

What Elementary Leaders Need to Know in Order to Observe Mathematics Instruction
and Provide Feedback to Teachers Effectively: A Delphi Study

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Abstract

Improving mathematics instruction is an essential issue many school leaders are encountering as they feel increased pressure to ensure high-quality learning for all students. Key responsibilities of school leaders in leading mathematics improvement include observing instruction and providing teachers with feedback. If school leaders fulfill these responsibilities effectively and help teachers become better practitioners in the classroom, they can have a substantial impact on raising student achievement. As a result of minimal research and contradictory recommendations guiding school leaders towards mathematics leadership, many school leaders are not effectively fostering growth in mathematics instruction. The purpose of this study was to provide clarity to school leaders by pinpointing what elementary school leaders need to know in order to effectively observe mathematics instruction and provide teachers with feedback. More specifically, the study examined the necessity of a school leader's mathematics content knowledge, student pedagogical knowledge, and knowledge of how teachers learn to teach mathematics.

The study was conducted using a three-round Delphi method completed by an expert panel composed of 15 stakeholders with diverse perspectives in the area of mathematics leadership. The study yielded guidelines regarding what school leaders need to know in order to effectively observe elementary mathematics instruction and provide informed feedback to teachers.

The experts unanimously concluded that school leaders must understand elementary mathematics as a process of reasoning rather than merely rules, facts, and procedures. One-hundred percent of the panel also strongly agreed that mathematics instruction must occur in student-centered classrooms where teachers act as a facilitator of learning and use effective questioning to engage students in developing mathematical understandings and connections. The study concluded with 11 additional critical findings.

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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF TABLES	viii
CHAPTER I: THE PROBLEM.....	1
Historical Context: The Math Wars.....	2
Purpose of the Study	5
Significance of the Study.....	6
Research Questions	7
Data Collection	8
Definition of Terms	8
Overview of the Dissertation.....	9
CHAPTER II: REVIEW OF RELATED LITERATURE.....	10
The Impact of School Leadership on Student Achievement.....	10
What School Leaders Need to Know.....	12
Knowledge of Math Content.....	13
Knowledge of Pedagogy.....	14
Methods of Instruction: Traditional v. Progressive Views of Mathematics Education.....	14
Traditional Instruction.....	14
Constructivist Instruction.....	15
Balanced Approach to Instruction.....	17
Implications of Methods of Instruction for Educational Leaders.....	19
Observing a Well-Balanced Classroom.....	19
The Danger of Set “Look-Fors”.....	20
Successfully Observing Today’s Mathematics Classroom.....	21
Knowledge of Teacher Growth.....	23
Effective Instructional Leaders.....	23
Domains of Discomfort.....	25
The Reality of Math Leadership in Elementary Schools.....	26

Comfort.....	27
Knowledge.....	28
Past Experiences.....	28
External Considerations.....	29
Summary.....	30
CHAPTER III: METHODOLOGY.....	31
Purpose of the Study.....	31
Role of the Researcher.....	32
Research Questions.....	33
Research Design and Rationale.....	34
Assumptions, Limitations, and Delimitations.....	36
Assumptions.....	36
Limitations.....	37
Delimitations.....	37
e-Delphi.....	38
The Delphi Process.....	39
Participant Selection.....	40
Defining the Qualifications of an Expert.....	40
Panel Size.....	41
Gaining Access and Entry.....	43
Assurance of Confidentiality.....	43
Delphi Rounds.....	43
Consensus.....	46
Reliability and Validity.....	48
Summary.....	49
CHAPTER IV: PRESENTATION OF THE FINDINGS.....	50
Round One (Delphi I).....	50
Content Knowledge.....	51
Pedagogical Knowledge.....	52

Knowledge of Teacher Growth.....	54
Round Two (Delphi II).....	56
Content Knowledge.....	57
Pedagogical Knowledge.....	59
Knowledge of Teacher Growth.....	61
Round Three (Delphi III).....	65
Content Knowledge.....	66
Pedagogical Knowledge.....	67
Knowledge of Teacher Growth.....	69
Summary.....	71
.	
CHAPTER V: SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS.....	72
Summary of the Study.....	72
Critical Findings.....	73
Findings Related to the Literature.....	74
Unintended Outcomes	79
Implications for Action.....	81
Recommendations for Further Research.....	82
Concluding Remarks.....	83
REFERENCES.....	84
APPENDIX A.....	93
APPENDIX B.....	95
APPENDIX C.....	97
APPENDIX D.....	99
APPENDIX E.....	100
APPENDIX F.....	108
APPENDIX G.....	119

LIST OF TABLES

Table 1: Proposed Timeline for Study Completion.....	42
Table 2: Panel Participants.....	47
Table 3: Results of Delphi I: Content Knowledge.....	52
Table 4: Results of Delphi I: Pedagogical Knowledge.....	53
Table 5: Results of Delphi I: Facilitating Teacher Growth.....	55
Table 6: Results of Delphi II: Content Knowledge.....	58
Table 7: Results of Delphi II: Pedagogical Knowledge.....	60
Table 8: Results of Delphi II: Facilitating Teacher Growth.....	63
Table 9: Results of Delphi II: Critical Findings.....	64
Table 10: Results of the Delphi III: Content Knowledge.....	67
Table 11: Results of the Delphi III: Pedagogical Knowledge.....	68
Table 12: Results of the Delphi III: Facilitating Teacher Growth.....	70
Table 13: Critical Findings of the Delphi II and III.....	71

CHAPTER I

THE PROBLEM

Improving mathematics instruction is a critical issue many school leaders are facing as they feel increased pressure to ensure high-quality learning for all students (Even & Ball, 2010). A substantial quantity of recent research contributes to the field of mathematics instruction in terms of defining effective instructional practices, materials, and professional development for teachers (Franke, Kazemi, & Battey, 2007). Lacking, however, is a sizable amount of research specifically addressing how school leaders can support instructional improvement in mathematics (Coburn, 2003; Cohen, Mofitt, & Goldin, 2007). To complicate matters, existing research reveals contradictory evidence regarding what school leaders need to know and do in order to be effective instructional leaders in the field of mathematics (Cobb & Jackson, 2011). As a result of minimal research and contradictory recommendations guiding school leaders towards mathematics improvement, school leaders are not measuring up to the challenge of fostering growth in mathematics instruction (Nelson, 2006; Spillane, 2005; Brenninkmeyer & Spillane, 2004; Burch & Spillane, 2003). The ability of school leaders to guide math instruction effectively must be strengthened given the important role school leaders play in promoting student achievement (Leithwood et al., 2004).

The importance and role of mathematics in the public education system within the United States has been examined for many years (Kilpatrick, 2009a). In the next section, I will place mathematics education in a historical context.

Historical Context: The Math Wars

The mathematics pendulum has been in full swing for decades, oscillating between emphasizing the importance of basic numbers facts and arithmetic, to focusing on problem solving and exploration (Kilpatrick 2001, 2009a; Herrera & Owens, 2001). The debate sparked interest around World War II, as educators and members of the lay public recognized that individuals needed to have a strong mathematical and technological background in order to compete within the changing world around them (Herrera & Owens, 2001). The Soviet Union's successful launch of Sputnik triggered great concern in 1957, as the U.S. felt threatened by the feat and concerned about the potential diminishing of international power (Schoenfeld, 2004; Kilpatrick 2009a). As a result, mathematics education in the United States headed in the direction of the "New Math Movement," in which elementary schools shifted the focus from basic arithmetic and computation to algebraic manipulation, base counting systems, and problem solving (Herrera & Owens, 2001; Woodward, 2004). In response to this new twist on math, many teachers and parents felt inadequate to teach or help children with the new curriculum (Schoenfeld, 2004). The movement did not sustain for these reasons (Herrera & Owens, 2001). The pendulum swung towards simplicity in the 1970s, as educators promoted a back-to-basics movement focusing on basic computational skills and algebraic manipulation (Herrera & Owens, 2001; Klein, 2003).

As results began surfacing from the back-to-basics swing, educators again noticed that students lacked problem solving and reasoning skills (Woodward, 2004). In 1980, the National Council of Teachers of Mathematics (NCTM) published *An Agenda for Action*, a document that emphasized the importance of problem solving, logical reasoning

and estimation, and minimized the need to focus on sheer basic facts. Once again, the pendulum was swinging back (Kilpatrick, 2009b).

After the publication of *An Agenda for Action*, the United States continued to struggle in mathematics achievement (Woodward, 2004). In the 1980s the United States faced more difficult times, as it competed with Japan and other Asian countries economically in terms of commerce, innovation, and technological advances (Schoenfeld, 2004). In 1983, the National Commission for Excellence in Education (NCEE) published *A Nation at Risk*, a report that equated the education in the United States with a national crisis similar to times before the New Math Movement (Herrera & Owens, 2001; Woodward, 2004). A statement evoking attention from the public read, "If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war," (NCEE, 1983, p. 5; Klein, 2003).

The National Council of Teachers of Mathematics noted the opinions and proposed fixes to the crisis that continued to persist in following years and took the lead by publishing the *Curriculum and Evaluation Standards for School Mathematics* in 1989, *Professional Standards for Teaching Mathematics* in 1991, and *Assessment Standards for School Mathematics* in 1995. (Herrera & Owens, 2001; Kilpatrick, 2009b; Schoenfeld, 2004). Collectively known as the *Standards*, these documents proposed necessary changes with content and pedagogy in the field of mathematics education. In terms of content, the *Standards* focused on real-life applications, problem solving, integrating mathematical concepts, higher order thinking, mathematical communication, and

reasoning. Pedagogically, the *Standards* addressed the need for group work, active involvement, concrete materials, and discourse (Herrera & Owens, 2001).

The federal government became involved in 2001 when Congress passed No Child Left Behind (NCLB) (Cobb & Jackson, 2011). Still in effect today, the purpose of NCLB is to ensure that all students achieve high academic standards in language arts and mathematics. (www.ed.gov, 2013). Three components of NCLB included content standards, tests to measure students' understanding of the standards, and means to hold schools accountable for test scores (www.ed.gov, 2013). Some researchers argued that NCLB weakened the scope of teaching the standards as many educators feel pressured to teach to state tests that measure basic skills (Resnick & Zurawsky, 2005). Unfortunately, while many states' standards explicitly described the need for a deep conceptual understanding of mathematics and developed problem solving skills, state tests often failed to assess these standards (Resnick & Zurawsky, 2005).

In 2010, individual states across the U.S. began to unite by adopting the Common Core Mathematics Standards. Created from collaboration between teachers, administrators, parents, experts in the field, and state leaders, the Common Core Mathematics Standards were meant to define a clear set of expectations for mathematics classrooms K-12. The standards were created to narrow the focus of content in each grade level and ensure that graduating students are adequately prepared to take college level courses or enter the workforce. Currently, 45 states, the District of Columbia, four territories, and the Department of Defense Education Activity have adopted the Common Core Standards. The Common Core Initiative contains Standards of Mathematical Practice, or habits educators are encouraged to develop in their students. Similar to

components to the NCTM *Standards*, the Common Core Standards of Mathematical Practice include, but are not limited to, making sense of problems, reasoning quantitatively and abstractly, modeling mathematics, and attending to precision (www.corestandards.org). Aside from content, researchers have also debated the effectiveness of various instructional methods in mathematics classrooms (National Mathematics Advisory Panel, 2008; Nelson & Sassi, 2005).

