed.
3. I tallied all the codes for each case to determine an overall score, which described the participant's overall view about mathematics-in-use (MIU). The categories or scores, were: A = No Mathematics, B = Modest MIU, C = Expanding MIU, D = Attending to Mathematical Thinking, and E = Big Picture. The coding scheme provided actual examples of what the principals said for each category. I used this as a reference to analyze the responses of each case in the current research study. There were no cases categorized in the No Mathematics category based on the data provided. The No Mathematics category referred to statements that were absent of mathematical content described in the classroom scenario. An example of what a response in the Big Picture category might look like was not provided. Therefore, I did not use the Big Picture category during the analysis of the responses. I did not feel comfortable making my own judgments about the category. The Big Picture category involved responses that extended beyond the scope of the mathematics that occurred within the classroom scenarios. The responses in this category included an understanding of K-8 mathematics teaching and learning. After I determined the score for each case, I reread the responses of

each case in its entirety to confirm my analysis.

4. After confirming my analysis I assigned an overall view of mathematics-in-use to each case. Three cases were described as having a Modest view of mathematics-in-use, two cases were described as having an Expanding view of mathematics-in-use, and one case was described as having an Attending to Mathematical Thinking view of mathematics-in-use. I used the following abbreviations to describe the views of mathematics-in-use for each case: Modest MIU, Expanding MIU, and Attending to Mathematical Thinking. Table 5 describes the group members based on the views of mathematics-in-use category and a description of each.
5. The transcriptions from the think aloud protocol and the SMPs follow-up interview were compared to the descriptions of the views of mathematics-in-use. This comparison revealed that the description of each administrator's view of mathematics-in-use was closely aligned to the administrator's behavior during the think aloud protocol.

Using pseudonyms, the participants were named Kelly, Zack, Lisa, Jessie, Slater, and Samuel. The completed profiles for each case are presented as individual cases.

Table 5

Classroom Reflections: Mathematics-in-Use Coding Scheme

Category	Participants	Description
Modest MIU	Kelly, Zack, and Lisa	Participants made general references to the mathematics. Comments reflected back or repeated the mathematics mentioned in the lesson. Comments tended to either be general about the mathematics, or they use the same words as those that appear in the lesson.
Expanding MIU	Jessie and Slater	Participants' comments about the mathematics did more than reflect back to lesson. Participants used their own words to describe what occurred mathematically. While references were made about the mathematical thinking of the students or teacher, the participants may not have provided detail about the statements they made.
Attending to Mathematical Thinking	Samuel	Participant's comments reflected an understanding of the mathematics with attention to how the teacher and students interacted with the mathematics during instruction. The participant also made conjectures about the thinking of the students and/or teacher and provided a rationale. Lastly, in the process of describing the mathematics, the participant may have made comments about the nuances of teaching it, the challenges of learning it, and possible misconceptions.

Source: Adapted from TMI Survey Coding Scheme, EDC, 2006

Leadership Profile of Individual Cases

The Leadership Profile Survey was used to provide information about each participant at the time of this research study. The description included background information such as the number of years the participants were classroom teachers, the subjects they taught, the number of years they have been administrators, their self-reported comfort level with mathematics, and their self-reported knowledge level of instructional leadership. Information regarding each participant's mathematics background was also included to illustrate the relationship between what he or she noticed in the classroom videos and his or her ability to identify students engaging in appropriate Standards for Mathematical Practice within each video. I did not distinguish between mathematics courses taken at the undergraduate or graduate level. The participants were Kelly, Zack Lisa, Jessie, Slater, and Samuel. Prior to the think aloud protocol, I verified the LPS information with each participant by having him or her review his or her LPS and provide any additional information. For example, a few participants selected N/A for professional development relating to mathematics instruction but later recalled a few trainings they attended. A rich description of participant follows.

Kelly

Kelly received degrees in Exceptional Education, Counselor education, and Educational Leadership. At the time of this study, Kelly had been a district level administrator for between four and nine years and taught high school social studies for less than three years. She reported having a Florida Level 1 Educational Leadership certificate. There are two types of certificates for school administrators that are issued by the Bureau of Educator Certification of the Florida Department of Education: Level 1 Educational Leadership, which typically qualifies a person to work as an assistant principal and Level 2 Educational Leadership, which typically qualifies a person to work as a school principal (FDOE, 2015). Kelly also has an Exceptional Education certification. Since her time as an administrator, Kelly reported having experience in observing K-12 mathematics, English language arts, reading, science, and social studies. Kelly rated herself as being comfortable with mathematics overall and comfortable with elementary and middle grades mathematics. According to the LPS, Kelly completed four or more years of high school mathematics up to trigonometry. At the undergraduate or graduate level, Kelly stated that she completed College Algebra, Statistics, and Mathematics for Teaching Methods. Her professional development included what she described as "professional development on elementary Common Core mathematics", two conferences relating to mathematics instruction and stated that she has also conducted her own research in mathematics instruction. Kelly rated herself as having a high knowledge level about a majority of the instructional leadership standards listed in the LPS but rated herself as having a low knowledge level about the standard relating to content and instruction and student achievement. Kelly also rated herself as having a moderate knowledge level of providing instructional leadership. Based on Kelly's views about mathematics-in-use from the LPS, she was placed in the Modest MIU group.

Zack

Zack received degrees in Parks and Tourism and Educational leadership. Zack taught middle and high school English language arts and electives for between three and nine years. He was a school dean for less than two years before becoming an assistant principal. Zack also reported having a Florida Level 1 Educational Leadership certificate. At the time of this study, Zack had been an assistant principal for less than three years. Zack reported having experience in observing grades 6-8 mathematics, science, and electives. He rated himself as being neutral in his overall comfort with mathematics and middle grades mathematics. However, Zack rated himself as being extremely comfortable with elementary mathematics. From the LPS, Zack completed three years of high school mathematics and completed College Algebra at either the undergraduate or graduate level. Zack's professional development included attending two mathematics instruction and curriculum trainings within his school district. For the instructional leadership standards, Zack rated himself as having a high knowledge level of instructional leadership in a majority of the standards. However, Zack rated himself as having a moderate level of knowledge in the standards that pertained to providing instructional leadership, relating content and instruction to achievement, and being aware of research on instructional effectiveness. Zack also reported having a moderate knowledge level of relating state standards to the needs of students and the community. Based on Zack's views about mathematics-in-use from the LPS, he was placed in the Modest MIU group.

Lisa

Lisa received degrees in Social Science education and Public Administration but did not list any certifications. She taught middle and high school English language arts for between10 and 20 years and at the time of this study had been a district level administrator for less than two years. Lisa stated that she has experience in observing Grades 3-12 mathematics, English language arts, social studies, and foreign language.

Her professional development related to mathematics instruction included what she described as "attend[ed] the steering committee meeting for the redesigned SAT with College Board where I reviewed the mathematics portion of the assessment to explain what students would have to be able to do". Lisa completed four or more years of high school mathematics including Algebra I & II, Geometry, and Pre-calculus. At the undergraduate or graduate level, Lisa completed College Algebra and Statistics courses. Lisa rated herself as being uncomfortable with mathematics overall as well being uncomfortable with middle grades mathematics; yet, she rated herself as being comfortable with elementary mathematics. With reference to instructional leadership, Lisa rated herself as having an overall high knowledge level of the instructional leadership standards listed in the LPS. However, she rated herself as only having a moderate level of knowledge in demonstrating knowledge of student performance evaluations. Based on Lisa's views about mathematics-in-use from the LPS, she was placed in the Modest MIU group.

Jessie

Jessie earned degrees in Liberal Studies, Educational Leadership, and a master's degree in teaching middle school mathematics along with Levels 1 and 2 Florida Educational Leadership and mathematics 5-9 certifications. She taught middle and high school mathematics for between three and nine years then served as an assistant principal for 10 or more years. At the time of this study Jessie had been a district level administrator for three years and has experience in observing K-12 mathematics, reading, science, social studies, foreign languages, and electives. Jessie selected that she had taken four or more years of high school mathematics beyond Algebra II and listed College Algebra, Linear Algebra, Calculus, Statistics, Mathematics for Teaching Methods, and Mathematics for Elementary and Secondary teachers as being completed at the undergraduate or graduate level. Overall, Jessie reported that she was extremely comfortable with mathematics and extremely comfortable with elementary and middle grades mathematics as well. However, Jessie did not list any professional development relating to mathematics instruction. For the instructional leadership standards, Jessie rated herself, as having a high to very high knowledge level of the instructional leadership within the LPS. I did not differentiate between those levels as I did with the participants who rated themselves as having a moderate or low knowledge level of the instructional leadership standards. Based on Jessie's views about mathematics-in-use from the LPS, she was placed in the Expanding MIU group.

Slater

Slater earned degrees in Liberal Studies and Educational Leadership and has a Level 2 Florida Educational Leadership certification. He was a classroom teacher for between three and nine years where he taught middle school mathematics and science. Slater was a school dean for between four and nine years, an assistant principal for between four and nine years, and a principal for between four and nine years. At the time of this study Slater had been a district level administrator for two years and stated that he has experience in observing mathematics, English language arts, reading, science, social studies, foreign language and elective courses at the K-12 grade levels. Slater indicated that he has attended mathematics curriculum trainings in his local school district for professional development. Slater completed four or more years of high school mathematics including Algebra I & II, Geometry, Trigonometry, Analytic Geometry, College Algebra, and College Trigonometry. Slater's undergraduate or graduate level mathematics courses included Calculus I, II, & III, Statistics, and Differential Equations. Slater rated himself as being extremely comfortable with mathematics overall as well as being extremely comfortable with both elementary and middle grades mathematics. Regarding instructional leadership, Slater rated himself as having a high to very high knowledge level of instructional leadership within the LPS. I did not differentiate between those levels as I did with the participants who rated themselves as having a moderate or low level of knowledge of the instructional leadership standards. Based on Slater's views about mathematics-in-use from the LPS, he was placed in the Expanding MIU group.

Samuel

Samuel received degrees in Interdisciplinary Studies and Nonprofit Management and has a Professional Educator certification. Samuel taught elementary, middle, and high school science for between three and nine years. Samuel was also a principal for less than two years at a charter school but returned to the classroom to teach Physics. I did not ask Samuel why he returned to the classroom. It is possible that the charter school was unsuccessful. An email was sent to Samuel to confirm this possibility, however, I did not receive a response to confirm his reason for returning to the classroom. During his time as a principal, Samuel stated that he as observed Grades 3-12 mathematics, English language arts, reading, science, social studies and foreign language. No other professional development related to mathematics curriculum or instruction was listed. Samuel completed three years of high school mathematics, which included Algebra I, Geometry, and Algebra II. At the undergraduate or graduate level, Samuel completed College Algebra, Pre-calculus, Calculus, and Statistics. Samuel rated himself as being extremely comfortable with mathematics overall and extremely comfortable with both elementary and middle grades mathematics. With respect to instructional leadership, Samuel rated himself as having a moderate knowledge level of all of the instructional leadership standards within the LPS. I referred to Samuel as an administrator since he had administrative experiences. Based on Samuel's views about mathematics-in-use from the LPS, he was placed in the Attending to Mathematical Thinking group.

Validation Strategies

Several validation methods or tests were used to ensure that I did not present a skewed view of the cases (Creswell, 2007). Construct validity was addressed by using multiple sources of evidence such as the Leadership Profile Survey, the think aloud protocol, and the SMPs Identification form during data collection. The second test, internal validity, was conducted during data analysis by using the analytic techniques of pattern matching within the transcriptions and views of mathematics-in-use. Replication logic through the individual case studies was used to complete the third test of external validity. Each case underwent the same process of being selected and engaged in specific measures during the data collection process. Finally, reliability was addressed during the data collection process through the use of protocols and detailed procedures.

Summary

This chapter described the think aloud protocol and rationale for the research design of this study. The think aloud protocol data was supported using the Leadership Profile Survey and the SMPs Identification Tool. The instruments and materials used in the study were presented and described in detail, which included the Leadership Profile Survey, classroom videos, and video rating protocols. The research questions were reiterated to support the data collection process and data analysis procedures. The data collection processes were described in three phases: the completion of the Leadership Profile Survey, the think aloud protocol, and the SMPs follow-up interview. The data analyses procedures were explained, which included the coding of the transcriptions and the classroom reflection scenarios within the LPS. The administrators' views of mathematics-in-use and how the data from the think aloud protocol and SMPs follow-up interview aligned, were also described and presented. A detailed process of how the individual case study profiles were compiled was described, which led to the thick descriptions of each case.

CHAPTER 4
DATA ANALYSIS

Purpose and Summary of Methods

The purpose of this study was to understand what administrators attend to during instruction and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice. The primary research methods for this study were qualitative where data were collected using think aloud protocol analysis (Appendix A) (Ericsson & Simon, 1993), video and audio recordings, and observational notes using Audio Note. Additional qualitative and quantitative data were collected using the Leadership Profile Survey (Appendix B) and the SMP Identification Tool (Appendix E) to aid in the sample selection, categorization of administrators, and analysis of data across the sample (Creswell, 2007). Individual case study techniques (Creswell, 2007; Stake, 1995) were used to conduct the preliminary analysis of the participants.

Description of Sample

The sample was drawn from a doctoral program at a university in Florida, as sampling from this program allowed access to a sample with varying levels of educational leadership and classroom teaching experiences. The participants within the doctoral program were employees in various K-12 schools, across several counties in Florida. These six participants were selected as individual case studies from a wide range of information-rich cases to provide variation on identifying the Standards for

Mathematical Practice and to provide wide and unique perspectives about issues of central importance to the purpose of the research (Patton, 2015; Stake, 1995). The six participants included one assistant principal, one former principal, and four district level administrators. The data from these six administrators were analyzed using individual case study techniques (Creswell, 2007, Stake, 1995) and categorized based on their views of mathematics-in-use. Table 6 describes the group members based on the views of mathematics-in-use category and a description of each.