Many researchers categorize methods of instruction on opposite ends of a spectrum (Kirschner et al., 2006). One end of the spectrum contains traditional views, where educators focus on content throughout the learning process (National Mathematics Advisory Panel, 2008; Ackerman, 2003). In opposition to traditional methods, progressive beliefs prevail when the educator focuses on students and their conceptual understandings, rather than the standards and rote memorization alone (National Mathematics Advisory Panel, 2008; Fox, 2001). In Chapter II, I will describe both views in greater detail. Overall, high quality instruction is not comprised of one method of instruction over another. Instead, a balance between the views must be reached. (National Mathematics Advisory Panel, 2008). Instruction in today's classrooms, however, does not reflect the balance of methods and tends to lean more towards traditional means of instruction (Silver, 2010; Kazemi, Franke, & Lampert, 2009). School leaders can assist teachers in striking the proper balance between the methods.

Purpose of the Study

Essential responsibilities of school leaders connected to leading mathematics improvement include observing instruction and providing teachers with informed feedback (Cobb & Jackson, 2011; Gamage et al., 2009). If school leaders fulfill these

responsibilities effectively and help teachers become better practitioners in the classroom, they can have a substantial impact on raising student achievement (Louis, Dretske, & Whalstrom, 2010; Leithwood et al., 2004; Waters, Marzano, & McNulty, 2003; Waters et al., 2003). Existing research is limited, however, and provides contradictory guidance in terms of what elementary leaders need to know and do in order to observe instruction and provide feedback successfully (Cobb & Jackson, 2011). Some research indicates that school leaders need a broad understanding of student pedagogy and effective teaching practices applicable to observing instruction in any subject (Hattie, 2012; Resnick & Glennan, 2002). Others adamantly propose the need for school leaders to possess subject specific knowledge (McConachie & Petrosky, 2009; Spillane, 2005; Burch & Spillane, 2003; Stein & Nelson, 2003), which includes content knowledge, an understanding of student pedagogy, and insight regarding how teachers learn to teach mathematics (Nelson & Sassi, 2005; Stein & Nelson, 2003). The purpose of this study is to provide clarity to school leaders and add to current literature by providing guidelines regarding what elementary school leaders need to know and do in order to effectively observe mathematics instruction and provide teachers with feedback.

Significance of the Study

Many school leaders are uncomfortable leading mathematics instruction and view improving mathematics instruction as the job of someone other than themselves (Nelson, Stimpson, & Jordan, 2007; Spillane, 2005; Brenninkmeyer & Spillane, 2004). School leaders should not avoid their responsibility to lead mathematics instruction, particularly in a time when increasing accountability demands are leading to the shared expectation that school leaders should act as instructional leaders in mathematics (Robinson, Lloyd,

& Rowe, 2008). Overall, research addressing how school leaders can influence effective instruction is minimal and outdated (Robinson, Lloyd, & Rowe, 2008). The lack of research linking school leadership and classroom teaching, "...indicates how radically disconnected leadership research is from the core business of teaching and learning," (Robinson, Lloyd, and Rowe, 2008, p. 670). Investigating how school leaders can impact improvements in mathematics through observing and providing feedback is an important step in giving school leaders the information they need to become comfortable with and take ownership of leading mathematics instruction.

Research Questions

This study will answer the overarching question: What should elementary school leaders know in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation? This investigation will also investigate the following sub-questions:

1. What should elementary school leaders know about mathematics content in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?
2. What should elementary school leaders know about student pedagogy in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?
3. What should elementary school leaders know about how teachers learn to teach mathematics in order to provide effective feedback to teachers after an observation?

Data Collection

I will use the Delphi technique in conducting this study. The Delphi technique is a process consisting of a series of sequential questionnaires or rounds, completed by a panel of experts on a topic (Linstone & Turnoff, 1975). After each round is completed, feedback regarding participants' responses is given back to the panel (Murphy et al., 1998). The end-result will be a consensus of opinion from a group of individuals knowledgeable about mathematics leadership (Linstone and Turoff, 1975). The study will conclude with guidelines regarding what school leaders need to know in order to effectively observe elementary mathematics instruction and provide informed feedback to teachers.

Definition of Terms

Attrition: A decrease in the number of participants who contribute to a study (Okoli & Pawlowski, 2004)

Delphi Technique: A research method used with a group of experts to reach a consensus regarding a certain issue (Linstone & Turoff, 1975)

e-Delphi: A Delphi study that utilizes the convenience of the internet to collect and disseminate data (Cole, Donohoe, & Stellefson, 2013)

Leadership Content Knowledge: The knowledge of subjects and how students best learn them (Stein & Nelson, 2003)

National Council of Teachers of Mathematics (NCTM): "The public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research" (www.nctm.org)

School Leaders: Principals, assistant principals, and math coaches

Overview of the Dissertation

This dissertation is presented in five chapters. Chapter One introduced the problem, placed the problem within a historical context, provided the purpose and significance of the study, outlined the research questions and methodology, provided definitions of terms, and addressed potential limitations and delimitations of the study. Chapter Two contains a literature review relating to the impact school leaders have on student achievement, the knowledge school leaders must have in mathematics to observe and provide feedback, and the current reality of mathematics leadership. Chapter Three outlines the research design, methodology, and data analysis used in this study. Chapter Four presents the findings. Chapter Five summarizes the study and provides conclusions and recommendations for future studies.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter examines the impact school leaders have on student achievement, the necessary knowledge leaders must possess in order to lead mathematics instruction effectively, and the reality of mathematics leadership in elementary schools today.

The Impact of School Leadership on Student Achievement

Many interwoven variables contribute to student learning. Research is laden with data linking factors such as school climate, instruction, community, relationships, teachers, demographics and funding to levels of student achievement (Leithwood et al., 2004).

School leadership impacts student learning to a significant degree. Leithwood, et al. (2004) stated, “It turns out that leadership not only matters: it is second only to teaching among school-related factors in its impact on student learning...” (p.3). A significant relationship connects leadership and student achievement, particularly when school leaders have deep knowledge of curriculum, instruction, and assessment (Waters, Marzano, & McNulty, 2003).

Day et al. (2009) collaborated to complete The Effective Leadership and Pupil Outcomes Project in order to study schools recognized for improving achievement over a consecutive three-year period. The authors examined the work of various school leaders in primary and secondary schools across England. The authors concluded that a leader’s values and strategic actions had a significant impact on raising student outcomes (Day et al., 2009). Two of the authors’ relevant findings include:

Claim 1: Headteachers [school leaders] are perceived as the main source of leadership by school key staff. Their educational values and leadership practices shape the internal processes and pedagogic practices that result in improved pupil outcomes.

Claim 2: Almost all successful leaders draw on the same repertoire of basic leadership values and practices. However, there are differences in the time and attention which heads [school leaders] give to elements within these (p.184-185).

The researchers further explained Claim 2 by describing the repertoire of basic strategies to include developing people and managing teaching and learning. Perceptions of key staff members supported these claims, as 92% of staff reported that that their principals had a positive effect on the quality of teaching and learning (Day et al., 2009). This research revealed the perception that principals' values and practices can ultimately lead to increased student performance, particularly when leaders have skills in developing teachers (Day et al., 2009).

In order to have a significant impact on student achievement, school leaders must provide instructional leadership by observing teachers in the classroom, providing teachers with informed feedback regarding their instruction, and facilitating discussions about instructional issues with staff (Gamage et al., 2009). The more active school principals are in teaching, learning, and development, either as a leader or learner in the development, the higher student outcomes tend to be. Teacher development includes informal discussions and instructional problem solving with teachers (Robinson et al., 2008). Stein and Nelson (2003) stated, "...as demands increase for them to improve teaching and learning in their schools, administrators must be able to know strong

instruction when they see it, to encourage it when they don't, and to set the conditions for continuous academic learning among their professional staffs” (p. 424).

Some research specifically connected leadership to student achievement in elementary mathematics. However, Louis, Dretzke, and Wahlstrom (2010) found that student math achievement scores were significantly connected with focused instruction, professional communities, and teachers’ trust in school leaders. Other researchers added that leadership was a positive and significant predictor of a teacher’s growth in mathematics instruction, ultimately leading to increased student performance (Supovitz, Sirinides, & May, 2009).

Overall, evidence suggests the potential of leadership to impact increased student achievement. Therefore, it is necessary to continue exploring what leaders need to know and do in order to have a positive impact in mathematics improvement.

What School Leaders Need to Know

Researchers debated the knowledge school leaders must have in order to observe classroom instruction and provide feedback effectively (Cobb & Jackson, 2011). Some research indicated that school leaders need a broad understanding of student pedagogy and effective teaching practices that they can draw on when observing instruction in any subject (Hattie, 2012; Resnick & Glennan, 2002). This may include a teacher’s ability to maintain high expectations in the classroom, provide appropriate feedback to students, differentiate instruction, and create a safe classroom environment (Hattie, 2012). Others adamantly supported the need for school leaders to possess subject specific knowledge (McConachie & Petrosky, 2009; Spillane, 2005; Burch & Spillane, 2003; Stein & Nelson, 2003).

In order to have a positive effect on student achievement, school leaders must have a base of content knowledge regarding elementary mathematics instruction (Stein & Nelson, 2003). One term that surfaced in research relating to the specific knowledge leaders need in order to lead mathematics instruction is Leadership Content Knowledge (LCK) (Stein & Nelson, 2003). LCK is the knowledge of subjects and how students can best learn them (Stein & Nelson, 2003). Stein and Nelson categorized mathematics LCK into three domains; a school leader's knowledge of the math content, student pedagogical processes, and how teachers learn to teach math. In the sections ahead, I consider these three domains of LCK.

Knowledge of Math Content

Leaders need to have a conceptual understanding of mathematics content that remains flexible and open to different approaches to teaching and learning (Nelson & Sassi, 2005). A conceptual understanding is defined as a deep insight of the, "...underlying structure of mathematics – the relationships and interconnections of ideas that explain and give meaning to mathematical procedures" (Eisenhart et al., 1993, p. 9). Conceptual knowledge also means understanding varying ways to solve problems and having the number sense to comprehend the true meaning of standard algorithms (Nelson, Benson, & Reed, 2004). Overall, leaders should have a solid understanding of the mathematics they are observing.

A leader's knowledge of mathematical content is important when observing math instruction, but it is not the only factor (Nelson & Sassi, 2005). Leaders must also understand how children learn and create meaning for mathematics so they can facilitate discussions with teachers that target elements of real learning. However, little research

analyzes how educational leaders are trained (Hess & Kelly, 2007) and less, still, about the nature of curriculum leadership (Handler, 2010). This is problematic, given that instructional leaders must have an understanding of curriculum theory if they hope to support faculty learning (Kliebard, 2004). In the sections ahead, I present the curricular issues that face school leaders, and begin to explore the implications for pedagogical practice.

Knowledge of Pedagogy

Methods of Instruction: Traditional v. Progressive Views of Mathematics Education

When thinking about the big picture of education, instructional methods are often reduced to traditional versus progressive views. Traditional views of curriculum generally focus on the role of content in the learning process. On the other hand, progressive, or constructivist, perspectives focus on the role of the learner, prioritizing holistic knowledge, and teaching the child, not the standards (Ackerman, 2003). For the purpose of this literature review, I will describe the views using the terminology traditional and constructivist, as those words frequently come to the surface when examining mathematics instruction.

Traditional instruction. One method of instruction often associated with pre-World War II and back-to-basics curricula of the 1970s is the traditional approach (Schoenfeld, 2004). Direct instruction, another term used when describing the traditional approach, occurs when an instructor provides information that explicitly explains mathematical concepts and the procedures that accompany the supporting operations (Kirschner et al., 2006). Eisenhart et al. (1993) linked traditional methods to a reliance on procedural knowledge, or the mastery of computation skills, rote knowledge of

procedures, algorithms, and definitions. Both the learner and the teacher have specific roles within the traditional classroom.

The learner in a traditional classroom often works silently and in isolation as they internalize knowledge transmitted from the teacher and arrive at the correct answers through a particular procedure or algorithm (Silver & Smith, 1996). Students in a traditional classroom frequently solve problems from textbooks involving bare numbers, or highly predictable word problems that only require the use of a specific algorithm previously learned in the chapter (Woodward, 2004). The student in the traditional classroom is proficient when he is able to implement computational strategies to solve a problem (Whitehurst, 2003). Aside from the learner, the traditional teacher also has specific roles in the classroom.

A traditional mathematics teacher provides authoritative knowledge to help students see what is right versus wrong (Schoenfeld, 2004). The goal of the traditional teacher is to teach correct mathematical facts, procedures, and conventional ways of solving problems, rather than focusing on ensuring that students gain a deep understanding (Whitehurst, 2003). Questioning in a traditional classroom appears predictable in that it tends to be low-level, requiring an answer that is either right or wrong, resulting in feedback that targets the correct procedure or specific steps for finding the answer (Woodward, 2004). The traditional teacher varies greatly from the teacher who embraces constructivist theories.

Constructivist instruction. The constructivist theory of teaching mathematics sits on the other end of the spectrum opposite of traditional theories. Fox (2001) defined constructivism as, "...a metaphor for learning, likening the acquisition of knowledge to a

process of building on construction” (p. 23). The idea of teaching mathematics constructively skyrocketed in the 1990s, after the release and implementation of NCTM *Standards*. Based on the theories from Swiss Psychologist, Jean Piaget, constructivist methods focus on student-directed activities instead of teacher driven direct instruction (Whitehurst, 2003). Also known as discovery learning, problem-based inquiry, and experimental learning, constructivism places an emphasis on acquiring conceptual knowledge rather than procedural knowledge (Kirschner, et. al, 2006). Conceptual knowledge is the true understanding of mathematical relationships and connections within numeracy. It is the reasoning behind, or *why*, algorithms work (Eisenhart, et. al, 1993).

Constructivist theories suggest that learning is a process in which the learner actively invents knowledge on a personal level and in a socially constructed manner, making sense of the world by grappling with open-ended, real-life, and challenging problems (Fox, 2001). Whitehurst (2003) suggested that learners acquiring knowledge through a constructivist lens learn for the sake of curiosity and exploration instead of the sake of external rewards. Measuring student success from constructivist methods of instruction looks different from traditional measures. Proficiency morphs from the definition of a mastery of computation needed to solve math problems, to the ability to understand mathematics concepts, apply the concepts to new situations and problems, and reason mathematically (Whitehurst, 2003).

The role of a constructivist teacher also varies greatly from the traditional instructor. The teacher is not a transmitter of knowledge, but rather acts as a facilitator who leads students through exploration, investigation, and discovery (Herrera & Owens,

2001). Constructivist teachers must listen to students talk through problems, guide instruction in response to student conversation, and facilitate the process of students working through discourse (Nelson, 1999). Constructivist teachers understand that students' thinking, while not always clean and correct, leads to their learning. Nelson (1999) explained that it is productive when students are, "...struggling to solve problems or resolve dissonances in order to come to a new understanding of the issues imbedded in the task" (p. 14).

While many researchers agree with the use of constructivist methods in mathematics instruction, some disagree. Kirschner et al. (2006) stated, "The past half-century of empirical research on this issue has provided overwhelming and unambiguous evidence that minimal guidance during instruction is significantly less effective and efficient than guidance specifically designed to support the cognitive processing necessary for learning" (p. 76). They found that constructivism may even have a negative impact when students create misconceptions from their disorganized thinking (Kirschner et al., 2006).

Some researchers supported the effectiveness of traditional methods of instruction, while others supported constructivist-based methods. However, many agreed about taking a balanced approach to instruction (Whitehurst, 2003; Fox, 2001; MacNab 2000; Stein & D'Amico, 2000; Wu, 1999).

Balanced approach to instruction. The inability of mathematicians and educators to reach a pure consensus regarding the most effective form of mathematics instruction leads many to see the benefits of balancing traditional and constructivist methods (Whitehurst, 2003). As Ackerman suggested, "...there is a promising pathway,

rooted in the intuition that we are dealing not with educational good and evil but with dual virtues that need to be boldly and imaginatively combined,” (2003, p. 346). Wu (1999) described the split between basic skills and deep conceptual understanding as a bogus dichotomy, stating that technique and conception go hand in hand. The roles of the student and teacher in a balanced classroom look slightly different from pure traditional or constructivist classrooms.

Learners in a balanced classroom must understand concepts, in addition to memorizing and recalling basic facts (Fox, 2001). Different situations require the application of basic skills and procedures while others lead to the exploration of authentic open-ended problems (Whitehurst, 2003). When students focus only on technique, it tends to lead to a reliance on rote procedures and memorization by students, while too much exploration can lead to the risk of losing track of student understanding regarding big concepts (Stein & D’Amico, 2000). A balance between procedures and exploration is necessary (Fox, 2001).

Teachers who lead a balanced classroom ensure that they effectively engage students with the learning in order to gain and apply particular mathematical knowledge and processes (MacNab, 2000). Students can benefit from the balance. For instance, directing a student to pay particular attention to a part in a math procedure can enhance or help to create the conceptual understanding (Whitehurst, 2003). MacNab (2000) described the importance of teachers understanding that, “...functional use does not always or necessarily require full understanding, but also that such use can help develop understanding,” (p. 76). An ideal teacher finds a balance between depth and coverage,

and expects students to make progress in personal excellence derived from absolute standards of excellence (Ackerman, 2003).

While some researchers tended to dichotomize traditional and constructivist methods others described the richness in balancing both approaches. Ackerman (2003) called them the, "...intertwined taproots of our professional outlook," (p.346). It is evident that a balance between traditional and constructivist methods of instruction is critical in order to effectively facilitate a mathematics classroom and raise student achievement, however, achieving a balance can be difficult in practice.

Implications of Methods of Instruction for Educational Leaders

School leaders must understand the merits of traditional and constructivist methods of instruction and help teachers use components of each to create a mathematics classroom based on a balanced approach. Ball et al., (2005) stated, "Decisions about what is better taught through direct instruction and what might be better taught by structuring explorations for students should be made on the basis of the particular mathematics, the goals for learning, and the students' present skills and knowledge." School leaders are in the position to assist teachers in terms of making these decisions (Ball et. al, 2005).

Therefore, they must know what to look for in a balanced classroom. In the next section, I will describe components to consider when observing a well-balanced mathematics classroom.

Observing a Well-Balanced Classroom

School leader observations of classrooms can play an essential role in leading mathematics instruction (Gamage et al., 2009). To do this effectively, an observer must have a solid grasp of what to pay attention to and focus on in a lesson. In the following

sections, I will consider the danger of sets of “look-fors” and what it means to observe today’s mathematics classroom successfully.

The danger of set “look-fors”. Many leaders have the misconception that observing math instruction requires checking off a list of desirable teacher behaviors (Nelson & Sassi, 2005). Conventional “look-fors” school leaders tend to seek include small group discussions, sharing student strategies, using manipulatives, and drawing pictures and/or diagrams (Nelson, Stimpson, & Jordan, 2007). Many researchers agreed, however, that adhering to this checklist simply is not enough (Nelson & Sassi, 2000; Nelson, Benson, & Reed, 2004; Nelson & Sassi, 2005; Nelson & Sassi, 2006; Nelson, Stimpson, & Jordan, 2007). Nelson and Sassi (2006) stated:

Small group work can miss the mathematical mark, work with manipulatives can fail to bring students into contact with the mathematical ideas that these instructional tools are intended to illuminate, and enumeration of student problem-solving strategies without comment about the accuracy or effectiveness of the strategies can deprive students of having serious mathematical discussions (p.3).

A skilled observer pays close attention to student thought processes, connections students are making between manipulatives and mathematical understandings, student discussions, and teacher feedback (Nelson & Sassi, 2006). Successful observations do not occur merely by adhering to a set checklist of “look-fors.” Therefore, next, I will explore what the literature says school leaders should focus on when observing a mathematics classroom successfully.

Successfully observing today's mathematics classroom. Current mathematics reform suggests that students must learn mathematics with an understanding, become actively engaged in the process to build new knowledge from experiences, and connect new ideas to prior knowledge (www.nctm.org, 2014, 2013; Kanold, Briars, & Fennell, 2012). Virtues of a reformed classroom include: deep thought about concepts, respect for others' thinking, trust in one another to withhold judgments regarding their thinking, and the commitment of teachers and students to support and investigate each other's thinking (www.nctm.org, 2014; Nelson, 1999). In order to facilitate rich mathematical discussions, the teacher must have the knowledge and flexibility to support students, pose guiding questions, and accurately diffuse student misconceptions as they engage in the process of developing mathematical ideas (Molina, 2014; Schoenfeld, 2004).

When observing a mathematics classroom, school leaders must look beyond the sheer use of group work and manipulatives, and recognize the depth of student thinking, how teachers use manipulatives to facilitate the exploration of mathematical ideas, and how group discussions and manipulatives help students make sense of the material (Reed, Goldsmith, & Nelson, 2006). In order to analyze learning occurring within the classroom, school leaders must observe how interactions unfold between students and teachers, paying attention to the validity of student responses and the follow up questions teachers ask (Kanold, Briars, & Fennell, 2012; Nelson & Sassi, 2005). Leaders must also take note of the follow-up tasks, dialogue with the students, and the feedback teachers provide (Nelson & Sassi, 2006). Ball, Thames, and Phelps (2008) suggested that observers need to recognize teacher errors in mathematical thinking, and teachers' abilities to correct themselves. Leaders must also recognize a teacher's capacity to analyze student errors

and provide feedback adequate for students to assess the validity of their own statements, and ultimately reach solid mathematical conclusions (Ball, Thames, & Phelps, 2008). Overall, school leaders should be aware of student mathematical understandings, how teachers guide student thinking and the effectiveness of teachers' error analyses.

Discourse is another critical component of an effective mathematics classroom (Frykholm, 2004). Nelson, Benson, and Reed (2004) found that lesson derailment, or veering from one's original objectives to explore and clarify student confusion pertaining to an unexpected issue, is not only acceptable, but also potentially powerful, as confusion is something from which students and teachers can learn. School leaders must be able to pinpoint the central mathematical idea of the lesson and observe how the students and teachers work together to grapple with the discourse and build their own understanding (Nelson & Sassi, 2000). Although cognitive dissonance and discourse can make math unpredictable and "messier", school leaders must understand that it is essential to a productive mathematics classroom (Hattie, 2012; Frykholm, 2004).