Table 6

Mathematics-in-Use Coding Scheme: Categories and Descriptions of Reflections

Category	Description
Modest MIU	Participants (Kelly, Zack, Lisa) made general references to the mathematics. Comments reflected back or repeated the mathematics mentioned in the lesson. Comments tended to either be quite general about the mathematics, or they use the same words as those that appear in the lesson.
Expanding MIU	Participants' (Jessie, Slater) comments about the mathematics did more than reflect back to lesson. Participants used their own words to describe what occurred mathematically. While references were made about the mathematical thinking of the students or teacher, the participants may not have provided detail about the statements they made.

Source: Adapted from TMI Survey Coding Scheme, EDC, 2006

Reminder of Individual Cases Leadership Profile

The participants were Kelly, Zack, Lisa, Jessie, Slater, and Samuel. The order of the participants was based on their views about mathematics-in-use (Table 6).

Kelly

At the time of this study, Kelly had been a district level administrator for between four and nine years and taught high school social studies for less than three years. Since her time as an administrator, Kelly reported having experience in observing K-12 mathematics, English language arts, reading, science, and social studies.

Zack

Zack taught middle and high school English language arts and electives for between three and nine years. He was a school dean for less than two years before becoming an assistant principal. At the time of this study, Zack had been an assistant principal for less than three years. Zack reported having experience in observing Grades 6-8 mathematics, science, and electives.

Lisa

Lisa taught middle and high school English language arts for between 10 and 20 years and at the time of this study, had been a district level administrator for less than two years. Lisa stated that she has experience in observing Grades 3-12 mathematics, English language arts, social studies, and foreign language classrooms.

Jessie

Jessie taught middle and high school mathematics for between three and nine years before serving as an assistant principal for 10 or more years. At the time of this study, Jessie had been a district level administrator for three years and had experience in observing K-12 mathematics, reading, science, social studies, foreign languages, and electives.

Slater

Slater was a classroom teacher for three to nine years where he taught middle school mathematics and science. Slater was a school dean for between four and nine years, an assistant principal for between four and nine years, and a principal for four to nine years. At the time of this study, Slater had been a district level administrator for two years and stated that he has experience in observing mathematics, English language arts, reading, science, social studies, foreign language and elective courses at the K-12 grade levels.

Samuel

Samuel taught elementary, middle, and high school science for between three and nine years. Samuel was also a principal for less than two years at a charter school but returned to the classroom to teach Physics. During his time as a principal, Samuel stated that he has observed Grades 3-12 mathematics, English language arts, reading, science, social studies and foreign language.

Reminder of Classroom Videos

As described in Chapter 3, the think aloud protocols were conducted using two videos from Inside Mathematics (2014). In video 1, *Multiple Representations of Numeric Patterning,* Mr. Dickinson led a number talk with his 5th/6th grade class on an input/output table, asking what is the rule. A number talk is defined as brief conversations among students to help them develop computational fluency (Parrish, 2010). Mr. Dickinson also gave attention to multiple ways of representing the rule 3x – 3. For example, he discussed how "three *x* minus three" would be the same as "*x* times three minus three". In video 2, *Algebraic Equations, Inequalities, & Properties*, Mr. Disston led a lesson highlighting the importance of using mathematical vocabulary such as commutative property, coefficient with his 7th-grade class. He also helped students to make connections between equations, inequalities, and expressions.

Findings: Research Question 1

Since I grouped the administrators by their views about mathematics-in-use, I answered this research question and provided supporting data by groups across the two classroom videos. Research Question 1 asked: How do administrators' leadership profiles relate to what they notice in the instructional environment? The administrators in the Modest MIU group, (Kelly, Zack, and Lisa,) noticed the teacher's use of instruction and classroom discourse between teachers and students, and demonstrated little knowledge or attention to student learning as it related to the content. The administrators in the expanding MIU group, (Jessie and Slater,) noticed student engagement, attention to academic vocabulary, and teacher instructional strategies. The former principal in the Attending to Mathematical Thinking group (Samuel,) noticed how students were interacting with the mathematics, the students' attempts to use academic language, teacher instructional strategies, and the use of formative assessments. Although it appeared that the members in each group attended to the same aspects of the instructional environment, it is important to note that the administrators' attention to details varied based on what they noticed. I provide support to this answer by discussing each group across both videos.

Supporting Data for Research Question 1

<u>Modest Mathematics-In-Use</u>

The analysis of the transcripts revealed that, as a group, a majority of the Modest MIU members attended more to the teacher in the first video and slowly transitioned to the students in the second video. Statements about the teacher and students pertained to the reasoning of students, their problem solving skills and how they had to make sense of the mathematics that occurred. However, the observations of those behaviors were infrequent. They often noticed how the teachers questioned the students, the behaviors of the students, and noted that the teacher repeatedly called upon the same students to answer questions or to make a comment. This group as a whole had a Modest MIU. Their statements mainly focused on the teachers' use of instruction, classroom discourse between teachers and students, and demonstrated little knowledge or attention to student learning. Select phrases with the most attention to mathematics, students, and teacher behaviors are provided from each member of this group to demonstrate what the participants noticed. The members of this group were Kelly, Zack, and Lisa.

Teacher Questioning

During both videos, Kelly focused the most on teacher moves and was the most teacher-focused in her verbalizations. A majority of her comments started with what the teacher was doing. She was slightly hesitant about thinking aloud during the first video. Kelly's verbalizations were slower as she struggled to think aloud. Yet, she noticed the teacher facilitated inquiry-based learning--how he allowed the students to process their thinking and how the teacher questioned the students:

> Kinda using more of an inquiry based learning to help them understand the process. Giving. . . uh. . . the students. . . time. . . to. . . um. . . to explain their process in groups. Listening to students as they offer solutions that some of the other students don't agree with.

Kelly was more comfortable during the second video, and she was able to verbalize her thoughts more frequently. She still noticed what the teacher was doing. "He was reflecting on their disagreement. . . he's apologizing, giving positive reinforcement, He's repeating, clarifying what their agreement is. . . Calling out students by name. . . ." Kelly's noticing behavior during the observation might be best described as providing a narrative of the teacher's instruction.

Lisa's thoughts flowed more consistently as she was thinking aloud during both videos, and her thoughts were slightly more sophisticated as she understood more about each lesson. Lisa's statements about the teachers in both videos were also focused on how the teachers questioned students and how they interacted with the students in general:

> The teacher is asking a question, asking them to review. . . Ok now he is asking her to explain what she means. . . The teacher is complementing the student and he keeps on prodding them. . . He is asking them why one would make an evaluative decision about which one is the best one that represents the rule he is trying to teach. Umm hmm. . . ok so now he's doing a think pair share.

Though still teacher focused, Lisa's statements did show that she gave attention to the mathematics that occurred in the middle school lesson:

> Ok he is asking them to differentiate between them and why. . . why the numerical phrase is different. . . he's talking a lot about the equal sign. . . symbol strings. He wants the difference between equation and expression . . . And now he's. . . this. . . ok. . . so now he's talking about numbers and variables. . . He talking about I guess. . . different ways they could group. . . Hmm. . . now he's going over. . . he's reviewing academic vocabulary. . . he pointed out the constant.

Lisa appeared to understand the goal of each lesson but maintained a focus on what the teacher was doing. She attended slightly more to how the teachers were using mathematics to question and probe their students.

Attention to Student Behavior and Interactions During Instruction

The members of this group noticed what students were doing in each lesson but only restated what occurred. A majority of their statements attended to the student behaviors within the classroom environment.

Zack's comments about the teachers were similar to Kelly's, but he really focused on the students' behaviors during instruction. He verbalized the most in this group which might have implied that he was very comfortable during the think aloud protocol. Yet, Zack's statements were general:

> K. . . so student asked a question. . . The second student giving this strategy. . . Okay Maddie's offering the rule. . . Oh wow. . . this kid is offering what he agrees then adding to it. . . Uh. . . ok. . . alright. . . so the students are offering multiple strategies to ultimately come up with either a rule or a process for solving these types of problems. . . kids offering their thinking so there's less social dominance.

Although Kelly verbalized the least about the students in the group, she did notice a few student behaviors during instruction.

> They're verbalizing the process of how they did. . . They are working backwards on how they solved the problem. . . Several students are raising their hands seemingly engaged. . . Students are looking at the problem in multiple ways. . . They're coming back together. . . and talking about what they discussed at the tables.

Lisa also noticed student behaviors and how they interacted with each other during instruction. She also offered her opinion about the student discourse.

> Kid is asking a question. . . he was. . . the child was asking a question to clarify. . . I . . . I like that the students are being allowed to really question the process and question each other's thinking which I think is an important part of arriving at what the right answer is. . .
>
> Now they are working cooperatively to arrive at the answer. . . You can tell that the kids really understand what they are talking about because the debate is going back and forth. . . they've had a lot of time with this particular content.

These excerpts illustrated what the members of this group noticed about the student behaviors and what they were doing during instruction, rather than what the teacher was allowing them to do.

Compliance/Management

The members in this group had the least administrative experiences at the school level compared to the other participants. Yet, it was evident that their leadership lens dominated what they noticed during the classroom videos. Zack verbalized the most about what he noticed as it pertained to instructional leadership in both videos. A majority of his comments involved the teachers' behaviors and their interactions with the students.

> Ok, he needs to manage his response rates better because he's just asking blatantly. . . so you get a little social dominance from the kids that really want to respond.

Here, Zack was being evaluative of the teachers by using instructional leadership jargon referring to how the teacher engaged students when asking a question, i.e., unison responses, wait time, and as a way to rate their competence of the classroom environment. He noticed the teacher and student interactions but failed to notice the content during the interactions. Again, Zack noticed what the teacher was doing and how it related to the overall instructional environment.

> So the teacher is asking questions and he's not offering students any answers. He's asking students to explain their reasoning and thinking which is great but it's also allowing for social dominance. . . the kids that don't want to respond don't have to. . . [Overall] this is a great strategy where he's moving around his responses.

Kelly was also being evaluative of the teachers based on what she noticed about the instructional environment.

> [He] is reinforcing their [the students] responses and clarifying for other students. . . He's apologizing, giving positive reinforcement. . . Acknowledging student disagreement. . . Asked closed ended questions. . . to the students. . . Calling out the students by name. . . He's validating their thought process and encouraging them to think for themselves. . .

<u>Knowledge of Content and Students</u>

This category refers to being aware of the content and also noticing specific things about the students that related to their understanding of the mathematics. Lisa was the closest to noticing knowledge of content and students as it related to expressions and equations. Zack's statements indicated that he did not notice how the students were interacting with the content in either video.

> Ok he is asking them to differentiate between them and why. . . why the numerical phrase is different. . . he's talking a lot about the equal sign. . . symbol strings. He wants the difference between equation and expression. And now he's. . . this. . . ok. . . so now he's talking about numbers and variables. He's talking about I guess. . . different ways they could group

Kelly noticed a few instances that pertained to content and students but mainly from the second video. [He asked] "What type of property is it. . . He's getting them to examine the different numbers and variables based on different patterns. . . He's getting them to look at it [equation] from a different angle. . . the equal sign. . . "

The statements about what the members in the Modest MIU group noticed suggest that they primarily attended to the general behaviors of the students and teacher with limited attention to the mathematics or student thinking. A few statements related to instructional leadership, but they did not consider the specific context of the class or how these teacher behaviors may have been affecting student thinking or learning. From video 1, the participants noticed how the students were able to make connections between the input/output table and functions; and from video 2, they noticed how the students were attempting to understand the differences between equations, expressions, and inequalities. This group also noticed if the students were able to make sense of the problems or activities, reason in their thinking and how the students were able to discuss their answers. The statements verbalized by the members of this group were consistent with a Modest MIU view where the participants made general references to the mathematics, reflected back or repeated the mathematics mentioned in the lesson, and tended to use comments that were quite general about the mathematics, or they used the same words as those that appeared in the lesson (EDC, 2006).

Expanding Mathematics-in-Use

The analysis of the transcripts revealed that, as a group, the Expanding members' cognitive thought processes revealed their understanding of mathematics. Several of their statements from the think aloud protocol were based on the students' interactions with the teacher and with the content, in addition to the teacher's questioning strategies. While the members in this group focused on the teachers and students, they also noticed how the teachers and students were responding to the mathematics, which was different from the Modest MIU group. Jessie and Slater were the members in this group and their statements also revealed their thoughts about student engagement, attention to academic vocabulary, and teacher strategies. Neither member of this group hesitated to express their thoughts during the think aloud protocol which might have implied they were comfortable with talking out loud. Across both videos, the Expanding MIU group attended to content-focused teaching strategies, knowledge of content and students, and compliance/management behaviors. Select phrases with the most attention to mathematics, students, and teacher behaviors were chosen from each member of this group to demonstrate what the participants noticed.

Content-focused Teaching Strategies

In both videos, Jessie noticed how the teacher questioned the students and the behaviors of the teachers during instruction. A majority of these comments restated what occurred in the videos but they illustrate her attention to the mathematics.

> He's talking about paring numbers and variables. . . that's the pattern that they are all the same. . . Talking about basic operations that are involved in each. . . He's keeping with the similar pairs. . . Now he's address the one. . . that there was an equal sign. . . but he. . . now he's asking about. . . if there's something there that shouldn't be grouped. . .

Slater's statements were similar to Jessie's, but he verbalized more of his thoughts during both videos. Like Zack, he interacted with the videos as if he were observing the teachers in his school. Slater noticed how the teacher used the mathematics during instruction.

> Ok so. . . He's making them explain. . . there. . . you know. . . examining or reasoning. Not to say that she's right or wrong but having her to defend why she thinks that the commutative property that's . . . that's good. . . All have addition and subtraction. . . they don't all have equal signs. . . ok. . . Sooo at this point we either need to delineate between an equation and expression that would be a good time for. . . a good time for us to set that up there. . . So He's giving them time to think about his question.

Jessie and Slater noticed what the teachers were doing with their students and were able to identify specific instances that pertained to mathematics. Although it may appear that Jessie and Slater attended to student thinking, they noticed the students' actions as a response to the teachers' actions.