Leaders who pay attention to central mathematical ideas, discourse, student engagement, and interactions between students and teachers walk away from lessons with much different insight than merely focusing on the checklist of "look-fors" (Nelson & Sassi, 2000). Instead of viewing a busy classroom full of active students as confusing and off-task, school leaders with informed views regarding reformed classrooms, find the activity and discourse to be productive (Nelson & Sassi, 2000). Overall, a solid platform for school leaders to provide support to teachers involves the awareness and critical eye for subject matter content, the interaction between the teacher and students, and students' thinking.

Lastly, leaders must also watch for varying assessment practices. Some researchers claim that assessment practices may be one of the most important factors a leader should consider when observing instruction as they can have a significant impact on student achievement (Hattie, 2012; Wiliam, 2007b). Leaders need to understand that high-quality assessment practices combine formative assessment for learning with summative assessment of learning (Kanold, Briars, & Fennell, 2012).

In addition to mathematical content knowledge and knowledge of pedagogical processes, administrators must also have an understanding regarding how teachers learn to teach math (Stein & Nelson, 2003). This knowledge helps teachers grow.

Knowledge of Teacher Growth

The nature of mathematics classrooms today reflects varying uses of traditional, constructivist, and balanced approaches to instruction. While mathematics reform has been in motion for decades, educational leaders continue to face challenges in terms of observing and facilitating teacher growth in mathematics instruction. In the next sections, I will address the importance of effective instructional leaders, how school leaders can support teachers, and the domains of discomfort leaders must understand in order to promote teacher growth.

Effective Instructional Leaders

Instructional leaders as observers, supporters, and agents for teacher growth, are critical factors in raising student achievement (Stein & Nelson, 2003). School leaders who focus time and energy on facilitating teacher growth can help teachers make powerful gains in their quality of instruction, ultimately resulting in increased student performance (May & Supovitz, 2010). The most effective instructional leaders know how

to target open-minded teachers who are willing to examine their own teaching practices and take an active role in the growth process. Successful school leaders also incorporate a balance of broad, philosophical development and targeted activities to strengthen teaching practices (May & Supovitz, 2010).

The role of school leaders in terms of observing instruction and providing feedback has transformed from an assessor of teacher competence to one who facilitates discourse and teacher growth through self-reflection (Reitzug, West, & Angel, 2008). Effective school leaders promote professional growth by encouraging discourse and self-reflection through a coaching relationship, rather than one with an evaluative nature (Blasé & Blasé, 2000). Powerful conversations result when a strong coaching relationship exists between observer and teacher, where they are able to challenge the thoughts and perspectives of each other (Vitcov, 2014). In addition to observing teachers, effective leaders focus conversations and questioning on their observations of students as well (Vitcov, 2014). Ultimately, teachers are more apt to grow if they experience authentic conversations and practices aimed at improving student learning, rather than judgmental interactions that focus only on teacher behaviors (Fulmer, 2006). In addition, connecting student performance with teacher behaviors is an important step in identifying next steps in terms of learning targets and instructional strategies (Vitcov, 2014).

Successful school leaders engage in collaborative inquiry and on-going discussions with teachers in order to stimulate deep reflection (Vitcov, 2014; Reitzug, West, & Angel, 2008). Among making suggestions, giving feedback, modeling, and giving praise, effective school leaders guide teachers through inquiry by posing varying questions throughout the observation process (Blasé and Blasé, 2000). Effective school

leaders ask questions rather than giving explicit directives in terms of improving instruction. This provides teachers the opportunity to construct their own meaning of effective instruction, rather than being told what they should or should not do (Nelson, 1999). Successful school leaders also propose open-ended questions focused on student learning, allowing teachers to feel comfortable participating in the conversation, instead of posing questions that target a teacher's actions, which will quickly stifle the conversation (Nelson, 1999).

A school leader's responsibilities include observing instruction and providing useful feedback to teachers. If done in a collaborative, inquiry-based manner involving varying levels of questioning, leaders can have a solid impact on teacher growth (Reitzug, West, & Angel, 2008; Fulmer, 2006). In order to effectively observe mathematics instruction and successfully provide feedback, school leaders must also beware of the varying levels of discomfort teachers may face in regards to facilitating balanced classroom.

Domains of Discomfort

School leaders must understand the domains of discomfort teachers face as they try to facilitate a balanced classroom in order to help them work through the discourse and grow. Frykholm (2004) defined the four domains of discomfort as cognitive, beliefs-driven, pedagogical, and emotional. Frykholm linked cognitive discomfort to one's uncertainty of content knowledge and connections between mathematics concepts, and beliefs – driven discomfort as the hesitation of how mathematics is best taught and learned. He described pedagogical discomfort as occurring when the teacher is managing discourse and an active learning environment, and emotional discomfort when they sense

loss of authority and/or vulnerability, not always able to predict where the lesson is heading. Frykholm articulated that these domains of discomfort are the core of a balanced classroom. They are:

... those critical moments in the classroom when children and teachers may meet – when the teacher’s willingness to let go overlaps with the child’s native curiosity, when teachers pose open-ended questions that foster creative ideas and strategies, when the teacher’s willingness to be vulnerable meets the child’s desire to trust, when the teacher’s decision to remain silent allows children to develop their own voices, when the teacher’s appreciation for the elegance of mathematics leads the child to life-long learning and appreciation of mathematics (p. 149).

If school leaders are aware of the domains of discomfort, they will have insight regarding reasons teachers may struggle to incorporate components of a balanced classroom, and have an understanding how to pose questions in order to help teachers navigate through the discourse.

It is clear that school leaders must possess a solid base of knowledge regarding mathematics content, student pedagogy, and how teachers learn mathematics pedagogy. In the next section, I will address the current state of research on mathematics leadership in elementary schools.

The Reality of Math Leadership in Elementary Schools

School leaders in elementary schools are more prominent in leading literacy instruction than mathematics instruction (Spillane 2005; Burch & Spillane, 2003). Spillane (2005) found that some school leaders spent as much as 54% of their time leading literacy instruction, while only spending 14% of their time leading mathematics

instruction. Overall, elementary school leaders are less likely to take on instructional leadership roles in math than language arts, and tend to place the responsibility of such leadership on the shoulders of classroom teachers, or other external sources (Reed, Goldsmith, & Nelson, 2006; Spillane, 2005; Brenninkmeyer & Spillane, 2004; Burch & Spillane, 2003). In the following sections, I will consider factors that may inhibit school leaders' abilities to lead mathematics improvement including school leaders' level of comfort, knowledge, past experiences, and external pressures.

Comfort

Many elementary school leaders are uncomfortable with mathematics in general (Nelson, Stimpson, & Jordan, 2007) and tend to talk with a more tentative attitude and negative emotion when talking about mathematics versus language arts instruction (Brenninkmeyer & Spillane, 2004). Reed, Goldsmith, and Nelson (2006) found that only 45% of principals responsible for mathematics instruction perceived themselves as confident and comfortable in doing so. In addition to being uncomfortable with the mathematics, some leaders may not address the discomfort, as elementary mathematics is a subject everyone took as students themselves, and it is often perceived that they should naturally understand and be comfortable with the subject (Huillet, Adler, & Berger, 2011). A lack of comfort may be one reason elementary school leaders do not lead mathematics instruction as often as they do literacy instruction. Also, school leaders may not have a strong understanding of mathematics content, student pedagogy, and how teachers learn to teach math (Cobb & Jackson, 2011).

Knowledge

Nelson et al. (2007) found that many elementary school leaders do not have the knowledge necessary to conduct classroom observations and provide feedback effectively. Many school leaders have weak conceptual mathematics understandings themselves, and hold traditional views of how teachers should lead mathematics instruction (Nelson, Stimpson, & Jordan, 2007). Although other leaders may understand the importance of teaching for a conceptual understanding, they do not necessarily have a solid idea of how to develop it (Eisenhart et al., 1993).

In a recent study, Schoen (2010) found that school leaders still tend to notice general pedagogical components of a lesson, rather than mathematics-specific aspects or tend to notice the strategies, but not the pedagogical principles or learning-related goals that they are intended to develop. For example, school leaders often recommend incorporating more group work and manipulatives without clarifying how to integrate these components for increased student learning (Schoen, 2010). Hand in hand, Day et al. (2009) found that many leaders could see and articulate the importance of the potential positive impact of providing teachers with meaningful feedback regarding instruction; however, they tended to lack the time and/or ability to do so.

Past Experiences

Nelson and Sassi (2005) addressed the manner in which many administrators learned mathematics themselves. They pointed out that current administrators tend to have a difficult time leading high quality instruction, comprised of rigorous thinking and mastery of computational procedures, because they learned in a time when that definition of mathematics simply did not exist. Many administrators learned mathematics, or even

first taught the subject themselves, in a time where the traditional, or sit and get, view of learning prevailed (Nelson & Sassi, 2005). Therefore, when they observe and evaluate teaching, they expect to see much of the same: lessons presented by the teacher, and students sitting at desks in rows working quietly from a textbook. The transformation in mathematics instruction has led to a misalignment between what administrators believe they should observe in a mathematics classroom versus instruction that truly builds a deep mathematical understanding. Stein and D'Amico (2000) added, "...it will be difficult for administrators to grasp what kinds of knowledge and experiences are essential for their teachers if they themselves have not experienced what it means to know and think in mathematical or literate ways," (p. 46).

External Considerations

School leaders face a litany of external forces to cope with as they lead mathematics instruction (Hess & Kelly, 2007). While school leaders may verbally support the need for deep conceptual knowledge, formal evaluation systems, standards, test preparation, and standardized assessments that measure sheer procedural knowledge create a disconnect between the definition of effective teaching and what needs to occur in the classroom to foster student achievement as defined by No Child Left Behind (Eisenhart et al.,1993). McInerney (2003) explained the predicament school leaders face as they, "...have to live with a high level of ambiguity as they attempt to balance the corporate objectives of the state education system and their own principles of what constitutes good teaching and learning," (p. 68). While some school leaders do not know how to balance state and federal demands with research proven effective instruction,

other school leaders are not even trying, as they see progressive instruction as disconnected and inappropriate in an accountability era (Ylimaki, 2011).

Many administrators simply do not lead mathematics instruction as frequently as language arts (Spillane, 2005). They struggle to take ownership of mathematics (Reed, Goldsmith, & Nelson, 2005), have a low level of comfort with mathematics instruction (Nelson, Stimpson, & Jordan, 2007), lack the knowledge necessary to lead reform effectively (Nelson et al., 2007) and struggle to cope with external factors (Ylimaki, 2011). Only a shallow base of research defines actions of effective instructional leaders, critical knowledge school leaders must possess, and components school leaders need to focus on when observing a mathematics classroom (Cobb & Jackson, 2011). In order to add to the depth of current research, I will explore what principals need to know and do to effectively observe mathematics instruction and provide feedback to teachers.

Summary

In this chapter, I addressed the impact of school leaders on student achievement, and the knowledge administrators must have in order to lead mathematics instruction effectively. Necessary knowledge included mathematics content, student pedagogy, and how teachers learn to teach mathematics. Lastly, I examined the current reality of elementary leadership, and potential barriers to highly effective mathematics leadership.

CHAPTER III

METHODOLOGY

In Chapter I, I introduced the problem, placed the problem within a historical context, provided the purpose and significance of the study, and outlined the research questions. In Chapter II, I reviewed relevant literature relating to the impact school leaders have on student achievement, the knowledge school leaders must have in mathematics to observe and provide feedback, and the current reality of mathematics leadership. In Chapter III, I will revisit the purpose of the study and provide a description of the role of the researcher, an explanation of the research design and rationale, and an outline of the procedure. I will also address the assumptions, limitations, and delimitations of the study.

Purpose of the Study

In order to lead mathematics improvement successfully, school leaders must effectively observe instruction and provide teachers with informed feedback (Cobb & Jackson, 2011; Gamage et al., 2009). School leaders can have a powerful impact on raising student achievement if they fulfill these responsibilities well (Louis, Dretske, & Whalstrom, 2010; Leithwood et al., 2004; Waters, Marzano, & McNulty, 2003; Waters et al., 2003). Existing research is limited, however, and provides contradictory guidance in terms of what elementary leaders need to know and do in order to observe instruction and provide feedback effectively (Cobb & Jackson, 2011). The purpose of this study is to provide clarity to school leaders and add to current literature by providing a list of what elementary school leaders need to know and do in order to effectively observe mathematics instruction and provide teachers with feedback.

Role of the Researcher

I am in my sixth year as the Assistant Principal of a Title I elementary school within a large, high performing district on the East Coast. Preceding my time as an administrator, I was a math specialist and sixth grade math teacher.

As a school leader, part of my responsibilities is to observe instruction and provide teachers with informed feedback. While I observe everything from preschool to physical education classrooms, I am particularly interested in observing mathematics instruction. Since beginning my career, almost a dozen years ago, I have spent a substantial amount of time reflecting on my own growth as an educator. My views of effective mathematics instruction morphed from a memorization of procedures and facts (the way I was taught as a child) to teaching for true understanding. I often think about this shift as I observe varying mathematics lessons within my building. Some teachers seem to have a solid grasp of teaching for a conceptual understanding; however, many quickly revert to rote procedures and memorization. Although research is laden with findings supporting the importance of teaching mathematics for understanding, that simply still is not the norm in elementary classrooms across the United States (Silver, 2010).

My personal experiences validate this claim. Recently, I observed a mathematics classroom and saw instruction that mirrored many traditional philosophies of instruction. The students were silently working on worksheets filled with problems requiring little more than following a list of steps that were included at the bottom of the paper (Woodward, 2004). Understanding the necessity of a balanced classroom, one incorporating exploration, discourse, conversations, and real-life connections (Nelson &

Sassi, 2000), I was not satisfied with what transpired throughout the lesson. In an attempt to validate my feelings towards the instruction I witnessed, I read past evaluations written for this teacher. The results were surprising. The observer detailed a similar lesson to the one I observed, however, provided positive feedback without addressing any actual learning that was or was not occurring throughout the lesson. At that point, I was confused. I tried to pinpoint the problem, however I could not decide if the issue was the teacher's lack of understanding effective instruction, the observer's, or both. Knowing that school leaders have the potential to impact student achievement by helping teachers fine-tune instruction (Gamage et al., 2009), I knew this was something I wanted to explore further. This led me to believe that perhaps school leaders really do not know how to effectively observe mathematics instruction and provide useful feedback to teachers. The disconnect between my understanding of effective instruction and how the previous administrator rated the same teacher's less-than-adequate lesson fueled my interests for this study. More specific research questions are listed in the following section.

Research Questions

This study addressed the overarching question: What should elementary school leaders know in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation? This investigation also investigated the following sub-questions:

1. What should elementary school leaders know about mathematics content in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?

2. What should elementary school leaders know about student pedagogy in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?
3. What should elementary school leaders know about how teachers learn to teach mathematics in order to provide effective feedback to teachers after an observation?

Next, I will describe the research design and rationale I used to answer my research questions.

Research Design & Rationale

The study was conducted using the Delphi technique, also referred to as the Delphi (Hasson, Keeney, & McKenna, 2000; Powell, 2002). The Delphi is an iterative process consisting of a series of sequential questionnaires or rounds, completed by a panel of experts (Linstone & Turnoff, 1975). After each round was completed, feedback regarding participants' responses was given back to the panel, and new questionnaires based on their input were generated (Murphy et al., 1998). The end-result was a consensus of opinion from a group of individuals knowledgeable about mathematics leadership (Linstone & Turoff, 1975). The research technique is based on the premise that the collective opinions of experts are more powerful than the limited view of an individual (Nworie, 2011). Linstone and Turoff (1975) described two criteria regarding the appropriateness of the Delphi:

- 1) the problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis

- 2) individuals who need to interact cannot be brought together in a face-to-face exchange because of time or cost constraints (p. 275).

My quest to pinpoint what elementary school leaders need to know and do in order to effectively observe instruction and provide useful feedback met both of these criteria. Because a depth of concrete research doesn't exist regarding the knowledge and actions of effective mathematics school leaders (Cobb & Jackson, 2011), and the study surveyed a national sample of panelists, I found the Delphi to be an appropriate methodology for this research. The Delphi technique has strengths, assumptions, limitations, and delimitations.

Strengths

Proponents of the Delphi find many benefits to the methodology. First, the method is one that capitalizes on the benefits of gathering information from many sources, or many individuals with expertise pertaining to a topic (Yousuf, 2007). Secondly, the Delphi is a process for informed individuals to come to an agreement pertaining to a topic in a convenient manner (Lindeman, 1975). The process can be described as an efficient process (Everett, 1993) that is inexpensive to facilitate (Jones et al., 1992). It has the ability to welcome perspectives from a diverse group of participants separated geographically (Jones et al., 1992) and allows flexibility for experts to respond on their own time (Brooks, 1979). Lastly, the Delphi technique maintains confidentiality among group members (Yousuf, 2007). The confidentiality is beneficial for group members who may feel uncomfortable expressing their opinions in a group, particularly when a few outspoken individuals dominate the group (Murphy et al., 1998; Linstone & Turnoff, 1975). The confidential nature of the panel also equalizes any negative effects

that may arise from panelists who feel inadequate compared to others who may have more seniority or experience in the field (Jairath & Weinstein 1994). Overall, the process conveniently utilized the thoughts of a group, and allowed participants to share ideas confidentially. The Delphi, however, is not without assumptions, limitations and delimitations.

Assumptions, Limitations and Delimitations

An assumption is, “any important ‘fact’ presumed to be true but not actually verified,” (Gay & Airasian, 2000, p. 56). Limitations are aspects of a study that may have a negative impact on the results or on the ability of the researcher to generalize, and are typically not within the control of the researcher (Roberts, 2010). Delimitations, on the other hand, define the scope and boundaries of a study, and remain within the control of the researcher (Simon, 2011). First, I will describe the assumptions of this study.

Assumptions. In accordance with the definition, assumptions of this study include:

- participant responses accurately reflect their professional opinion (Roberts, 2010)
- participants are truly knowledgeable about mathematics leadership (Altschuld & Thomas, 1991)
- more people are less likely to produce inaccurate results compared to one individual (Hasson, Keeney, & McKenna, 2000)
- school leaders are not certain how to effectively observe instruction and provide feedback, otherwise they would

Limitations. One potential limitation and threat to credibility of the Delphi is the possibility of participants conforming to others' statements in subsequent questionnaires as a response to the feedback from previous rounds (Murphy et al., 1998). This may be based on the, "subtle pressure to conform with group ratings," (Witkin & Altschuld, 1995, p. 188). In other words, some panelists may change their opinions based on the feedback from the previous round in order to move with the flow of the group rather than basing their responses on their true personal opinion (Cole, Donohoe, & Stollefson, 2013). Because some participants might change potentially relevant views in response to different views from the rest of the panel, it is important to note that the final consensus doesn't necessarily represent a 'correct' answer, rather an agreed upon conclusion (Keeney, Hasson, & McKenna, 2011). In order to counterbalance this possibility and strengthen the validity of the Delphi, I will ensure that my panelists are knowledgeable about mathematics instruction and leadership, and have an interest in the topic (Goodman, 1987).

Another limitation pertains to the final-outcome of the Delphi rounds. While the goal of the Delphi is to reach a consensus, survey iteration can actually conclude in a lack of agreement and consensus (Cole, Donohoe, & Stollefson, 2013). That is, a consensus, according to the researcher's definition, may never be reached. The following section includes the delimitations of the study.

Delimitations. Delimitations of this study include:

- potential attrition due to time commitment and/or a decline in interest (Nworie 2011)

- defining what constitutes an ‘expert’ (Keeney, Hasson, & McKenna, 2011)
- defining a ‘consensus’ (Powell, 2002)
- focusing strictly on elementary school leaders
- time of the study: October 2013 – February 2014 (Roberts, 2010)

There are strategies that I employed, however, in order to minimize the effects of the delimitations, and increase the credibility of the study.

e-Delphi

In an attempt to make the process simple for the participants, I conducted the study via an e-Delphi approach, a method that utilized the internet for communications and data collection (Cole, Donohoe, Stollefson, 2013; Gill, Leslie, Grech, & Latour, 2013). I used e-mail to communicate with panelists and I administered the questionnaires using www.survey.vt.edu, an online survey platform used to create and administer the survey to panelists. I chose the survey tool accessed through Virginia Tech because it is a secure platform approved by the Virginia Tech Institutional Review Board. Also, results from the survey could be easily transferred to an Excel document. Using the internet to facilitate the transmission of data helped the issue of attrition by shortening the potentially lengthy and frustrating timeframe in between rounds (Donohoe & Needham, 2009). Facilitating the process online also saved money, eliminating the need for paper products and postage (Hung & Law, 2011). Overall, the internet was an appropriate medium for the study, as it allowed me to gather the input of a geographically diverse panel, and communicate and share information in a convenient, secure, timely, and inexpensive manner. Next, I will describe the steps in the Delphi process.

The Delphi Process

The Delphi technique consists of a series of questionnaires or ‘rounds’ to seek the knowledge and opinions of a group of participants regarding a topic they are perceived as having expertise (Keeney, Hasson, & McKenna, 2011). Brooks (1979) proposed the following steps to use throughout the Delphi:

1. Identify a panel of experts.
2. Determine willingness of individuals to participate.
3. Gather individual input on the issue being studied.
4. Analyze initial data from the panel.
5. Compile information and develop a new questionnaire for a second round of input.
6. Analyze second round input and return to panel members.
7. Request that all panel members evaluate their responses relative to responses from the group.
8. Analyze input and conduct a third and final round of question (p. 379).

I followed Brooks’ eight-step plan. Table 1 lists the steps I took to conduct the Delphi, including a timeline for completion. Another critical factor in the process included piloting the questionnaires for each round (Gill et al., 2013). Piloting the questionnaires ensured that the instrument was technically unchallenging, clear and concise, and contained unambiguous instructions for the panelists (Cole, Donohoe, & Stollefson, 2013). To ensure its simplicity, I piloted my questionnaires with other principals, assistant principals, and math coaches with whom I work.