Knowledge of Content and Students

Jessie noticed how students were attempting to understand expressions and equations and noted their process in doing so. She made references to the mathematics but did not offer additional explanations as to why the students were responding this way. Jessie stated:

> This girl even went more general and said properties not getting specific. She wants to move one of them [cards] from a different grouping over to the others. She's. . . she. . . was justifying her answer, I think she just took herself back to not agreeing with her own recommendation. . . somebody yelled out outlier. . . She's starting to combine like terms, that's part of her explanation.

Slater's statements involved his thoughts about why the students were saying what they did and how they interacted with the teachers. He used the mathematics in both lessons to illustrate his point.

> Do they know what a rule is. . . do they know what the definition of the rule is? Alright. . . right. . . so. . . so we're sitting in groups. . . we didn't really process anything. . . I think they processed it as a whole talking to him. . . I don't know if they had a chance to work it out with each other. Ok so. . . so now that rule is almost an equation at that point. . . it is an equation at that point.

Jessie and Slater noticed what the students were doing with some attention to how they should be thinking about function rules and expressions.

Compliance/Management

Both Jessie and Slater made comments that illustrated their leadership backgrounds. Their attention to what the teacher did and what the teacher should have done demonstrated their Expanding MIU view as it relates to instructional leadership, content, students, and the teachers. Jessie's comments were general overall but illustrated her attention the mathematics:

> Looks like he did a little. . . a little crowd control but he asked the same question four times before he allowed somebody to answer it. Now he's he pulling the definitions out between the expressions and equations...umm. . . he left the boy without probing him for that answer. . . He's giving some positive reinforcement for their thinking generically. . . Verified. . . but used unison response on the expression . . . vocab word.

Jessie moved fluidly from her attention to the instructional environment, classroom management, and mathematics vocabulary. A majority of Slater's comments illustrated his understanding of instructional leadership and his years of experience teaching mathematics. This was evident in what he noticed about the teacher and student during instruction:

> I woulda looked for vocabulary such as coefficient umm during the exit. . . that would have been a great time to roll in that kind of verbiage to make sure students

> were uh using proper math vocabulary. . . that's a big thing. . . minus you know. . . ah. . . 3 times. . . actually writing 3 times out. . . I woulda expect by the end of it we would have had a rule that was succinct

Slater also expressed his thoughts as the middle school lesson concluded:

> I don't know that if we . . . ever really closed anything out especially in that property area. . . I don't know that we ever validated this was commutative, this was the distributive. . . this was associative. I don't. . . I don't recall umm. . . seeing that umm there was . . . um any closure to that and then moved into the expressions and equations which he did get to the difference between expressions and equations which I was looking for. . .

The analysis from this group revealed that Jessie and Slater's mathematics and leadership background influenced what they noticed about the teacher, students, and content throughout the lessons. Although Slater was more vocal in his instructional leadership comments, both members of the Expanding MIU group had multiple instances where they noticed the mathematics and often used their own words to describe what occurred. The Expanding MIU group noticed how the students used the visual models of expressions, equations, and inequalities to help them understand the features and relationships between them. The members of the group also attended to how the students were engaged in discussions among each other while using proper academic vocabulary. The statements verbalized by the members of this group were consistent with an Expanding MIU view in that the participants did more than reflect back to the lesson and used their own words to describe what occurred mathematically. Although references were made about the mathematical thinking of the students or teacher, the participants did not provide details about the statements they made (EDC, 2006).

Attending to Mathematical Thinking

The analysis of the transcripts revealed that the Attending to Mathematical Thinking member, Samuel, had an understanding of how the students and teachers processed the mathematics in each lesson. Samuel was able to unpack how and why the teachers questioned the students and noticed where students might have been frustrated as each lesson continued. Samuel rated himself as having a modest level of knowledge of the instructional leadership standards; yet, he was able to think deeply about the relationship among teachers, students, and mathematics. Though Samuel made several assertions about teachers, his attention was on how the teachers prompted and probed students to answer various questions.

Attention to Teacher Instructional Strategies

Samuel noticed how the teacher created a learning environment for the students and how the teachers questioned them about their thinking. Although Samuel's thoughts involving the teacher were general and focused on teacher behaviors that occurred throughout each video, they did involve mathematical language. Samuel verbalized his thoughts that extended beyond what he saw in the videos. This might suggest he was very comfortable with the think aloud protocol. He was also the only administrator to speak in first person. As with the Modest MIU and Expanding MIU groups, only select phrases with the most attention to mathematics, students, and teacher behaviors were chosen from each member of this group to demonstrate what the participants noticed.

> Ok I. . . I notice again that it seems like. . . uh. . . sort of having the students discover sort of different things by having them talk about it. . . he's. . . he's engaging every student it seems. . . . oh some are equations some are just expressions and he's. . . uh having the students try to sort them uh. . . into groups there and trying to connect that back to. . . what property do we see here. . .

Although Samuel's language was evaluative toward the teacher and overall instruction (similar to Kelly, Zack, and Slater), he went beyond general terms and focused on how the teachers' instructional choices affect student thinking and learning throughout the videos.

> So he's . . . he's trying to guide their thinking to say hey maybe we should you know. . . take this equal sign out of here. . . Which is the appropriate way to do this kind of discovery learning . . . to sort of guide the students thinking . . . we can sort of discover these principles. . . but again...its. . . you know. . . it can be frustrating I think for some students ...so it has to be done very well.

Knowledge of Content and Student Inquiry

A majority of Samuel's verbalizations attended to students in both videos. This was consistent with the way he viewed mathematics-in-use. His attention was focused on how the students learned and how they interacted with the mathematics. Samuel was placed in this category alone, because he uniquely noted how students might have been frustrated by the teacher's questioning strategies and attempts at what he called discovery learning. During the think aloud protocol, Samuel provided evidence as to why he made certain statements. He did not explain his thinking; rather it was an extension of the original thought. He noticed "that the students use academic language you know. . . instead of calling it a letter she calls it a variable. . . so she recognizes those symbols or variables". He then continued his thoughts about what occurred.

> So I note that the student is. . . umm. . . sometimes students will understand something without knowing the name for that. . . and I think that that's. . . important to really know what. . . what. . . the property is and so in knowing the name of it. . . it's important to know that too.

Samuel also noted how students might feel during instruction in the expression and equation video.

> And again. . . I. . . I see the same kind of you know mixed. . . mixed feelings about this. . . where it could be confusing to some students to who would just need to know. . . what is the rule and tell me that. . . and. . . and sort of having expressions with equations may lead to confusion. . . you know why are these grouped together this way. . .

Samuel attended to how the students interacted with the mathematics and was able to provide evidence of how they might understand the lessons.

Attention to Use of Assessments

Although Samuel's attention mainly focused on the students and what teachers could do to better assist students throughout each lesson, he briefly shifted to addressing how assessments could be used during instruction to drive what students learn.

> The same time an authentic assessment would realize students that actually understood the concepts as well as perhaps connecting the academic language to it. . . and both are really important. . . Although it's difficult to assess sort of. . . .what each student is thinking. . .

Overall, Samuel was attentive to student thinking and how the teachers were responsible for facilitating the learning environment. His statements provided details about how the students might be making sense about mathematics and shared his thoughts about discovery learning. Samuel noticed the importance of students understanding the goal of the lesson, how students were thinking differently about abstract situations, and how the students were able to communicate and share their ideas with each other. Given his background as a physics teacher, Samuel probably had a broad perspective on the mathematical ideas and how students should apply them for a deeper understanding of the content. Consistent with Attending to Mathematical Thinking view of mathematics-in-use, Samuel also noticed how the students were attempting to use appropriate language to support their claims about the similarities and differences between equations, expressions, and inequalities.

Summary of Findings: Research Question 1

Research Question 1 asked: "How do administrators' leadership profile relate to what they notice in the instructional environment?" To answer this question, six administrators with various administrative experiences and views about mathematics-in-use were asked to think aloud while watching two mathematics instruction videos about Multiple Representations of Numeric Patterning and Algebraic Equations, Inequalities, & Properties. Participants were categorized into three groups based on their views about mathematics-in-use. The analysis of administrators' interpretations of mathematics instruction generated key findings that included differences in what they noticed about students, teachers, mathematics content, and instructional leadership. These findings were related to the amount of mathematics each administrator noticed in the instructional environment. The members in the Modest MIU group, Kelly, Zack, and Lisa, attended to very little mathematics, only making general references. These members did not have experience teaching mathematics. The members in the Expanding MIU group, Jessie and Slater, noticed more mathematics, which demonstrated their engagement with the content. This was consistent with their experience in teaching mathematics, above the elementary level. The member in the Attending to Mathematical Thinking group, Samuel, attended more to how the teachers and students interacted with the mathematics during classroom instruction. He also provided details about how the students might be making sense of the mathematical content and described the teacher's role in this process. Although Samuel did not have experience teaching mathematics, as did Jessie and Slater, he did teach physics which requires a level of mathematical understanding. To illustrate what the administrators noticed during instruction across both videos, I created a frequency chart to indicate the utterances that pertained to general instructional practices of the teacher, general behaviors of the students, and the occurrences of the instructional leadership language used by the administrators in each classroom video.

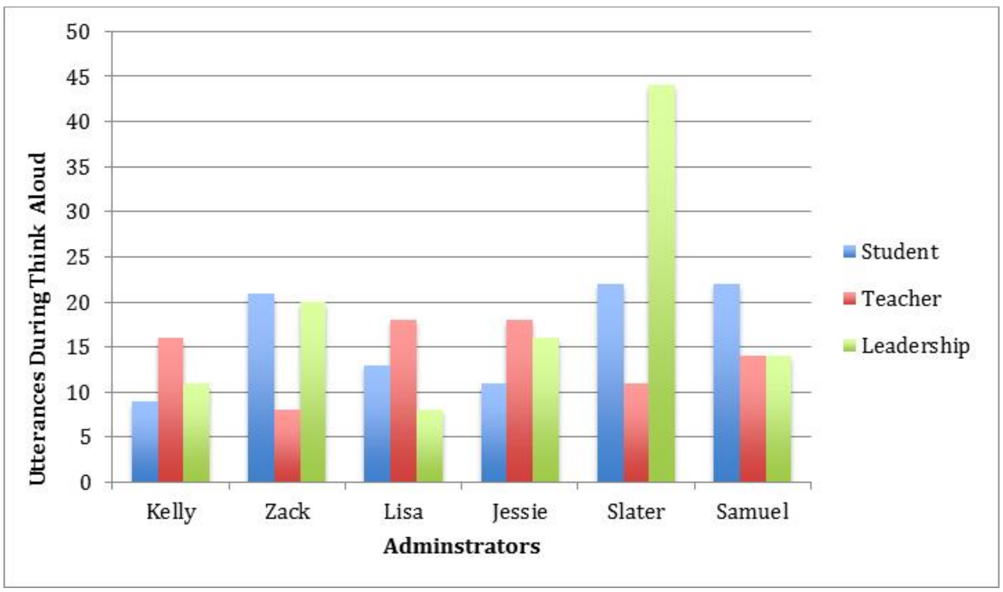

Figure 1. Utterances Noticed During the Think Aloud Protocol

Although the administrators were not asked to identify the Standards for Mathematical Practice during the think aloud protocol, their language about what they noticed during instruction were similar to the NCTM Process Standards, as discussed in chapter 2. The NCTM Process Standards (i.e., problem solving, reasoning and proof, communication, connections, and representation) described the approach to understanding the content standards (NCTM, 2000). Inferences were made using the knowledge of content and students and the broad category of attention to students was used to note the relationship between the verbalizations made by the administrators and the NCTM process standards, which embody characteristics of the Standards for Mathematical Practice. The administrators were not given any reference of the NCTM Process Standards during think aloud protocol. There were similarities amongst the groups pertaining to the language they used to describe what they noticed during the classroom videos and how that language related to the NCTM Process Standards.

The verbalizations made by the Modest MIU group, (Kelly, Zack, and Lisa,) were similar to the NCTM Process Standards Reasoning and Proof and Problem Solving, which are related to SMPs 1 and 3 (Seeley, 2014). Reasoning and Proof involves students making sense of mathematical situations, investigating mathematical conjectures, and being able to provide justifications (NCTM, 2000). Problem Solving pertains to students reflecting upon their thinking while incorporating various strategies they have developed from solving other mathematical problems (NCTM, 2000). The administrators in this group noticed how students were offering a variety of solutions when they did not understand the problem, explaining their reasoning to each other and the teacher, and expressing their disagreement about another student's answer.

In the Expanding MIU group, the administrators, (Jessie and Slater,) verbalized statements that were related to the NCTM Process Standards Problem Solving, Reasoning and Proof, and Communication, which are related to SMPs 1, 2, 3, and 6 (Seeley, 2014). The administrators noticed that the students were making sense of the activities and problems in both classroom videos and they verbalized how the students were providing explanations and justifications when responding to questions, which were similar to the Modest MIU group. However, Jessie and Slater noticed how the students were using academic vocabulary coefficient, clear definitions of expressions and inequalities, and symbolic language. The attention to how the students were using the vocabulary and definitions to clearly express their thinking relates to the process standards of Communication. The Expanding MIU group members recognized the difference between stating the correct vocabulary and understanding the terms as it related the classroom instruction.

The administrator in the Attending to Mathematical Thinking group, (Samuel,) also noticed elements of the instructional environment that were related to the NCTM Process Standards Reasoning and Proof, Problem Solving, and Communication. Yet, he also noticed characteristics of two additional process standards, Connections and Representations, which are related to SMP 7. The Connections process standard involves students having a deeper understanding of mathematics and seeing concepts as a coherent whole rather than isolated ideas (NCTM, 2000). Representations refer to the way mathematical ideas can be demonstrated or represented (NCTM, 2000). Samuel noticed how the teacher was using multiple ways to represent a function in video 1 and how the students were working to connect their understanding of expressions and equations to the commutative property in video 2.