Participant Selection

Choosing the panel of participants is a critical component of the Delphi (Hsu & Sandford, 2007). Some argue that choosing an appropriate panel is the most important step in the Delphi process in order to ensure high quality and credible results (Nworie, 2011). Ultimately, my goal was to select a panel of participants who was knowledgeable and interested in the topic. Two aspects of the panel selection include: 1) defining what constitutes an expert, and 2) selecting the size of the panel (Powell, 2003).

Defining the qualifications of an expert. Researchers debate the definition of an expert and how they should be identified (Keeney, Hasson, & McKenna, 2011).

Essentially, panelists should be experienced, knowledgeable professionals who can provide informed feedback regarding the area of study (Nworie, 2011; Hsu & Sandford, 2007). I selected panelists who were well-informed about mathematics instruction and leadership, had a willingness to contribute, and the dedication to complete the Delphi questionnaires (Keeney, Hasson, McKenna, 2011). To identify potential candidates, I employed snowball sampling (Nworie, 2011, Patton, 2002, Louis, 1994). Also known as chain sampling, this purposeful means of selecting participants provided me panelists I invited personally as well as other panelists recommended by the experts I initially contacted.

I began by identifying qualified individuals who had the potential of positively contributing to my study. I contacted authors who have written journal articles in the field of mathematics instruction, professors from top ranking universities according to the U.S. News and World Report (2014), editors of highly revered professional journals, and leaders in relevant professional organizations. I also contacted textbook authors of

various series and publishers, and principal investigators of reputable studies funded by organizations such as The Math and Science Partnership Network. I emailed these individuals and asked them if they would participate in my study and/or would recommend mathematics leaders who might be beneficial to my study. Eventually, through identifying individuals myself and snowball sampling, I was able to gather a panel of 15 experts.

Reaching out to these individuals provided samples from professionals, or current principals and mathematics leaders working within school systems, and academics who are researchers and/or professors knowledgeable about the topic (Cole, Donohoe, & Stollefson, 2013). This helped balance perspectives from researchers and practitioners in the field (Briedenhann & Butts, 2006). As I selected my final panel, I also considered a representation in the years of experience, grade levels supported, and geographical locations. Table 2 outlines each participant's credentials. In addition to the composition of the panel members, the size of the panel is another factor I will consider in the following section.

Panel size. Similar to the process of defining what constitutes an expert, opinions regarding the appropriate size of a panel vary (Nworie, 2011; Keeney, Hasson, & McKenna, 2011). Delphi pioneers, Linstone and Turoff (1975) endorse panels ranging from 10 to 50 participants. More recent proponents of the technique agree that a panel between 10 and 20 is sufficient (Okoli & Pawlowski, 2004). Ultimately, the goal is to find a balance between having too few versus too many panelists (Hsu & Sandford, 2007). Having a panel that is too small might lead to an inadequate representation of opinion, while have a panel that is too large could potentially result in an overabundance

of data to process, or a difficult time encouraging all participants to respond (Nworie, 2011; Hasson et al., 2000). I tried to achieve this balance by creating a panel of about 15 members.

Table 1

Proposed Timeline for Study Completion

Date	Task
August 2013	Identify professional contacts
November - December 2013	Attain IRB Approval Form Expert Panel Create secure e-portal Develop Round I Instrument Pilot Round I Instrument
January 2013	Send Round I Instrument Return Round I Instrument Analyze Round I Results Develop Round II Instrument
February 2014	Send Round II Instrument Return Round II Instrument Analyze Round II Results Develop Round III Instrument
March 2014	Send Round III Instrument Return Round III Instrument Analyze Round III Results

Gaining access and entry. Before individuals were asked to commit to the study, I ensured that they fully understood my background, the goals of my research, the process of the Delphi, and how the information gleaned from the study would be used (Patton, 2002; Hasson et al., 2000). This began to build a relationship between participant and researcher which helped panelists feel invested in the process, resulting in a lower rate of attrition (Hasson et al., 2000). I informed the participants of this information via an emailed letter prior to their participation (Appendix B).

Because this study involved human subjects, I strictly adhered to the guidelines set by the Virginia Tech Institutional Review Board, (Patton, 2002). I informed participants of the voluntary nature of their participation and of their right to conclude their involvement in the study at any point throughout the study, without fear of retribution. Next, I will discuss assurances of confidentiality.

Assurances of confidentiality. One underlying principle of the Delphi is the confidentiality of the process (Hsu & Sandford, 2007). Only I, as the researcher, had access to individual answers throughout each round of the Delphi, therefore, responses remained confidential (McKenna, 1994a). I stored questionnaire data on a USB stick and kept it in a locked filing cabinet. Individuals did not know any identifying information about one another during the process.

Delphi Rounds

A formula does not exist to determine the number of rounds required to complete a Delphi (Hsu & Sandford, 2007), however, the researcher's ultimate goal is to reach a consensus in opinion between the participants (Nworie, 2011). While a typical Delphi contains three rounds of questionnaires, (Powell, 2003) the key to determining the appropriate number is to balance meaningful responses and participation fatigue, or the

rate of diminishing returns (Hasson et al., 2000; Murphy et al., 1998). Three rounds are considered typical in a Delphi and an adequate amount for reaching a valid conclusion (Keeney, Hasson, & McKenna, 2011). I implemented three rounds of questionnaires in the Delphi study.

The data collection instrument I administered in the first round (Delphi I) consisted of three open-ended questions. Although some researchers use existing literature to develop a structured questionnaire for the first round to narrow potential responses into a manageable amount (Hasson et al., 2000), my sample size of approximately 15 was a reasonable size and allowed me to use an open-response questionnaire in order to capture a wide scope of views (Keeney, Hasson, & McKenna, 2011). The questions for the Round I instrument are as follows:

(a) what should elementary school leaders know about mathematics content in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?

(b) what should elementary school leaders know about student pedagogy in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?

(c) what should elementary school leaders know about facilitating teacher growth in order to provide effective feedback to teachers after an observation?

I requested that participants complete the questionnaire within a two week period (Cole, Donohoe, & Stollefson, 2013), and followed-up with non-responders via email. This helped increase response rates, and therefore strengthen the credibility of the Delphi (Hasson et al., 2000).

Once I received responses from Round I, I conducted a content analysis, a thorough approach to analyzing the data (Bernard & Ryan, 2010). First, I entered individual responses into an Excel spreadsheet containing three separate worksheets entitled: content knowledge, pedagogical knowledge, and teacher growth. Then, I sorted through the responses, looked for emerging themes, and grouped similar items together according to the theme (Bernard & Ryan, 2010). Next, I examined each group of similar items and decided whether there were any identical or highly similar responses that could be collapsed into one statement (Keeney, Hasson, & McKenna, 2011). Before I consolidated similar responses, I ensured that all grouped statements fit into the same theme (Bernard & Ryan, 2010). The end result was a consolidated list of statements used as the questionnaire for the second round (Delphi II).

The Delphi II was formatted as a forced choice instrument. I used the collapsed list of responses from the Delphi I and asked the panel members to rate each of the items on a four point Likert scale of importance in relation to the overarching question. Ratings on the scale were 4 = strongly agree, 3 = agree, 2 = disagree, and 1 = strongly disagree. The Round II instrument was distributed electronically to the participants, and again, participants were encouraged to complete their ratings within a two-week period.

In order to analyze the information, I calculated the mean level of agreement for each statement and the percentage of responses for each level of agreement. Originally, survey items that did not rate within the two most favorable categories by at least 60% of the panelists were not going to be considered for the Delphi III instrument. When finding out that 99% of my statements rated within the two most favorable categories by at least 60% of the panel, I decided to narrow the study by focusing solely on the percentage of

participants who strongly agreed with each item. Ultimately, I created the Delphi III questionnaire by using statements with which at least 60% of the participants strongly agreed.

Items that rated in the strongly agree category by at least 80% of the panelists at the conclusion of round two or three were considered as essential knowledge elementary school leaders must have in order to effectively observe mathematics instruction and provide feedback to teachers after an observation. In the following section, I will consider the meaning of a consensus as it applies to Round two and three of my Delphi study.

Consensus

Understanding when a consensus has been reached is an essential component of the Delphi study (Powell, 2003). Similar to the lack of agreed upon rules for selecting participants, research doesn't support one particular definition of consensus in a Delphi study (Hasson et al., 2000). Some researchers suggest that consensus occurs when at least 51% of the panelists agree on an issue (Loughlin & Moore, 1979) while others argue that 80% of the panelists should agree (Green et al., 1999). Other researchers remain ambiguous in their definition by stating that a consensus is reached when *most* of the respondents agree (Butterworth & Bishop, 1995), or when a consensus can be *implied* from the results (Beech, 1997). Keeney, Hasson, & McKenna (2011) state that the level of consensus should be defined based on the importance of the topic. For instance, they argue that a life or death situation would require a 100% agreement, while choosing the color of a new uniform might only require 51% of the responses. Taking into account the recommendations set for by existing research and gauging the importance of mathematics education and leadership, I used 60% as my definition for consensus for items to move to the third round, and 80% as a consensus for my final round.

Table 2

Delphi Participants

Location	Type	Role	Years of Experience	Experience Level
Southeast	Academic	Journal Editor; Professor of Math Education	23	Elementary & Secondary
Southeast	Professional	Principal	32	Elementary
Southeast	Academic	Assistant Professor of Math Education	30+	Elementary & Secondary
Southeast	Professional	K-6 Math Specialist	15	Elementary
Southeast	Academic	Professor of Education; Textbook author	48	Elementary & Secondary
Northeast	Academic	Professor of Math; Textbook author	26	Elementary & Secondary
Midwest	Professional	Assistant Principal	20	Secondary
West	Professional	Math Professional Development (PD) Leader	45	Elementary & Secondary
Southwest	Academic	Retired Professor of Education; Textbook author	40+	Early Childhood
Northeast	Academic	Math Curriculum Developer; PD Leader	34	Elementary
Southeast	Professional	K-12 Math Coordinator	47	Elementary & Secondary
Northeast	Academic	Researcher	25	Elementary & Secondary
Midwest	Professional	Math Consultant	37	Secondary
Midwest	Academic	Math Education Specialist; PD Leader	30+	Elementary & Secondary
Southeast	Academic	University Math Specialist Program Advisor	46	Elementary & Secondary

Reliability and Validity

Reliability refers to the consistency of an instrument. In other words, a reliable instrument used across several studies under the same conditions will yield similar results (Roberts, 2010). The Delphi technique assumes reliability as it avoids group bias and is delivered to each panelist with identical direction and information (Keeney, Hassan and McKenna, 2011). Some researchers question the reliability of the Delphi method based on the nature of the method. Because participants in a Delphi are given the opportunity to revise their opinions based on the feedback from others, some researchers may see this as a weakness in the method (Murphy et al., 1998). Others see the change in opinion as necessary in order to move towards a consensus, and productive because some panelists may identify relevant viewpoints that others may not have thought of themselves (Keeney, Hasson, & McKenna, 2011). In order to strengthen the reliability of the study, I explained the measures I will take to secure a highly knowledgeable panel, and decided that the panel would include about 15 participants, a number sufficient to produce credible results (Okoli & Pawlowski, 2004).