Findings: Research Question 2

After analyzing the transcriptions from the SMP follow-up interview, the original categorizations of the administrator's views of mathematics-in-use held. Although the participants were still grouped by the views of mathematics-in-use categories, I answered this research question and provided supporting data by discussing each classroom video separately. It was important to discuss each video separately, as I described how each member within the different groups selected the SMPs and how they came to those conclusions. Research Question 2 asked: "How does what the administrators noticed in the instructional environment relate to their ability to identify students engaging in appropriate Standards for Mathematical Practice?" This analysis demonstrated that the mathematical language of the participants and attention to how students interacted with the content increased when the administrators were presented with the Standards for Mathematical Practice Identification form during the SMPs follow-up interview. With the aid of the SMPs Identification Tool, the administrators overall were able to accurately select a majority of the Standards for Mathematical Practice that were listed for each video according to Inside Mathematics (2014). I supported this answer by discussing the classroom videos separately while maintaining the structure of each group. As described in Chapter 3, two videos that were selected from Inside Mathematics (2014): Mr. Dickinson's 5th/6th lesson on *Multiple Representations of Numeric Patterning* and Mr. Disston's 7th grade lesson on *Algebraic Equations, Inequalities, & Properties.* The SMPs identified within Mr. Dickinson's lesson by Inside Mathematics were:

1. Make sense of problems and persevere in solving them.

3. Construct viable arguments and critique the reasoning of others.

6. Attend to precision.

7. Look for and make use of structure.

8. Look for and express regularity in repeated reasoning.

The Standards for Mathematical Practice identified in Mr. Disston's lesson were 1, 3, and 6.

Supporting Data for Research Question 2: Classroom Video 1

The following sections provide an analysis of Mr. Dickinson's 5th- and 6th-grade lesson. The source of the data was classroom video 1.

<u>Modest MIU Group</u>

As a group, the members of the Modest MIU group selected SMPs 2, 3, 7 where attention was given to how the students were thinking and how the teacher asked questions. Kelly selected SMP 2 because she thought the teacher "was trying to get students to look at the problem in a more abstract way and think at a more higher level of skills". Zack also identified SMP 2 as a focus for Mr. Dickinson's class, noting that "Students were offering multiple strategies of what the rule may be or how the rule was used and that there was not one particular solid answer and because of that it was an abstract situation." Zack offered no additional explanations or specific mathematical examples from the video that led to this decision.

Standard for Mathematical Practice 3 was selected as a focus, established by the interactions between the students. Lisa noticed the culture of the classroom where students were allowed to share their thoughts and stated that "the kids answered but they also had to say what they thought it was. . . he allowed the students to have a viable argument." Zack's rationale for selecting SMP 3 focused on the students as well, where

"They offered their reasoning as to why other responses were correct or incorrect and [how] they added to it if they thought it was correct." Again, these explanations target student engagement but could be used in other subject areas. Kelly selected SMP 7 based on the activities the students did in Mr. Dickinson's class. In her identification of the practice, Kelly stated that the "students demonstrated their flexibility in writing in a number of different ways. . . equation being looked at in different ways." Lisa identified SMP 7 based upon "students demonstrating their flexibility in representing mathematics in a number of ways [where students] thinks this was the rule and how it was changing."

In addition to SMPs 2, 3, and 7, Kelly was the only participant in the group to select SMP 1 and Lisa was the only participant to select SMP 6. Kelly mentioned that the teacher "encouraged students to represent their thinking while problem solving and thinking aloud." Lisa selected SMP 6 because the "kids were communicating with the teacher [and] they had to use academic vocabulary in what they were saying about mathematics." A majority of Lisa's comments attended to vocabulary which could be attributed to the fact that she was an English teacher prior to becoming an administrator.

Expanding MIU Group

The members in this group were in agreement with the selection of SMP 7 as the focus for Mr. Dickinson's class. Given their mathematics teaching background, perhaps they understood the goal of the lesson and were able to notice how the students reacted to hearing "*x* time three minus three, times three minus three, and 3*x* minus three" from their classmates. Jessie's rationale for identifying SMP 7 was based on the input/output activity Mr. Dickinson presented to his class. She stated that the teacher "made a list of what the students were saying. . . no matter what they said. . . once they got the list they discussed the common elements from what everyone said but never closed the lesson to make sure students all had an understanding." This was in reference to students looking for patterns and the teacher providing ways for students to think about functions in different ways. Slater selected SMP 7 for similar reasons. He noticed that the students were "having to create a rule based on a pattern of an X and Y t-chart." Slater's explanation used specific mathematical language when selecting this practice.

Although the members in this group identified SMP 7 as a focus for Mr. Dickinson's class, they differed in opinion selecting SMPs 2 and 3. Jessie identified SMP 2 based upon the students' perspective. She indicated "talking about three times x then three dot x, then $3x$. . . this is very abstract for students that age [5^{th}/6^{th} grade] for them to understand that all of these were the same thing." Slater noted that the teacher was "decent there. . . asking probing questions having to defend their own. . . teacher wasn't taking the safety net away but defending why students said what they said a asking do you agree or disagree asking why." Both members were careful in their selection of the SMPs for this lesson.

<u>Attending to Mathematical Thinking</u>

Prior to selecting the practices for each video, Samuel revealed his familiarity with the SMPs from the posters displayed in his classroom which he said were used in conjunction with his science standards. Samuel was making reference to the Next

Generation Science Standards, Appendix L (2013), which makes connections to the Common Core State Standards for Mathematics and the Standards for Mathematical Practice. Samuel identified SMPs 1, 2 and 3 as the primary focus for Mr. Dickinson's lesson. He selected SMP 3 referencing when students were trying to find a rule for the function as "students were asking other students questions and asking why did you say three dot *x* instead of three next to *x*" and how they were asking, "what was happening to x to get the y." Referencing the description of the lesson, Samuel also noted that the students were required to engage in brief conversations with each other to discuss the "rule of a function." For SMP 2, Samuel described how the students might have thought about the input/output table and stated that "having students try to figure out what a function is. . . that [is] pretty [much] an abstract idea. . . sort of a magic trick." Thinking back to how the lesson unfolded, Samuel selected SMP 1 based upon the teacher's instructional strategies. He mentioned how the teacher constantly:

> Refined the students thinking, showing the different ways to say three times *x* and 3*x* showing that it's the same things. Also by persevering in recognizing what the function was, what's happening to the number and encouraging students to represent their thinking while problem solving.

As a secondary focus Samuel selected SMPs 4, 7, and 8. Although his rationale for including SMPs 7 and 8 were based on the descriptions from the SMPs Identification Tool, Samuel perhaps selected SMP 4, model with mathematics, in relation to his Physics background.

Table 7 provides a presentation of the combined Standards for Mathematical Practice. The table contains each of the standards linked to each of the participants for video 1.

Table 7

Combined Standards for Mathematical Practice Selection of Video 1: Mr. Dickinson

Participant	SMP1	SMP2	SMP3	SMP4	SMP5	SMP6	SMP7	SMP8
Kelly	X	X	X				X	
Zack		X	X				X	
Jessie		X					X	
Lisa			X			X	X	
Slater	X		X				X	
Samuel	X	X	X	X			X	X

Supporting Data for Research Question 2: Classroom Video 2

The following sections provide an analysis of Mr. Disston's 7th-grade lesson. The source of the data was classroom video 2.

<u>Modest MIU Group</u>

The members in the Modest MIU group verbalized more during the think aloud protocol of Mr. Disston's class and while selecting the Standards for Mathematical Practice. As a group, SMPs 1, 3, 6 and 7 were selected as the focus of this lesson. Again, more mathematical language and evidence from the video were used; however, the rationales were general. Kelly was hesitant in selecting the SMPs for this video but she was more vocal in verbalizing her thoughts. For SMP 1, Kelly observed that the teacher "encouraged students to represent their thinking while problem solving." Zack indicated SMP 1 as being a focus of Mr. Disston's lesson "because the teacher was encouraging the students to represent their thinking out loud while they were problem solving." Lisa chose SMP 3 as a focus for the lesson based upon the students having to work in a continual process. Adding to SMP 3, Kelly noted how the "students [were] making arguments for why it was the way they thought." Zack identified critical thinking as a reason for selecting SMP 3. The group did not provide specific evidence from the lesson to support their selection of SMP 3.

For SMP 6, all members noticed the use of clear definitions, however; Zack supported his decision by mentioning how:

> Students were speaking about clear definitions in regards to the structure of the equations or inequalities [and that] they had to know whether or not it was an expressions, equation, or inequality, they stated the meaning of those symbols as well.

When selecting SMP 7, Zack referred to how the students were looking for different ways to identify expressions, equations, and inequalities by noting that students were able to think "not only in their own thinking but also in their cooperative groups and in comparison with the other groups." Kelly selected SMP 7 as the students were "looking for different patterns within the equations they were looking at to determine what groups they go in and how."

In addition to the previous SMP, each member also identified other practices as the focus for Mr. Disston's lesson. Lisa selected SMP 5; use appropriate tools strategically, which was not selected by any other participant from either group, from a pedagogical perspective. As a group, the students in this lesson were sorting cards on the blackboard that included an equation, expression, or inequality. Lisa viewed this activity as a tool, indicating that the class "had a very good use of the sort even though it's not technology" and by "making the activity tactile students will remember just by moving." Here, she identified with the students saying "I would remember the movement by using the sort if I was a student." Kelly selected SMP 4, model with mathematics, because the "teacher brought in other terms from previous lessons like different properties, expressions what not" which demonstrated how "students were building off previous knowledge from what was being demonstrated in the previous lesson." Zack also selected SMP 8 regarding how the teacher "was urging [the students] to evaluate the reasonableness of their results" and how "he continued to ask why and never offered any explanation of why regardless if the student was right or wrong he just continued to probe their reasoning."

Each member in the Modest MIU group used the SMPs Identification Tool to scaffold their thinking with attention to the students and teacher. In retrospect, the group noticed more of the mathematical content as compared to their behaviors during the think aloud protocol. Although the participants used more mathematical language when selecting the SMPs compared to their think aloud protocol, it is important to understand that the terminology was still general without sufficient support. This was comparable to their behaviors as a group during the think aloud protocol.

Expanding MIU Group

Collectively, SMPs 3, 6, and 7 were selected as the focus for Mr. Disston's Algebra lesson. Jessie combined SMPs 6 and 7 when verbalizing her thoughts and stated that the "intention was mathematical vocabulary. . . a lot intentional use of the language by asking students go up and place their solution to justify their answers puts it into patterns and structures." This was in reference to the students using cards with examples to categorize them as an expression, equation or inequality. There were no additional statements to support her rationale for selecting SMPs 6 and 7. Slater also identified SMPs 6 and 7 as a focus but mentioned that these practices were selected based on the mathematical content of the lesson. He had stated that he "would like to say that it [SMP 6] was an attempt but don't think we got there. . . don't know how clear it was. . . think it was an intent . . . stating the meaning and emphasizing symbols . . . but not a positive outcome for all the students." For SMP 7, Slater simply said "trying to group them" referencing how the students were looking for patterns when identifying expressions, equations, and inequalities. For SMP 3, both members of this group had similar thoughts. Jessie observed how the teacher was "helping students to justify their answers by asking why and show me", and Slater stated how the students "defended every decision made" and how the teacher "allowed other student to refute." Slater added how SMP 3 was "based on the pedagogy of the teacher", which is also why he selected SMP 1 as "a pedagogical focus for this lesson."

Both members noticed how the teacher and students used the mathematics when identifying the Standards for Mathematical Practice. By making inferences about the content that extended beyond what occurred in the lesson, and drawing upon their previous experiences as mathematics teachers and current roles as administrators, the group members were able to use the SMPs Identification Tool to provide additional support to what they noticed in the videos. This was comparable to their behaviors as a group during the think aloud protocol.

Attending to Mathematical Thinking

Throughout the SMP selection process of Mr. Disston's lesson, Samuel was more analytical when identifying SMPs 2, 3, and 6 by providing detailed explanations. Samuel referenced the videos holistically and stated that SMP 2 was evident through the process of "assigning rules to different things that mathematics do or concepts with in mathematics" where the teacher was "trying to connect the academic language to the vocabulary without telling them directly." He provided evidence by referencing the student who found the one equation that had only one variable and one operation sign. Samuel stated that the "teacher had to guide their thinking by focusing on the equal sign" instead of the operations and "trying to [make] the connection of the broader idea of the mathematics." In the video where Mr. Disston asked what would happen if the students only focused on the addition sign when grouping their cards, Samuel noted this as an example of SMP 3, stating that the students were engaged in "cooperative learning by agreeing and disagree then stating their reason." He called this process discovery learning.

Continuing with the notion of discovery learning, Samuel selected SMP 6 based on his overall analysis of the lesson. He believed that precision of definitions was the goal of the teacher but it took the entire length of the video clip to make that connection. Samuel suggested that the "teacher knew the students, and they were ready for the discovery lesson by using the formative assessment on the spot," allowing them to "recognize that there is a precise name for things to build up to future studies in mathematics." Once again, Samuel connected SMP 6; attend to precision, to physics by mentioning the famous physicist, Richard Feynman, and the law of inertia. Paraphrasing Samuel's story, he said that many people know the term, law of inertia, but cannot explain what it really means. Samuel mentioned the importance of knowing the difference between simply knowing the name for a concept and what it actually means. Minimal attention was given to SMP 8 by briefly mentioning the description on the SMPs Identification Tool where the teacher evaluated the reasonableness of the students' results through discovery learning.

Though Samuel's statements during his selection of the SMPs appeared to be general, they were in reference to the larger context of how students should be thinking about mathematics. Samuel used mathematical terms and examples from both videos to support his decisions, and he used more of his classroom experience and understanding of teaching and learning to select a majority of the practices he thought were the focus of the classroom video lesson. This was consistent with his behaviors during the think aloud protocol. Although Samuel was the most familiar with the Standards for Mathematical Practice, he did rely on the SMPs Identification Tool to confirm his decisions about the practices he selected.