Validity refers to the degree to which findings from the instrument are true (Roberts, 2010). Different factors contribute to the validity of a Delphi including the definition of a consensus, the number of rounds used, response rates, and the selection of the expert panel (Hasson et al., 2000). In order to strengthen the validity of the study, I defined a consensus occurring when 80% of the panel agrees (Green et al., 1999), and explained that the study will contain at least three consecutive rounds of questioning (Powell, 2003). Three rounds is the most commonly accepted number and has “proved sufficient to attain stability in the responses; further rounds tended to show very little

change and excessive repetition was unacceptable to participants” (Linstone & Turoff, 1975, p.223). I also addressed how I will ensure a high level of response rates by conducting the study online and following up with non-respondents (Keeney, Hasson, & McKenna, 2000), and identified how I will choose an expert panel by utilizing the opinions of individuals from NCTM, National Association of Elementary School Principals, and the U.S. Department of Education via snowball sampling. Combining these factors together will help build a reliable and valid study (Keeney, Hasson, & McKenna, 2011).

Summary

Chapter Three contained the purpose of the study, role of the researcher, and an overview of the research design and rationale for selecting this methodology. It also discussed the benefits, limitations, and delimitations of the study, an overview of the Delphi process, and means for increasing credibility. In the next chapter, I will present my findings.

CHAPTER IV

PRESENTATION OF FINDINGS

In order to understand what school leaders need to know to observe a mathematics classroom and provide feedback to teachers effectively, I conducted a three round Delphi study. I gathered a panel of 15 individuals with varying backgrounds and levels of experience in order to have a diverse selection of participants ranging from academics to practitioners actively working in the field (see Table 2 in Chapter 3). First, the panelists developed a list of important factors regarding content knowledge, pedagogical knowledge, and the knowledge of facilitating teacher growth. Then, in two separate rounds, the panel was asked to rate their level of agreement with each statement. The consensus of the group is presented in the following sections.

Round One (Delphi I)

The Delphi I questionnaire (Appendix C) contained three open ended questions. The three questions targeted what school leaders need to know in terms of (a) mathematics content knowledge, (b) mathematics pedagogy, and (c) facilitating teacher growth.

All 15 panelists responded to the Delphi I. Some panelists contributed up to 17 ideas for each question, while other panelists stated one or two ideas per question. After moving some responses between answer sets, I found that the panelists contributed the most ideas regarding mathematics pedagogy, sharing 111 ideas. Following pedagogy, the panelists listed 88 ideas for facilitating teacher growth and 75 ideas for content knowledge.

Content Knowledge

First, the experts answered the question: *what should elementary school leaders know about mathematics content in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?* After consolidating similar statements, the original list of 75 ideas was collapsed into 18 ideas (see Table 3).

The two responses receiving the most comments from panelists referred to the level of knowledge school leaders must have about national, state, and district standards. The experts revealed 14 statements indicating that leaders must have *some* knowledge of standards, and nine ideas stating the importance of school leaders having a *deep* understanding of standards. Some statements were standards specific while others targeted the standards in general. One panelist's opinion changed depending on the standard. S/he stated that school leaders should have a deep understanding of rational numbers and algebra, and some knowledge of how geometry and measurement are connected across grade levels. The 23 total statements referring to the standards were reduced to the two statements: *leaders should have a DEEP understanding of national/state/district elementary mathematics standards* and *leaders should have SOME understanding of national/state/district elementary mathematics standards*. Later rounds of the Delphi further investigated what level of knowledge school leaders need for mathematics standards.

More than half of the panel mentioned the need for school leaders to understand progressions between grades. Additionally, they needed to understand how to solve problems in multiple ways. Forty percent of the panel also stated that school leaders

should understand how lessons and standards build and connect with one another, and have an understanding of the cognitive underpinnings of mathematical ideas.

Table 3

Results of Delphi I: Content Knowledge

Item	Number of Responses
Some understanding of standards	14
Deep understanding of standards	9
Progressions between grades	8
Solve problems in multiple ways	8
Lessons and standards build	6
Why behind algorithms	6
Stages of conceptual development	5
Process of reasoning	4
Problem solving	3
Procedural vs. conceptual knowledge	3
Basic facts: understanding to recall	2
Across the curriculum outside of mathematics	1
Decomposing numbers	1
District's approach to curriculum	1
Four operations: concrete to algorithm	1
Middle and high school content	1
Ten to one relationship in base ten	1
Vocabulary	1

Pedagogical Knowledge

Next, panelists were asked to respond to the question: *what should elementary school leaders know about student pedagogy in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?* Forty-two unique ideas emerged from the list totaling 111 statements (see Table 4).

Sixty percent of the panel mentioned that school leaders should understand the importance of using multiple representations when working with a mathematical concept. Examples of representations included graphs, equations, base-ten blocks, drawings,

symbols, algebraic sentences, and manipulatives. The two items receiving the next most responses from participants included the importance for leaders to be able to recognize genuine engagement and understand the need to create time for students to communicate their mathematical ideas, discoveries, and understandings to one another. Over 60% of the condensed statements were stated by two or more panelists.

Table 4

Results of Delphi I: Pedagogical Knowledge

Item	Number of Responses
Multiple representations	9
Genuine engagement	7
Social interactions/communication	7
Effective questioning	6
Rich mathematical tasks	6
Student-centered classrooms	6
Common Core Standards of Mathematical Practice	4
Differentiation	4
Error analysis	4
Classroom discourse	3
Classroom environment	3
Concrete to pictorial to abstract	3
Instilling confidence in students	3
Manipulatives	3
NCTM Process Goals	3
Process vs. product	3
Time to wrestle with ideas	3
Age appropriate tasks	2
Contextual situations	2
Different work-based configurations	2
Effective curriculum materials	2
Formative and summative assessments	2
High expectations	2
Lesson structure	2
Providing interventions	2
Student self-monitoring	2
Anticipating responses and misconceptions	1
Clear learning target	1
Derailed lessons	1

(continued)

Table 4 (continued)

Results of Delphi I: Pedagogical Knowledge

Item	Number of Responses
Direct instruction will fail	1
Estimations	1
Incorrect solutions are ok	1
Math “tricks”	1
Messy math	1
Problem solving	1
Sharing student strategies	1
Socio-constructivist teaching	1
Student feedback	1
Students as resources	1
Teacher as facilitator	1
Technology	1
Wait time	1

Knowledge of Teacher Growth

Participants brainstormed a list of 88 ideas in response to the question: *what should elementary school leaders know about facilitating teacher growth in order to provide effective feedback to teachers after an observation?* Of the 88 ideas presented, 40 captured the essence of the panelists’ recommendations (see Table 5).

There was less of a consensus on the items listed by the panelists for the question regarding teacher growth as compared to the first two. Six of the 15 panelists mentioned a school leader’s role as a mentor, coach and/or consultant. Some experts stated that a school leader should coach teachers, while other experts claimed that school leader should act more as a mentor or consultant. One panelist stated the importance of school leaders understanding the difference between coaching and mentoring. This feedback was

condensed into the statement: *leaders should understand when to utilize coaching versus mentoring versus consulting roles with teachers.*

One-third of the panelists recommended that a school leader be able to successfully foster Professional Learning Communities, (DuFour & DuFour, 2012) or groups of teachers who meet regularly to plan, support one another, and analyze student data for the sake of raising student achievement. One-third of the panel also advised that school leaders ground feedback on specific events in a lesson.

Table 5

Results of Delphi I: Facilitating Teacher Growth

Item	Number of Responses
Coaching vs. mentoring vs. consulting	6
Professional Learning Communities	5
Specific events	5
Change can be challenging	4
Change takes time	4
Planning	4
Professional development	4
Reflection	4
Time for teachers to grapple with growth	4
Lesson studies	3
Positive before negative feedback	3
Small number of high-leverage practices	3
Teacher stages of development	3
Assessing professional development	2
Developing relationships	2
Feedback anchored in student learning	2
Feedback towards goal/common vision	2
Math resources	2
Model best practices	2
Respect and trust	2
Teacher phobias	2
Utilizing math specialists	2
Approaching difficult situations	1
Assessing growth	1
Common vision	1

(continued)

Table 5 (continued)

Results of Delphi I: Facilitating Teacher Growth

Item	Number of Responses
Conducting post conference	1
Effective questioning strategies	1
Focus on learner and teacher	1
Following up	1
Humor	1
Kindness	1
Mini observations	1
No value judgments	1
Pedagogy, growth, then content	1
Theories of engaging adult learners	1
Three components of feedback	1
Timely feedback	1
Vertical articulation	1
Video recording methods	1
Work with receptive teachers first	1

Round Two (Delphi II)

The Delphi II survey (Appendix D) was created using the collapsed statements from the Delphi I. Round two included 100 statements categorized into three domains: content knowledge, pedagogical knowledge, and knowledge of facilitating teacher growth. Fourteen of the 15 original panel members contributed to the Delphi II. The experts were asked to choose whether they strongly agreed, agreed, disagreed, or strongly disagreed with each statement. Two panelists asked for clarification regarding my definition of a school leader. For the purposes of this study, I defined school leaders as principals, assistant principals, and school based math coaches.

At least 80% of the panel strongly agreed with nine total statements in the second round. Two surfaced in content knowledge, five in pedagogical knowledge, and two

regarding the knowledge required to facilitate teacher growth. These nine statements were considered to be critical findings of the study after the second round as they met the final level of consensus without progressing through the Delphi III.

Content Knowledge

The second round findings related to content knowledge are presented in Table 6. In the table, the essence of each question is stated. Also included is the number of participants who responded to the question (N), the average of the responses (M) when strongly agree = 4, agree = 3, disagree = 2, and strongly disagree = 1, and the percentage of participants who strongly agreed and agreed with each statement.

Two critical findings surfaced in Round II of the study, as at least 80% of the panelists strongly agreed with the statements. First, 100% of the panel strongly agreed that school leaders should understand that mathematics is a process of reasoning rather than just facts, rules and procedures. Next, 86% of the panel also strongly agreed that school leaders should understand the content well enough to distinguish between procedural and conceptual teaching.

On the other hand, just one of the experts felt strongly that school leaders should understand how mathematics connects to other curricular areas. In addition, only three of the 14 panelists strongly agreed that elementary leaders should understand the mathematics students will encounter in middle and high school.

In terms of understanding the standards, 64% of the panel strongly agreed that school leaders should have *some* understanding of them while 57% felt strongly that leaders should have a *deep* understanding. The mean rating was the same at 3.43. Because only statements that received at least 60% responses as strongly agree moved

onto the Round III questionnaire, the only standards statement to progress to the final round was: *leaders should have SOME understanding of national/state/district elementary mathematics standards.*

Three additional statements progressed to the final round. The three statements included the need for leaders to understand their district’s approach to the curriculum, the ten to one relationship in the base ten system, and the “why,” or cognitive underpinnings, of algorithms.

Table 6

Results of Delphi II: Content Knowledge

Item	N	M ^a	% Strongly Agree	% Agree
Process of reasoning	14	4.00	100	0
Procedural vs. conceptual knowledge	14	3.86	86	14
District’s approach to curriculum	14	3.71	71	29
Ten to one relationship in base ten	14	3.69	64	29
Why behind algorithms	13	3.54	64	14
Some understanding of standards	14	3.43	64	21
Deep understanding of standards	14	3.43	57	19
Vocabulary	14	3.62	57	36
Stages of conceptual development	14	3.62	57	36
Lessons and standards build	13	3.54	57	29
Solve problems in multiple ways	13	3.46	57	21
Progressions between grades	14	3.43	50	43
Problem solving	13	3.38	50	29
Stages of conceptual development	13	3.38	50	29
Decomposing numbers	13	3.23	43	36
Basic facts: understanding to recall	13	3.38	36	57
Middle and high school content	14	3.14	21	71
Across the curriculum outside of mathematics	13	3.08	7	86

M^a Rating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Pedagogical Knowledge

For this portion of the survey, the panelists were asked to respond to 42 statements related to the pedagogical knowledge leaders should possess in order to observe mathematics instruction and provide feedback to teachers effectively. This type of knowledge represented the most questions in the survey. The experts strongly agreed with a greater percentage of statements regarding pedagogical knowledge than content knowledge.