Table 8 provides a presentation of the combined Standards for Mathematical Practice. The table contains each of the standards linked to each of the participants for video 2.

Table 8

Combined Standards for Mathematical Practice (SMP Selection of Video 2: Mr. Disston

Participant	SMP1	SMP2	SMP3	SMP4	SMP5	SMP6	SMP7	SMP8
Kelly	X		X	X		X	X	
Zack	X	X	X			X	X	X
Jessie			X			X	X	
Lisa			X		X	X		
Slater	X		X			X	X	
Samuel		X	X			X		

Summary of Findings: Research Question 2

Research Question 2 asked: "How does what the administrators noticed in the instructional environment relate to their ability to identify students engaging in appropriate Standards for Mathematical Practice?" This analysis demonstrated that the mathematical language of the participants and attention to how students interacted with the content increased when the participants were presented with the SMPs Identification during the SMPs follow-up interview. From the think aloud protocol, each administrator noticed aspects of instructional leadership, student thinking and engagement, teacher instructional practices, and mathematical content. The administrators were able to use what they noticed as a reference when selecting the Standards for Mathematical Practice they thought were the focus of each lesson. As a whole and across both videos, the administrators selected SMPs, 3, 6, and 7 with a little attention to SMPs 1 and 2. The administrators were able to identify these practices based on what they noticed in each classroom video and using the SMPs Identification Tool as a guide. For SMP 3, they noticed how the students were engaged in discourse by asking each other questions, stating whether or not they agreed with each other, and noticed how the teachers were creating a safe environment to allow such interactions to occur. These were evident in the student actions in the SMPs Identification Tool. Attention was given to the use of academic vocabulary and how the teachers prompted the students to clarify their meanings. The administrators identified these student and teacher actions on the SMPs Identification Tool which aided in the selection of SMP 6. Although administrators noticed how the teachers used open-ended questioning and allowed the students to explore patterns based on the properties, a majority of the administrators selected SMP 7 for video 1 based on an example, e.g., 76 = (7 x 10) + 6, within the SMPs Identification form. The lesson in the classroom video included different ways to say 3x – 3, and the administrators used that example to aid in their selection of SMP 7.

To emphasize the increase in attention to the teacher and students' interaction and mathematical language, a frequency chart was created to note the difference between what the administrators noticed during the think alouds and after they were give the SMPs Identification Tool during the SMPs follow-up interview across both classroom videos. There was a decrease in the use of mathematical language and attention to the student's interaction with the content for Jessie and Slater, as they noticed more mathematics during the think alouds.

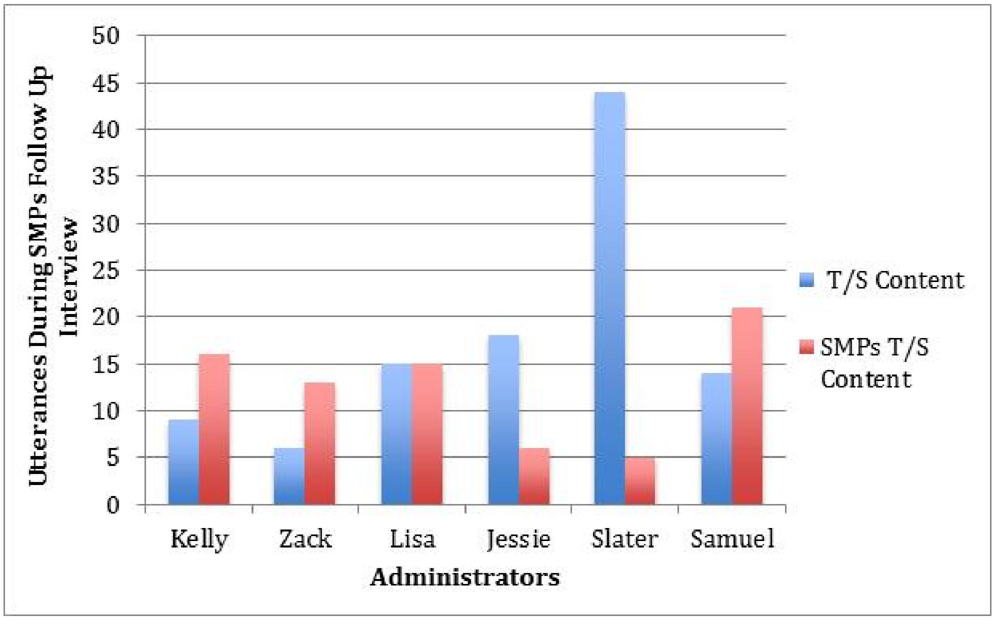

Figure 2. Difference Between Think Aloud Protocol and SMP Identification Tool

Summary

In this chapter, the purpose and summary of methods used in this research study were restated. A description of the sample and a brief description of the administrators' profiles were presented along with a description of the views of mathematics-in-use categories. Next, brief descriptions of the classroom videos and the identified Standards for Mathematical Practice for each video were provided. Finally, each research question was answered, and the findings for each of the questions were presented with supporting data. The analysis of administrators' interpretations of mathematics instruction generated key findings that included differences in what they noticed about students, teachers, mathematics content, and instructional leadership. These findings were related to the administrators' teaching experiences and what they noticed during the classroom videos. These findings also demonstrated that the mathematical language of the participants and attention to how students interacted with the content increased when the participants were presented with the SMPs Identification Tool during the SMPs follow-up interview. In the following chapter, the findings are discussed with the practical implications, study limitations, and suggestions for future research.

CHAPTER 5
DISCUSSION

Purpose and Overview of Methodology

The purpose of this study was to understand what administrators attend to during instruction and how what they notice influences their ability to identify the Common Core State Standards, Standards for Mathematical Practice. This study represents an examination of the theory of leadership content knowledge (Stein & Nelson, 2003), the concept of noticing (Nelson & Sassi 2000a), and the concept of knowledge of content and students (Ball et al., 2005, 2008; Hill et al., 2008) of administrators related to mathematics instruction. The primary research methods for this study were qualitative though quantitative data were used. The qualitative data were collected using a think aloud protocol (Ericsson & Simon, 1993) of two mathematics classrooms videos (Inside Mathematics, 2014), and the Standards for Mathematical Practice follow-up interview using the SMPs Identification Tool (ASCD, 2012; Fennell, 2011; NGA & CCSSO, 2010). The quantitative data were collected through the Leadership Profile Survey (LPS) adapted from the TMI Survey and the Florida Department of Education leadership standards (EDC, 2006; FDOE, 2013, 2015). Both methods aided in the sample selection, categorization of administrators, and analysis of data across the sample (Creswell, 2007). Individual case study techniques (Creswell, 2007; Stake, 1995) were used to conduct the preliminary analysis of six administrators followed by a categorization based upon their view of mathematics-in-use (MIU) using the TMI survey coding scheme (EDC, 2006). The groups consisted of three members in the Expanding MIU group, two members in the Modest MIU group, and one member in the Attending to Mathematical Thinking MIU group.

Summary and Discussion of Key Findings

Noticing in Classroom Videos

The analysis of Research Question 1 yielded key findings related to aspects of the administrators' leadership profile and what the administrators noticed during the think aloud protocol of two classroom videos. The administrators noticed aspects of the classroom instruction related to their views of mathematics-in-use, self-reported knowledge level of instructional leadership, and their teaching experiences. The views of mathematics-in-use categories (Modest MIU, Expanding MIU, and Attending to Mathematical Thinking) were important to this study, as they provided a way to interpret and describe what the administrators noticed about the instructional environment. This related to the level of attention that was given to teachers, students, and mathematics content.

The amount of attention given to the mathematics content and how the teachers and students interacted with the content aligned to the administrator's teaching experiences. The three administrators with mathematics teaching experience or experience teaching a subject related to mathematics, e.g., physics, noticed more about the content and were able to understand the overall goals of the lessons. Information regarding the administrators' self-reported knowledge level of instructional leadership aligned to the quantity of evaluative language used by the administrators during the think aloud protocol.

Ability to Identify the Standards for Mathematical Practice

The analysis of Research Question 2 yielded key findings related to the administrators' identification of the Standards for Mathematical Practice within two classroom videos. Using the SMPs Identification Tool, each administrator was able to identify multiple SMPs that were presented in the lessons. They also selected practices that were not present in the lessons. Across the sample, Standards for Mathematical Practice 3, 6, and 7 were identified. The administrators selected the SMPs based on their interpretation of the teacher and student actions within the form and what they noticed in the classroom videos. For example, one administrator identified SMP 5 (use appropriate tools strategically) based on the sorting activity used in the Algebra lesson. Although the students used cards with examples of expressions, equations, and inequalities, the teacher provided the cards and the students did not have a choice in other models to aid in their understanding of properties. The administrators also identified SMPs based on their understanding of mathematics. The administrators who understood the mathematics within the classroom videos were able to provide evidence beyond restating what occurred in the lessons.

Although the administrators selected SMP 3 (construct viable arguments and critique the reasoning of others), only the administrators with a deeper understand of mathematics teaching and learning were able to note the difference between general student conversations and when the students were asking clarifying questions about definitions and rules to defend their answers. The administrators also identified SMP 6 (attend to precision) across the classroom videos. The administrators in the Modest MIU group, Kelly, Zack, and Lisa, were able to identify SMP 6 by noticing teacher questioning and use of academic vocabulary and definitions within the lessons. They did not provide additional support for identifying this practice. Jessie, Slater, and Samuel, administrators in the Expanding MIU and Attending to Mathematical Thinking groups, were hesitant about identifying SMP 6 as a focus for either lesson. Although they noticed the use of academic vocabulary and definitions, they did not consider this a strong reason to select SMP 6 as a focus of the lesson. They identified SMP 6 based on the student actions, e.g., clear definitions, within the SMPs Identification Tool.

Although SMP 7 (look for and make use of structure), was identified across the sample, each administrator provided different rationales to support their decision. It was difficult to determine if the administrators were able to identify SMP 7 solely based on the SMPs Identification Tool or if the administrators with mathematics teaching experience were able to interpret the student and teacher actions based on what they noticed in the classroom videos. Jessie and Slater, administrators with the Expanding MIU group, were able to provide evidence from the classroom video such as identifying what was considered pattern within the lesson and the different ways students were thinking about the relationships between the equations and properties. They were also able to provide evidence from the teacher actions, such as noticing the open-ended questions the teachers asked about the patterns in addition to the multiple ways of representing 3x – 3. Kelly, Zack, and Lisa, administrators in the Modest MIU group, identified SMP 7 by noticing the different ways to represent three times *x* from the function lesson and by describing the Algebra activity of making connections between equations, inequalities, and expressions as patterns.

Corroborations and Contradictions with Earlier Research

The findings of what the administrators noticed during classroom instruction as it related to general pedagogy of the teachers' instruction and student behavior confirmed several issues already identified in the literature that suggest that administrators noticed pedagogical practices of the teacher during instruction. The administrators in this study noticed teacher questioning, how the teacher called on the same students, and how the teacher was were requiring students to explain their answers. They also noticed the student behaviors such as raising hands, and some interaction between the students and content. These findings are similar to those of a few other researchers (DiPaola & Hoy, 2008; Ing, 2009; Johnson et al., 2011; Nelson, 1998; Schoen, 2010) who examined the role of administrators during classroom observations and the observations of mathematics instruction. An example of examining what administrators noticed during mathematics instruction was provided by Nelson and Sassi (2000b). These researchers found that the initial focus during classroom observations of their 24 participants was on general pedagogical practices. By the end of a yearlong professional development involving classroom videos, the administrators attended to how mathematics was learned, the nature of student engagement, and aspects of mathematical knowledge. The participants in this study were able to view a classroom video two separate times, once at the beginning and then at the end, of the study. During the first viewing, the administrators noticed what they thought was important during instruction such as wait time, number of student responses, and the teachers' ability to gage student understanding. Nelson and Sassi (2000b) confirmed the importance of these aspects of teaching and learning but emphasized that this was not sufficient. By the conclusion of the study, a few participants began noticing how students were provided with the opportunity to think and talk about mathematical ideas.

Schoen (2010) conducted a study with 73 elementary principals to test their content knowledge using the Mathematics Knowledge for Teaching instrument (Hill & Ball, 2004; Hill et al., 2004) in addition to what they noticed as they watched classroom videos through follow-up questions. Schoen found that there was no correlation between the content knowledge of elementary principals and their experience in observing classroom instruction. Schoen did, however, confirm that the elementary principals in his study noticed general pedagogical processes of the teacher, referenced student engagement, and rarely provided evidence of attending to mathematical ideas during instruction. Schoen's study is important as it relates to what administrators notice in the instructional environment. However, the administrators in this study did attend to mathematical ideas during instruction.

Unlike the studies of Nelson and Sassi (2000b) and Schoen (2010), the administrators in this study were able to notice how students and teachers interacted with the content without being able to watch classroom videos multiple times or have the opportunity to reflect on what they saw. This finding might suggest that different research methods should be used to explore what administrators attend to in real time. The research methods used in this study allowed me to examine the role of administrators' views of mathematics-in-use in relation to the Standards for Mathematical Practice, adding to the literature of instructional leadership and mathematics education. Schoen (2010) and Nelson (2010) used mathematics content knowledge to measure what administrators would notice during classroom instruction. Although the administrators in this study took additional mathematics courses at either the undergraduate or graduate level, suggesting some level of content knowledge, only the administrators who previously taught mathematics above the elementary level or subjects that integrated mathematical ideas (such as physics) were able to attend to the mathematical thinking of the students as they watched the classroom videos. These administrators also noticed nuances of teaching that might be attributed to student learning.

Other researchers have found that beliefs and perceptions of administrators concerning mathematics instruction determine what they attend to during classroom observations (Nelson & Sassi, 2000a, 2000b; Schoen 2010; Stein & Nelson, 2003) through the use of Likert scale surveys, interview questions, or assessments. However, the data from this study suggest that reflections from classroom scenarios in which administrators are asked to identify the mathematical ideas of a lesson and state what students should be learning with supporting evidence, corresponds to what they notice when watching a mathematics classroom video clip. The think aloud protocol provided a window into the cognitive frames (Stuart-Olsen, 2010) of administrators as they made in-the-moment decisions about what to attend to in the instructional environment of a mathematics classroom.

The key finding from the identification of the Standards for Mathematical Practice relates to the educational leadership literature which has been focused on administrators' roles as instructional leaders and how they use the data gathered from classroom observations to make decisions about teacher effectiveness and student achievement (DiPaola & Hoy, 2008; Downey et al., 2004; Good & Dweck, 2006; Glickman et al., 2004; Ing, 2009). One method of collecting data from classroom observations is through the use of protocols, rubrics, or checklists with predetermined "look-fors" describing teacher questioning techniques, teacher moves, and the classroom environment which also includes ensuring that equity is present during instruction (Danielson, 2013a; Gewrtz, 2005; Marzano, 2012; NCTM, 2014). The administrators in this study were familiar with similar observational tools. Unlike these tools, which involved general pedagogical practices and characteristics of student behaviors, the tool used by the administrators in this study included content-specific actions of both teachers and students that aligned to the Standards for Mathematical Practice. Although the language of the administrators when describing what they noticed during the think aloud protocol pertained to the characteristics of the SMPs, the data suggested that there was an increase in mathematical language and attention to how students interacted with the content when presented with the SMPs Identification Tool. This is similar to what Cobb et al. (2003) described as boundary objects or tools, i.e. pacing guides, rubrics, etc. Though these tools may have different meanings in different communities of practice, i.e., teachers and administrators, they can be used to bridge the gap between different point of views and context. The data suggest that the use of the SMPs Identification Tool did not change the focus of what the administrators noticed in the classroom videos, but it served as a tool to give reason for the decisions they made regarding which SMPs were the focus of each lesson (Cobb et al., 2003).

Implications

This study has important implications for educators who teach or conduct professional development for administrators. It is important to understand that administrators might have general ideas of what student engagement in a mathematics class might look like. Therefore, an assessment of how administrators view mathematics-in-use may be needed to interpret their level of understanding about mathematical thinking of students. This research suggests that the roles of the administrators as instructional leaders are most beneficial when they have an understanding of mathematics teaching and learning along with knowledge of content and students.

Although the administrators in this study may not have identified every correct SMP for each classroom video, or perhaps they interpreted the meaning of a practice incorrectly, they were able to use occurrences within the videos to support their decisions. This may lead to either of two implications: (a) administrators notice how students are thinking and interacting with the mathematics during instruction but attempt to separate the content based on what they may have learned to be best instructional practices when making decisions about teacher effectiveness, or (b) regardless of subject matter teaching experience, when administrators are provided with a tool similar to the SMPs Identification Tool, their understanding of standards-based instruction and instructional leadership may allow them to make inferences about the SMPs as they relate to content and student achievement. This could not be determined based on the sample size of the study.

The use of general observation protocols such as the Marzano Teacher Evaluation Model (Marzano, 2012) or the Danielson Framework (Danielson Group, 2013) might cause the administrator to over notice what occurs during instruction instead of focusing on specific aspects of instruction geared towards the student's understanding of the content. Nonetheless, administrators require training that will provide them with the skills to look beyond surface level best practices and focus on how teachers are ensuring that their students are meeting the rigor of the content standards through the use of the Standards for Mathematical Practice. Such trainings may involve similar practices related to think aloud type protocols or reflections about classroom scenarios where the administrator's responses could be used to develop differentiated mathematics-in-use instruction. The data suggest that it is important to understand administrators' views of mathematics-in-use and what they initially attend to during classroom observations.

Limitations of Study

With the interesting findings from the study, it is important not to overlook the limitations of this research. First, the study involved analytic generalization (Schwandt, 2007; Yin, 2010). I attempted to link the findings of focusing on the cognitive process of administrators during the think aloud protocol to the theories of leadership content knowledge and the concepts of noticing and knowledge of content and students as it pertained to the Standards for Mathematical Practice. These results could not be statistically generalized to the broader population of administrators. Second, due to the limited empirical research on the Standards for Mathematical Practice, there was not a wide range of classroom videos that included segments or full lessons of actual mathematics teachers teaching unscripted lessons. With the use of classroom videos in the current study, there was always an underlying notion from the administrators that the students and teachers were behaving differently due to the presence of cameras in the classrooms. Third, the Leadership Profile Survey involved a self-assessment of the participants' instructional leadership knowledge and their reflections to classroom scenarios which might illustrate that these self-assessments were not valid. Hence, the measure of the LPS presented another limitation to the study. Next, the use of a think aloud protocol provided raw data and access to the administrators' thinking while the participants were watching the classroom videos, but it was difficult to generalize how the administrators would perform when watching different levels of mathematics instruction. Subsequently, among the administrators who participated in the study, there was not sufficient differentiation between the sample regarding years of mathematics teaching experience, range in administrative experiences, or levels of administration such as current assistant principals, principals, superintendents, at the time of the study. However, a few of the participants had previously served in those roles. Finally, the categorization of the small sample size produced an unequal number of administrators in each group, limiting the data regarding the different views of mathematics-in-use.

Recommendations for Future Research

Future research is needed in various areas. An examination of what administrators attend to in the instructional environment of a high school mathematics course as it pertains to the content and the Standards for Mathematical Practice might produce interesting key findings. Given the various mathematics courses offered in a high school, it may be worth conducting the think aloud protocol within each area and examining how administrators identify the SMPs.

Next, it would be interesting to conduct think aloud protocols of mathematics classrooms via Skype or FaceTime. The use of technology and virtual observations might provide insight into how administrators are thinking and what they are noticing in real time.

In addition to real-time classrooms, it might be beneficial for the administrator to focus on a specific SMP, either identified by the teacher during a preconference session or by the researcher. By focusing on one SMP, it might allow for a deeper examination of what administrators notice in regards to the mathematical proficiency of students. An adaptation of the Leadership Profile Survey with additional grade level classroom scenarios might provide further insight into the administrator's views of mathematics-in-use.

A larger, more diverse sample size might also contribute to this insight. At the conclusion of the think aloud protocol and SMPs follow-up interview, a focus group of the participants might provide additional data or suggestions for the research study. It might be interesting to obtain their collective thoughts about the process and identify a need for future research. Finally, addressing the previously mentioned recommendations for future research with aspiring administrators would contribute to the literature in both mathematics education and educational leadership.

APPENDIX A
PROTOCOL INSTRUCTIONS

THINK ALOUD PROTOCOL INSTRUCTIONS

Hi thank you for coming in.

In this study, I am interested in what you are thinking as you watch and listen to classroom videos about mathematics with attention to student engagement and teacher instruction. In order to do this, I am going to ask you to THINK ALOUD as you watch the videos. What I mean by Think Aloud is that I want you to say everything that you are thinking from the beginning of the video until the end of the video. The videos will be approximately 3 to 8 minutes long. In this process, you are asked to say out loud whatever you are thinking from the beginning of the videos until the end of the videos. I do not want you to feel as if you have to plan what you are going to say or that you have to explain what you have said. Act as if I am not in the room and you are here speaking out loud and viewing the videos by yourself.

Do you have any questions about what I have asked you to do?

[Sample Video]

Let us begin by viewing a sample video clip of a think aloud. Pay attention to the participant as she verbalizes her thoughts while watching the video. Notice that she is not explaining her thoughts or planning what she is about to say. The participant is acting as if she is alone in the room.

Now I want to hear how much you can remember about what you were just thinking from the time you viewed the video clip until the video ended. I am interested in what you can actually REMEMBER rather than what you think you must have thought. If possible, I would like you to tell me about your memories in the sequence as they happened while you were viewing the video clip. Please tell me if you are uncertain about any of your memories. I do not want you to explain, just report all you can remember thinking about when viewing the video clip. Now, tell me what you remember.

You are going to place the headphones on your head and press play for the first video. Once you have completed saying your thoughts out loud, you are going to press play for the second video.

[After both videos]

Thank you. Now, what I would like for you to do is select which practice or practices you thought was the focus of the lesson in VIDEO 2 and tell me why?

Thank you. Now, what I would like for you to do is select which practice or practices you thought was the focus of the lesson in VIDEO 2 and tell me why?

Now we are ready to move on to the videos for the study. During each video, you will continue to use the same protocol as you did for your two sample videos. Pay attention to the students' interactions with each other, the teacher, and any material from the lesson. Tell me everything that you are thinking from the moment you begin viewing the video. As you think aloud, please free to write any notes. When you finish with one video, I may ask you to remember what you were thinking while viewing the video. If I am not going to ask you this, I will simply ask you to view the second video. Remember to think aloud as you view the video. Tell me everything that you are thinking and doing from the moment you first begin viewing the video. Thank you.

APPENDIX B
LEADERSHIP PROFILE SURVEY

Leadership Profile Survey

Q1 Please select your gender.
- ❍ Male (1)
- ❍ Female (2)
- ❍ Prefer not to answer (3)

Q2 Please select the degree(s) you have earned and enter the major.
- ❑ Bachelors (1) ____________________
- ❑ Master's (2) ____________________
- ❑ Specialist (3) ____________________
- ❑ Doctorate (4) ____________________
- ❑ Other (Specify below) (5) ____________________

Q3 Please select all Florida Certifications that you have.
- ❑ Florida Level 1 Educational Leadership (1)
- ❑ Florida Level 2 Educational Leadership (2)
- ❑ Other (Specify below) (3) ____________________
- ❑ Not Applicable (4)

Q4 Have you ever been a classroom teacher?
- ❍ Yes (1)
- ❍ No (2)

Q5 If yes, how many years have you been or were you a classroom teacher?
- ❍ Less than 3 years (1)
- ❍ 3 to 9 years (2)
- ❍ 10 to 20 years (3)
- ❍ Over 20 years (4)
- ❍ Not Applicable (5)

Q6 If you were a classroom teacher, what content area(s) did or do you teach? Select all that apply.

- ❑ Elementary School (1)
- ❑ Middle School (2)
- ❑ High School (3)
- ❑ Mathematics (4)
- ❑ English/Language Arts (5)
- ❑ Reading (6)
- ❑ Science (7)
- ❑ Social Studies (8)
- ❑ Foreign Language (9)
- ❑ Electives (10)
- ❑ Other (11)
- ❑ Not Applicable (12)

Q7 Have you ever been a school administrator?

- ❑ Yes (1)
- ❑ No (2)

Q8 If you were a school administrator please indicate the number of years in each position.

	Less than 2 Years (1)	2 Years (2)	3 Years (3)	4 - 9 Years (4)	10 or More Years (5)	Not Applicable (6)
Dean (1)	❍	❍	❍	❍	❍	❍
Assistant Principal (2)	❍	❍	❍	❍	❍	❍
Principal (3)	❍	❍	❍	❍	❍	❍
Other (Specify below) (4)	❍	❍	❍	❍	❍	❍
Not Applicable (5)	❍	❍	❍	❍	❍	❍

Q9 Have you ever been a school district level administrator?
- ❍ Yes (1)
- ❍ No (2)

Q10 If yes, then how many years were you or have been a school district level administrator?
- ❍ Less than 2 Years (1)
- ❍ 2 Years (2)
- ❍ 3 Years (3)
- ❍ 4 to 9 Years (4)
- ❍ 10 or More Years (5)
- ❍ Not Applicable (6)

Q11 What grade level(s) have you observed? Select all that apply.
- ❑ K-2 (1)
- ❑ 3-5 (2)
- ❑ 6-8 (3)
- ❑ 9-12 (4)
- ❑ Not Applicable (5)

Q12 What content area(s) have you observed? Select all that apply.
- ❑ Mathematics (1)
- ❑ English/Language Arts (2)
- ❑ Reading (3)
- ❑ Science (4)
- ❑ Social Studies (5)
- ❑ Foreign Language (6)
- ❑ Electives (7)
- ❑ Other (8)
- ❑ Not Applicable (9)

Q13 What professional learning related to mathematics instruction have you attended from July 1, 2013 through April 30, 2015? Please include professional learning titles related to mathematics instructional standards. Enter N/A if you have not completed any professional learning during this time.

Q14 How many years of mathematics coursework did you complete while in high school? Select the best one that represents your experience.
- ❍ 1 Year or Less (1)
- ❍ 2 Years (2)
- ❍ 3 Years (3)
- ❍ 4 Years or More (4)
- ❍ Cannot Remember (5)

Q15 Which of the following courses did you complete in high school? Select all that apply.
- ❑ Algebra I (1)
- ❑ Algebra II (2)
- ❑ Geometry (3)
- ❑ Trigonometry (4)
- ❑ Calculus (5)
- ❑ Statistics and Probability (6)
- ❑ Applied Mathematics (7)
- ❑ Other (Specify below) (8) ____________________
- ❑ Not Applicable (9)

Q16 Which of the following courses did you complete as a college or university undergraduate or graduate student? Select all that apply.
- ❑ College Algebra (1)
- ❑ Geometry (2)
- ❑ Linear Algebra (3)
- ❑ Pre-Calculus (4)
- ❑ Calculus (5)
- ❑ Statistics (6)
- ❑ Probability (7)
- ❑ Mathematics teaching methods (8)
- ❑ Mathematics for elementary teachers (9)
- ❑ Mathematics for secondary teachers (10)
- ❑ Other (Specify below) (11) ____________________
- ❑ Not Applicable (12)

Q17 How would you rate your comfort with mathematics in the following areas? Select one response for each question.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
Overall comfort with mathematics (1)	❍	❍	❍	❍	❍
Comfort with elementary mathematics (2)	❍	❍	❍	❍	❍
Comfort with middle-grades mathematics (3)	❍	❍	❍	❍	❍

Q18 This section contains two subsections, each asking you about your thoughts regarding teaching and learning mathematics. The sub-sections include: A) A classroom reflection. B) Views about mathematics

Q19 Part 2 Section A. Classroom Reflection Instructions: Many people think the classroom is the best context for thinking about teaching and learning. Below is one classroom scenario with three of the teachers statements underlined. Please read the scenario all the way through. Then, reread each underlined statement and think about each statement in the context of the entire scenario. For each statement answer the questions in the corresponding box at the end of the scenario. (For example statement A, box A). In each box you will be asked: What was the teacher doing? Was it evidence based or not? Why? There are no right or wrong answers here - I am interested in learning your thoughts about what the teacher and the students are doing. Please explain your thinking as thoroughly as possible, so that I can understand your views.

Q20 Scenario. Ms. M., a fourth grade teacher, called on Joe, one of the 29 students in class. "Joe, what is problem 9?" "Five divided by thirty-nine," Joe replied.2.A.1. Ms. M. paused. "The problem in the book is 39 divided by 5, but let's think about 5 divided by 39 for a minute. What would the answer to the problem 5 divided by 39 look like?" All hands went up. Ms. M. called on Keesha. "Seven remainder four," Keesha replied confidently "If the problem is five divided by thirty-nine, is seven remainder four the answer?" Ms. M. asked the class. The students all said that it was. Ms. M. waited for a moment. T.C. spoke. "The number will be like - I say zero. You can't divide five with a thirty-nine 'cause it's a higher number. You can't divide a number that's lower by one that's higher."2.A.2. Ms. M. looked at the other students and asked, "Is it true that you can't divide a small number by a large number? "Yes, that's true," answered Al. "5 can't divide by 39. If you had 39 kids and 5 dollars, you can't do that in a fair way. You will give 1 dollar to 5 persons and the other people will be mad." Dan agreed. "He's right, because the answer will be something about zero 'cause there is no answer for a problem like that. "You cannot do 5 dived by 39", Jackie added, "because on a calculator it won't work out. It will come out to be a number in the minus. It will be...." Jackie's voice dropped, and she stopped. "Is there another situation you can think of?" asked Ms. M. "Well, 5 people and 39 desks," offered Dan. Cynthia spoke up. "What T.C. said is true. If there were 39 principals and I had 5 pieces of candy to give them, then only 5 principals could have a piece. The other 34 would be mad at me and I would lose my job."2.A.3. "What about a different problem," asked Ms. M., "what about 39 principals and 5 pizzas? Or 1 pizza and 4 kids?"

Q21 Each box below corresponds to one of the underlined statements in the scenario. Please comment on each statement taking into account the context of the entire scenario.

Q22 2.A.1. Ms. M. paused. "The problem in the book is 39 divided by 5, but let's think about 5 divided by 39 for a minute. What would the answer to the problem 5 divided by 39 look like?"2.A.1. "What was the teacher doing? Was it evidence based or not? Why?

Q23 2.A.2. Ms. M. looked at the other students and asked, "Is this true that you can't divide a small number by a large number?"2.A.2. "What was the teacher doing? Was it evidence based or not? Why?

Q24 2.A.3. "What about a different problem," asked Ms. M., "what about 39 principals and 5 pizzas? Or 1 pizza and 4 kids?"2.A.3. "What was the teacher doing? Was it evidence based or not? Why?

Q25 Please respond to the question below based on the scenario you have just read. 2.A.4. What were the mathematical ideas involved in this classroom scenario?

Q26 Please respond to the question below based on the scenario you have just read. 2.A.5. What can students learn in this class?

Q27 Part 2 - Section B1. Learning Mathematics How much do you agree or disagree with the following statements about learning mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
a. When students can solve problems, it is usually because they remember the right formula or rule. (1)	❍	❍	❍	❍	❍	❍	❍
b. If elementary and middle school students use calculators, they won't learn the mathematics they need to know. (2)	❍	❍	❍	❍	❍	❍	❍
c. One can learn a lot by watching an expert mathematician "think aloud" while solving problems. (3)	❍	❍	❍	❍	❍	❍	❍

Q28 Part 2 - Section B1. Learning Mathematics Continued... How much do you agree or disagree with the following statements about learning mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (8)	4 (9)	5 (10)	6 (11)	7 (12)
d. If students get into disagreements about ideas or procedures in math class, it can impede their learning of mathematics. (1)	❍	❍	❍	❍	❍	❍	❍
e. In learning mathematics, students must master topics and skills at one level before going on. (2)	❍	❍	❍	❍	❍	❍	❍
f. For students to understand K-8 mathematics they only need to know the correct procedures and when to apply them. (3)	❍	❍	❍	❍	❍	❍	❍

Q29 Part 2 - Section B1. Learning Mathematics Continued... How much do you agree or disagree with the following statements about learning mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
g. A teacher should wait until pupils are developmentally ready before introducing new ideas and skills. (1)	❍	❍	❍	❍	❍	❍	❍
h. It is important for pupils to master the basic computational skills before studying topics like probability and logic. (2)	❍	❍	❍	❍	❍	❍	❍
i. If teachers target their lessons to individual students' learning styles, student learning in mathematics will improve. (3)	❍	❍	❍	❍	❍	❍	❍

Q30 Part 2 - Section B1. Learning Mathematics Continued... How much do you agree or disagree with the following statements about learning mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
j. Mathematics is a subject in which effort matters a lot more than natural ability. (1)	❍	❍	❍	❍	❍	❍	❍
k. Since older students can reason abstractly, the use of models and other visual aids becomes less necessary for them. (2)	❍	❍	❍	❍	❍	❍	❍

Q31 Part 2 - Section B2. Strategies for Teaching Mathematics How much do you agree or disagree with the following statements about strategies for teaching mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
a. Students should not leave mathematics class (or end the mathematics period) feeling confused or stuck. (1)	❍	❍	❍	❍	❍	❍	❍
b. If a student is confused in mathematics, the teacher should go over the material again more slowly. (2)	❍	❍	❍	❍	❍	❍	❍
c. Teachers should not necessarily answer students' questions but should let them puzzle things out themselves. (3)	❍	❍	❍	❍	❍	❍	❍

Q32 Part 2 - Section B2. Strategies for Teaching Mathematics Continued... How much do you agree or disagree with the following statements about strategies for teaching mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
d. Creating a classroom climate that promotes students' self-esteem will result in improved math learning. (1)	❍	❍	❍	❍	❍	❍	❍
e. Students should "show their work" when they solve math problems. (2)	❍	❍	❍	❍	❍	❍	❍
f. The most important issue is not whether the answer to any mathematics problem is correct, but whether students can explain their answers. (3)	❍	❍	❍	❍	❍	❍	❍

Q33 Part 2 - Section B2. Strategies for Teaching Mathematics Continued... How much do you agree or disagree with the following statements about strategies for teaching mathematics? (Mark one response on each line)

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
g. The range of ability in most classes makes whole group teaching in math virtually impossible. (1)	❍	❍	❍	❍	❍	❍	❍
h. It is not a good idea to have students work together in solving mathematics problems because the brighter students will do all the work. (2)	❍	❍	❍	❍	❍	❍	❍
i. It is as important for students to understand the concepts underlying algorithms as it is to know how to use them. (3)	❍	❍	❍	❍	❍	❍	❍

Q34 Part 2 - Section B2. Strategies for Teaching Mathematics Continued... How much do you agree or disagree with the following statements about strategies for teaching mathematics? (Mark one response on each line) Click to write the question text

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
j. If students are having difficulty in mathematics, a good approach is to give them more practice in the skills they lack. (1)	❍	❍	❍	❍	❍	❍	❍
k. Because every student is different, it's best to let them progress at their own individual pace in mathematics. (2)	❍	❍	❍	❍	❍	❍	❍
l. When teaching mathematics, an effective teacher uses different models to represent mathematical ideas. (3)	❍	❍	❍	❍	❍	❍	❍

Q35 Section 3. Instructional Leadership Please select the rating that best represents your level of knowledge.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
a. Relating content and instruction to the achievement of established standards by students. (1)	❍	❍	❍	❍	❍
b. Providing instructional leadership. (2)	❍	❍	❍	❍	❍
c. Being aware of research on instructional effectiveness and will use it as needed. (3)	❍	❍	❍	❍	❍

Q36 Section 3. Instructional Leadership Continued... Please select the rating that best represents your level of knowledge.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
d. Demonstrating knowledge of student performance evaluation. (1)	❍	❍	❍	❍	❍
e. Identifying skills necessary for the planning and implementation of improvements of student learning. (2)	❍	❍	❍	❍	❍
f. Working to relate state standards, the needs of the students, the community and the school's goals. (3)	❍	❍	❍	❍	❍

Q37 Section 3. Instructional Leadership Continued...Please select the rating that best represents your level of knowledge.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
g. Identifying teaching and learning needs among the staff and teachers. (1)	❍	❍	❍	❍	❍
h. Understanding and recognizing the benefits for students in active teaching and learning strategies. (2)	❍	❍	❍	❍	❍
i. Understanding and recognizing the benefits for students in standards-based instructional programs. (3)	❍	❍	❍	❍	❍

Q38 Since this is a two phase study I will need your name and email address to contact you if you are selected to continue.

APPENDIX C
CLASSROOM RATING VIDEO PANEL PROTOCOL

Greetings:

Thank you for taking the time to participate in my research study. Please read this document carefully.

On your own time, you will watch two videos of mathematics instruction from Inside Mathematics. I ask that you to observe the video from every angle of your experiences and background. I would like for you to focus on the teacher, student, classroom environment, and content.

I have provided a rating form for you to complete. This form contains “look fors” related to the Common Core State Standards for Mathematical Practice (SMP).

You will watch and complete a rating form for each video. I suggest that you familiarize yourself with the form prior to watching the videos.

You will rate each video based on the sections provided. Space will be provided next to each cluster of student and teacher action items or “look fors” for additional comments.

The form includes a brief title of the Standard for Mathematical Practice along the top, followed by three to five student and teacher actions. As you watch the videos you will mark the action items associated with the related SMP.

It is important to note that each item does not have to be marked under student or teacher actions to show evidence of a particular SMP. For example, under SMP 1, you may see evidence of three student action items and one teacher action item. I consider this to be evidence of SMP 1. You may also find evidence of multiple practices in each video, which is a possibility.

When you make your decision about which SMP(s) were evident, please indicate the specific action items from the student and teacher columns that informed your decision. You may also include information that may not have been listed for either the student or teacher. Any additional comments are encouraged.

The rating form is a Word document if you decide to type your comments directly on the form. By the end of the rating process you should have two forms, one for each video. Please indicate the number of times you watched each video.

Once you have completed the rating form for each video and have inserted your comments, please send your documents to Vernita.Glenn-White@ucf.edu.

Thank you again for your time and willingness to participate.

~Vernita Glenn-White

APPENDIX D
STANDARDS FOR MATHEMATICAL PRACTICE RATER FORM

Classroom Video Rating Form

Teacher:	**Grade:**	**Topic:**
Standard for Mathematical Practice 1 Make sense of problems and persevere in solving them.		
<u>Student Actions</u> ☐Understands the meaning of the problem and looks for entry points to its solution ☐Analyzes information (givens, constrains, relationships, goals) ☐Monitors and evaluates the progress and changes course as necessary ☐Checks their answers to problems and ask, “Does this make sense?”	**<u>Teacher Actions</u>** ☐ Involve students in rich problem-based tasks that encourage them to persevere in order to reach a solution ☐ Provide opportunities for students to solve problems that have multiple solutions ☐Encourage students to represent their thinking while problem solving	**<u>Comments:</u>**
Standard for Mathematical Practice 2 Reason abstractly and quantitatively.		
<u>Student Actions</u> ☐Make sense of quantities and relationships in problem situations ☐Represent abstract situations symbolically and understand the meaning of quantities ☐Create a coherent representation of the problem at hand ☐Flexibly use properties of operations	**<u>Teacher Actions</u>** ☐Model context to symbol and symbol to context. ☐Create problems such as, “What word problem will this equation solve?” ☐Give real-world situations. ☐Offer authentic performance tasks. ☐Value invented strategies.	**<u>Comments:</u>**

Standard for Mathematical Practice 3 Construct viable arguments and critique the reasoning of others.

Student Actions	**Teacher Actions**	**Comments:**
☐Uses definitions and previously established causes/effects (results) in constructing arguments ☐Makes conjectures and attempts to prove or disprove through examples and counterexamples ☐Communicates and defends their mathematical reasoning using objects, drawings, diagrams, actions ☐Ask useful questions to clarify or improve the arguments	☐Create a safe and collaborative environment. ☐Provide find-the-error problems. ☐Provide and orchestrate opportunities for students to listen to the solution strategies of others, discuss alternative solutions, and defend their ideas ☐Ask higher-order questions which encourage students to defend their ideas	

Standard for Mathematical Practice 4 Model with mathematics.

Student Actions	**Teacher Actions**	**Comments:**
☐Apply prior knowledge to solve real world problems ☐Identify important quantities and map their relationships using su two-way tables, graphs, flowcharts, and/or formu las ☐Use assumptions and approximations to make a problem simpler ☐Check to see if an answer makes sense within the context of a when necessary	☐Provide meaningful, real-world, authentic, performance-based tasks. ☐Use mathematical models appropriate for the focus of the lesson ☐Remind students that a mathematical model used to represent a pr work in progress,' and may be revised as needed	

Standard for Mathematical Practice 5 Use appropriate tools strategically.		
<u>Student Actions</u> ☐ Make sound decisions about the use of specific tools (Examples might include: calculator, concrete models, digital technologies, pencil/paper, ruler, compass, protractor) ☐ Use technological tools to visualize the results of assumptions, explore consequences, and compare predications with data ☐ Identify relevant external math resources (digital content on a website) and use them to pose or solve problems ☐ Use technological tools to explore and deepen understanding of concepts	**<u>Teacher Actions</u>** ☐Use appropriate physical and/or digital tools to represent, explore and deepen student understanding ☐ Help students make sound decisions concerning the use of specific tools appropriate for the grade level and content focus of the lesson ☐ Provide access to materials, models, tools and/or technology-based resources that assist students in making conjectures necessary for solving problems	**<u>Comments:</u>**
Standard for Mathematical Practice 6 Attend to precision.		
<u>Student Actions</u> ☐ Communicate precisely using clear definitions ☐ State the meaning of symbols, carefully specifying units of measure, an accurate labels ☐ Calculate accurately and efficiently, expressing numerical answers ☐ Provide carefully formulated explanations ☐ Label accurately when measuring and graphing	**<u>Teacher Actions</u>** ☐ Ask probing questions. ☐Use English language arts strategies of decoding, comprehending, and text-to-self connections for interpreting symbolic and contextual math problems. ☐ Emphasize the importance of precise communication by encouraging students to focus on clarity of the definitions, notation, and vocabulary used to convey their reasoning ☐ Encourage accuracy and efficiency in computation and problem- based solutions,	**<u>Comments:</u>**

	expressing numerical answers, data/measurements with a degree of precision appropriate for the context of the problem	
Standard for Mathematical Practice 7 Look for and make use of structure.		
<u>Student Actions</u> ☐ Look for patterns or structure, recognizing that quantities can be represented in different ways ☐ Recognize the significance in concepts and models and use the patterns or structure for solving related problems ☐ View complicated quantities both as single objects or compositions of several objects and use operations to make sense of problems	**<u>Teacher Actions</u>** ☐ Let students explore and explain patterns. ☐ Use open-ended questioning. ☐ Ask for multiple interpretations of quantities. ☐ Engage students in discussions emphasizing relationships between particular topics within a content domain or across content domains ☐ Provide activities in which students demonstrate their flexibility in representing mathematics in a number of ways e. (7 x 10) + 6; discussing types of quadrilaterals, etc.	**<u>Comments:</u>**
Standard for Mathematical Practice 8 Look for and express regularity in repeated reasoning.		
<u>Student Actions</u> ☐ Evaluate the reasonableness of intermediate steps. ☐ Notice repeated calculations and look for general methods and shortcuts ☐ Continually evaluate the reasonableness of intermediate results (comparing estimates), while attending to details, and make generalizations based on findings	**<u>Teacher Actions</u>** ☐ Provide tasks that allow students to generalize. ☐ Don't teach steps or rules, but allow students to explore and generalize to discover and formalize. ☐ Ask deliberate questions. ☐ Draw attention to the prerequisite steps necessary to consider when solving a problem ☐ Urge students to continually evaluate the reasonableness of their results	**<u>Comments:</u>**

Source Adapted from Common Core State Standards for Mathematics: Standards for Mathematical Practice; ASCD Professional Development Institute 2012 & Elementary Mathematics Specialists & Teacher Leaders Project, 2012 (EMS&T)

APPENDIX E
STANDARDS OF MATHEMATICAL PRACTICE IDENTIFICATION TOOL

Common Core State Standards for Mathematics
Standards for Mathematical Practice

Classroom Video 1 – Mr. Dickinson 5th and 6th Grade Mathematics – Multiple Representations of Numeric Patterning

Which Standard(s) for Mathematical Practice were the focus of this lesson and tell me why?

1. Make sense of problems and persevere in solving them.	S. Understand the meaning of the problem and look for entry points to its solution S. Analyze information (givens, constrains, relationships, goals) • T. Encourage students to represent their thinking while problem solving
2. Reason abstractly and quantitatively.	• S. Represent abstract situations symbolically and understand the me • T. Provide opportunities for students to decontextualize (abstract a situation) and/or contextualize (identify referents for symbols involved) the mathematics they are learning
3. Construct viable arguments and critique the reasoning of others.	• S. Decide if the arguments of others make sense and ask probing questions to clarify or improve the arguments • T. Ask higher-order questions which encourage students to defend their ideas • T. Provide prompts that encourage students to think critically about the mathematics they are learning
4. Model with mathematics.	• S. Apply prior knowledge to solve real world problems • S. Check to see if an answer makes sense within the context of a situation and change a model when necessary • T. Remind students that a mathematical model used to represent a problem's solution is 'a work in progress,' and may be revised as needed
5. Use appropriate tools strategically.	• S. Make sound decisions about the use of specific tools (Examples might include: calculator, concrete models, digital technologies, pencil/paper, ruler, compass, protractor) • T. Provide access to materials, models, tools and/or technology- based resources that assist students in making conjectures necessary for solving problems
6. Attend to precision.	• S. Communicate precisely using clear definitions • S. State the meaning of symbols, carefully specifying units of measure, and providing

	accurate labels • T. Emphasize the importance of precise communication by encouraging students to focus on clarity of the definitions, notation, and vocabulary used to convey their reasoning
7. Look for and make use of structure.	• S. Look for patterns or structure, recognizing that quantities can be represented in different ways • T. Provide activities in which students demonstrate their flexibility in representing mathematics in a number of ways e.g., 76 quadrilaterals, etc.
8. Look for and express regularity in repeated reasoning.	• S. Notice repeated calculations and look for general methods and shortcuts • T. Draw attention to the prerequisite steps necessary to consider when solving a problem • T. Urge students to continually evaluate the reasonableness of their results

(over)

Additional Comments

Common Core State Standards for Mathematics
Standards for Mathematical Practice

Classroom Video 2 – Mr. Disston 7th Grade Mathematics – Algebraic Equations, Inequalities, & Properties

Which Standard(s) for Mathematical Practice were the focus of this lesson and tell me why?

1. Make sense of problems and persevere in solving them.	S. Understand the meaning of the problem and look for entry points to its solution S. Analyze information (givens, constrains, relationships, goals) • T. Encourage students to represent their thinking while problem solving
2. Reason abstractly and quantitatively.	• S. Represent abstract situations symbolically and understand the me • T. Provide opportunities for students to decontextualize (abstract a situation) and/or contextualize (identify referents for symbols involved) the mathematics they are learning
3. Construct viable arguments and critique the reasoning of others.	• S. Decide if the arguments of others make sense and ask probing qu improve the arguments • T. Ask higher-order questions which encourage students to defend their ideas • T. Provide prompts that encourage students to think critically about the mathematics they are learning
4. Model with mathematics.	• S. Apply prior knowledge to solve real world problems • S. Check to see if an answer makes sense within the context of a si model when necessary • T. Remind students that a mathematical model used to represent a problem's solution is 'a work in progress,' and may be revised as needed
5. Use appropriate tools strategically.	• S. Make sound decisions about the use of specific tools (Examples might include: calculator, concrete models, digital technologies, pencil/paper, ruler, compass, protractor) • T. Provide access to materials, models, tools and/or technology-based resources that assist students in making conjectures necessary for solving problems
6. Attend to precision.	• S. Communicate precisely using clear definitions • S. State the meaning of symbols, carefully specifying units of measure, and providing

	accurate labels • T. Emphasize the importance of precise communication by encouraging students to focus on clarity of the definitions, notation, and vocabulary used to convey their reasoning
7. Look for and make use of structure.	• S. Look for patterns or structure, recognizing that quantities can be represented in different ways • T. Provide activities in which students demonstrate their flexibility in representing mathematics in a number of ways i.e., 76 = (7 x 10) + 6; discussing types of quadrilaterals, etc.
8. Look for and express regularity in repeated reasoning.	• S. Notice repeated calculations and look for general methods and shortcuts • T. Draw attention to the prerequisite steps necessary to consider when solving a problem • T. Urge students to continually evaluate the reasonableness of their results

(over)

Additional Comments

APPENDIX F
UCF INSTITUTIONAL REVIEW BOARD APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Vernita Glenn-White**

Date: **April 22, 2015**

Dear Researcher:

On 04/22/2015, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Exempt Determination
Project Title:	An Examination of Administrators' Knowledge of the Standards for Mathematical Practice - A Think-Aloud
Investigator:	Vernita Glenn-White
IRB Number:	SBE-15-11263
Funding Agency:	
Grant Title:	
Research ID:	N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Joanne Muratori

Signature applied by Joanne Muratori on 04/22/2015 09:24:18 AM EDT

IRB manager

Page 1 of 1

APPENDIX G
UCF INSTITUTIONAL REVIEW BOARD APPROVAL--ADDENDUM

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Vernita Glenn-White**

Date: **April 28, 2015**

Dear Researcher:

On 04/28/2015, the IRB approved the following minor modification to human participant research that is exempt from regulation:

Type of Review: Exempt Determination
Modification Type: An additional method of recruitment is being added for phase one of the study. In addition to visiting Educational Leadership classes, the PI will e-mail or ask faculty members to e-mail the consent document and link to Qualtics survey to their students and invite them to take part in the research study.
Project Title: An Examination of Administrators' Knowledge of the Standards for Mathematical Practice - A Think-Aloud
Investigator: Vernita Glenn-White
IRB Number: SBE-15-11263
Funding Agency:
Grant Title:
Research ID: N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Joanne Muratori

Signature applied by Joanne Muratori on 04/28/2015 01:00:10 PM EDT

IRB manager

Page 1 of 1

APPENDIX H
EDUCATIONAL LEADERSHIP FACULTY COMMUNICATION

School of Teaching, Learning, and Leadership
Mathematics Education

Dear Educational Leadership Faculty,

I am Vernita Glenn-White, a doctoral candidate in Mathematics Education, and I am seeking your assistance for my dissertation research study.

In general, I am interested in exploring current and aspiring administrators' knowledge of the Common Core State Standards, Standards for Mathematical Practice.
If possible, I would like for you to email the attached consent form and survey link to the students in your class. The directions and information are listed on the form.

Qualtrics Link http://ucf.qualtrics.com//SE/?SID=SV_0jsAJm1DxF2cAux

I am available to answer any questions and discuss my study at your leisure.

Sincerely,

Vernita Glenn-White, M.S., Ed.S.

APPENDIX I
PARTICIPANT SURVEY CONSENT FORM

EXPLANATION OF RESEARCH

Title of Project: An Examination of Administrators' Knowledge of the Standards for Mathematical Practice – A Think-Aloud

Principal Investigator: Vernita Glenn-White

Other Investigators: N/A

Faculty Supervisor: Dr. Juli K. Dixon

You are being invited to take part in a research study. Whether you take part is up to you.

The purpose of the research study is to understand how administrators and aspiring administrators' leadership content knowledge (LCK) and noticing influences his or her vision of the students' role in mathematics instruction during classroom observations.

- You will be asked to participate in two parts of the study. The first part will include a questionnaire administered through Qualtrics. You will be categorized based on your leadership content knowledge profile, which are the results from the instructional leadership and Thinking About Mathematics Instruction (TMI) questionnaires. Demographic data will be collected with the questionnaires and information about your individual schools will be collected from a public source (i.e. school website) if applicable.

- The questionnaire will include questions about the your demographics, education, professional development, knowledge of the Instructional Leadership standards, teaching experiences, and mathematics coursework. The questionnaire will also require you to reflect on classroom scenarios and complete Likert Scales based on your comfort with mathematics and your views about mathematics teaching and learning.

- The questionnaire is expected to take about thirty minutes to complete.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, talk to Vernita Glenn-White, Doctoral Candidate, Mathematics Education Program, College of Education and Human Performance by email at Vglenn-white@knights.ucf.edu or Dr. Juli K. Dixon, Faculty Supervisor, College of Education and Human Performance by email at Juli.Dixon@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

APPENDIX J

PARTICIPANT THINK-ALOUD INTERVIEW CONSENT FORM

EXPLANATION OF RESEARCH

Title of Project: An Examination of Administrators' Knowledge of the Standards for Mathematical Practice – A Think-Aloud

Principal Investigator: Vernita Glenn-White

Other Investigators: N/A

Faculty Supervisor: Dr. Juli K. Dixon

You are being invited to take part in a research study. Whether you take part is up to you.

The purpose of the research study is to understand how administrators and aspiring administrators' leadership content knowledge (LCK) and noticing influences his or her vision of the students' role in mathematics instruction during classroom observations.

- You will be asked to participate in two parts of the study. The first part will include a questionnaire administered through Qualtrics. You will be categorized based on your leadership content knowledge profile, which are the results from the instructional leadership and Thinking About Mathematics Instruction (TMI) questionnaires. Demographic data will be collected with the questionnaires and information about your individual schools will be collected from a public source (i.e. school website) if applicable.

- The questionnaire will include questions about the your demographics, education, professional development, knowledge of the Instructional Leadership standards, teaching experiences, and mathematics coursework. The questionnaire will also require you to reflect on classroom scenarios and complete Likert Scales based on your comfort with mathematics and your views about mathematics teaching and learning.

- The questionnaire is expected to take about thirty minutes to complete.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints, or think the research has hurt you, talk to Vernita Glenn-White, Doctoral Candidate, Mathematics Education Program, College of Education and Human Performance by email at Vglenn-white@knights.ucf.edu or Dr. Juli K. Dixon, Faculty Supervisor, College of Education and Human Performance by email at Juli.Dixon@ucf.edu.

IRB contact about your rights in the study or to report a complaint: Research at the University of Central Florida involving human participants is carried out under the oversight of the Institutional Review Board (UCF IRB). This research has been reviewed and approved by the IRB. For information about the rights of people who take part in research, please contact: Institutional Review Board, University of Central Florida, Office of Research & Commercialization, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901.

APPENDIX K
POWERPOINT PRESENTATION

PowerPoint presentation provided to participants in outline form.

- Dissertation Research Study
- Vernita Glenn-White
- Sample Clip
- Classroom Video 1
- Mr. Dickinson
- 5th and 6th Grade Math – Multiple Representations of Numeric Patterning
- Fran Dickinson leads a number talk on an input/output table and graph, asking "What's my rule?" In this clip, he wraps up the number talk, and the learners mention many different ways of representing the rule: x3 – 3, times 3 minus 3, 3x – 3. Dickinson notes that "So we're doing a lot of talking about this rule. What is the rule? Can we write a rule here?"
- Classroom Video 2
- Mr. Disston
- 7th Grade Math – Algebraic Equations, Inequalities, & Properties
- Jacob Disston leads a lesson on connections between ideas about equations, inequalities, and expressions, helping students to use mathematical vocabulary for a purpose to describe, discuss, and work with these symbol strings.

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