At least 80% of the panel strongly agreed with five of the statements. One hundred percent of the panel strongly agreed that school *leaders should know that mathematics classrooms need to be student-centered, where student exploration and conversations precede formal presentation*. One hundred percent of the panel also agreed that school *leaders should understand the use of effective questioning to engage students in developing mathematical understandings and connections*. All but one panel member strongly agreed that elementary school *leaders should understand how to utilize formative and summative assessments*. Eighty-six percent of the panel also strongly agreed that leaders should understand that math can be messy and must take place in a safe environment in which students can feel comfortable taking risks.

Nineteen additional statements were strongly agreed with by at least 60% of the panel (see Table 7). These statements were added to the Round III Delphi instrument.

In round one, many panelists stated the need for leaders to understand the importance of using multiple representations, recognizing genuine engagement, and providing students time to communicate their understandings and discoveries. Results from round two remained consistent, as 71% of the panel strongly agreed that leaders

should understand the importance of using multiple representations and time to communicate, and 64% strongly agreed that leaders must be able to recognize genuine engagement. All three statements progressed to the survey in the third round.

Although zero of the panel members strongly disagreed with any of the statements regarding pedagogical knowledge, four experts did not believe that school leaders should be able to anticipate student responses and possible misconceptions. Two panelists also disagreed that leaders need to understand how to incorporate rich mathematical tasks that have high levels of cognitive demand into daily instruction or how to use technology to strengthen students' mathematical understandings. Lastly, two experts disagreed with the statement: *leaders should understand that direct instruction will fail to reach all students.*

Table 7

Results of Delphi II: Pedagogical Knowledge

Item	N	M ^a	% Strongly Agree	% Agree
Effective questioning	14	4.00	100	0
Student-centered classrooms	14	4.00	100	0
Formative and summative assessments	14	3.93	93	7
Classroom environment	14	3.86	86	14
Messy math	14	3.79	86	14
Student feedback	14	3.79	79	21
Teacher as facilitator	14	3.79	79	21
Problem solving	14	3.71	79	14
Multiple representations	13	3.77	71	21
Social interactions/communication	13	3.77	71	21
Time to wrestle with ideas	13	3.77	71	21
Derailed lessons	14	3.71	71	29
Different work-based configurations	14	3.71	71	29
High expectations	14	3.71	71	29
Common Core Standards of Mathematical Practice	14	3.64	71	21
Process vs. product	14	3.64	71	21
Rich mathematical tasks	14	3.57	71	14
Differentiation	12	3.75	64	21

(continued)

Table 7 (continued)

Results of Delphi II: Pedagogical Knowledge

Item	N	M ^a	% Strongly Agree	% Agree
Instilling confidence in students	13	3.69	64	29
Lesson structure	14	3.64	64	36
Math “tricks”	14	3.64	64	36
NCTM Process Goals	14	3.64	64	36
Genuine engagement	14	3.57	64	29
Direct instruction will fail	13	3.54	64	14
Students as resources	12	3.67	57	29
Classroom discourse	13	3.62	57	36
Concrete to pictorial to abstract	13	3.62	57	36
Estimations	13	3.62	57	36
Effective curriculum materials	14	3.57	57	43
Incorrect solutions are ok	14	3.57	57	43
Wait time	14	3.57	57	43
Clear learning target	13	3.54	57	29
Manipulatives	13	3.46	50	36
Socio-constructivist teaching	13	3.54	57	29
Providing interventions	13	3.54	50	43
Age appropriate tasks	12	3.50	43	43
Contextual situations	14	3.43	43	57
Student self-monitoring	14	3.43	43	57
Error analysis	13	3.38	43	43
Sharing student strategies	14	3.36	43	50
Anticipating responses and misconceptions	13	3.08	36	29
Technology	14	3.07	21	64

^a Rating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Knowledge of Teacher Growth

For the final segment of the Delphi II, participants were asked to rate their level of agreement on 40 items regarding the knowledge elementary leaders must have about facilitating teacher growth. Two critical findings of the study emerged. 12 of the 14 experts strongly agreed that leaders should focus on the teacher and the students when

observing a classroom and understand that trust and respect are essential when supporting teacher growth. More information regarding the results of facilitating teacher growth can be found in Table 8.

At least 79% of the panel either agreed or strongly agreed with 39 of the 40 statements. The statement to receive less than 79% agreement was: *leaders should master knowledge of student pedagogy first, followed by facilitating teacher growth, and content last*. The only additional statement that received a mean rating of less than 3 pertained to the statement: *leaders should understand the need to work with receptive teachers who want assistance before working with resistant staff*.

There was a notable difference in the order of the items from the first round to the second round. Of the top three ideas panelists contributed in the first round regarding facilitating teacher growth, only one idea progressed to the third round. Sixty-four percent of the panel strongly agreed that leaders should know how to foster Professional Learning Communities, or groups of teachers who can collaborate regularly. The statements that dropped in the list and did not meet the criteria included: (a) *leaders should understand when to utilize coaching versus mentoring versus consulting roles with teachers* and (b) *leaders should be able to ground debriefing discussions on specific events in the lesson*.

On the other hand, only one expert mentioned the importance of using observation techniques that focus on the learner and the teacher in round one, while 86% of the panel strongly agreed with this idea in the second round. Similarly, the importance of creating a climate of respect and trust and developing relationships with teachers made a notable rise in their level of consensus.

Table 8

Results of Delphi II: Facilitating Teacher Growth

Item	N	M ^a	% Strongly Agree	% Agree
Focus on learner and teacher	14	3.86	86	14
Respect and trust	14	3.86	86	14
Developing relationships	13	3.85	79	14
Approaching difficult situations	14	3.79	79	21
Common vision	14	3.79	79	21
Time for teachers to grapple with growth	14	3.79	79	21
Effective questioning strategies	14	3.71	71	29
Planning	14	3.71	71	29
Math resources	13	3.69	64	29
Reflection	13	3.69	64	29
Assessing professional development	14	3.64	64	36
Change can be challenging	14	3.64	64	36
Change takes time	14	3.64	64	36
Professional development	14	3.64	64	36
Professional Learning Communities	14	3.64	64	36
Timely feedback	14	3.64	64	36
Vertical articulation	14	3.64	64	36
Small number of high-leverage practices	14	3.57	64	29
Utilizing math specialists	14	3.57	64	29
Following up	14	3.57	57	43
Feedback anchored in student learning	13	3.54	57	29
Assessing growth	13	3.54	50	43
Model best practices	13	3.54	50	43
Specific events	13	3.54	50	43
Theories of engaging adult learners	14	3.50	57	36
Humor	12	3.50	43	43
Teacher stages of development	12	3.50	43	43
No value judgments	14	3.43	50	43
Three components of feedback	12	3.42	36	50
Coaching vs. mentoring vs. consulting	13	3.38	43	43
Feedback towards goal/common vision	14	3.36	36	64
Lesson studies	12	3.33	36	43
Kindness	13	3.31	36	50
Video recording methods	14	3.31	36	50
Conducting post conference	13	3.31	29	64
Teacher phobias	14	3.21	29	64
Mini observations	13	3.15	29	57
Positive before negative feedback	13	3.15	29	50

(continued)

Table 8 (continued)

Results of Delphi II: Facilitating Teacher Growth

Item	N	M ^a	% Strongly Agree	% Agree
Work with receptive teachers first	13	2.92	14	64
Pedagogy, growth, then content	12	2.42	7	29

^a Rating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Overall, at least 80% of the panel strongly agreed with nine total statements in the second round. Two surfaced in content knowledge, five in pedagogical knowledge, and two regarding the knowledge required to facilitate teacher growth. These nine statements were considered to be critical findings of the study after the second round as they met the final level of consensus without progressing through the Delphi III (Table 9).

Table 9

Results of Delphi II: Critical Findings

Item	% Strongly Agree	Domain
Effective questioning	100	Pedagogical Knowledge
Process of reasoning	100	Content Knowledge
Student-centered classrooms	100	Pedagogical Knowledge
Formative and summative assessments	93	Pedagogical Knowledge
Classroom environment	86	Pedagogical Knowledge
Focus on learner and teacher	86	Facilitating Teacher Growth
Messy math	86	Pedagogical Knowledge
Procedural vs. conceptual knowledge	86	Content Knowledge
Respect and trust	86	Facilitating Teacher Growth

Round Three (Delphi III)

I created the Delphi III instrument (Appendix E) by using select statements from round two. In order for an item to move forward to the third round, the percentage of participants who strongly agreed with the statement needed to fall between 60% and 80%. Items that rated at an 80% or higher on the Delphi II were automatically considered to be critical findings of the study. As predetermined before the study began, statements that were not met with strongly agree by at least 60% of the participants were not considered for the third round. Participants were asked to respond to the items summarized in Tables 10, 11, and 12 for the final round of the Delphi study.

Initially, I was going to consider statements for the third round if at least 60% of the panel strongly agreed or agreed with them. Because 99 out of 100 statements fell into this category, I decided to tighten the findings by only considering the percentages in the strongly agree category. This narrowed the Delphi III to 40 total statements.

All but one expert of the 15 member panel completed the third and final questionnaire. Due to the confidential nature of the study, I can't be certain if the panel member who didn't respond in the second round was the same panelist who did not respond in the third round. As the participants responded, they were provided the percentages of the level of agreement for each statement from the second round. Overall, six statements were added to the previous nine to create 15 critical findings of this study.

Two panel members commented that some questions were difficult to answer because I defined a school leader as a principal, assistant principal, or a school based math coach. These two participants did not feel that the expectations for a math coach

were the same for principals or assistant principals. This definition creates a delimitation to the study.

Another panel member commented that the wording of some statements prohibited him/her from agreeing with them. For example, many statements began with the phrase, “leaders *should*...” The panel member commented that in an ideal world, school leaders *should* understand and implement certain practices, such as choosing high leverage practices to focus on when facilitating teacher growth, however, s/he did not think the research and teacher education community has figured out how to take advantage of such practices yet. Therefore, s/he did not find it fair to expect leaders to fully grasp the idea and be able to do it quite yet.

Content Knowledge

The panel was asked to rate their level of agreement with four statements regarding content knowledge. Only one of the four statements surfaced as an additional critical finding of the Delphi study. Eighty-six percent of the panel strongly agreed that school leaders should have *some* knowledge of national, state, and district standards. There was a 22% increase in the percentage of panel members who strongly agreed with this idea in the third round compared to the second round. The elimination of the deep knowledge statement in the second round might have contributed to this consensus by taking away a statement that may have been dividing votes.

There was a decrease in the percentage of panelists strongly agreeing with two of the remaining statements from the Delphi I to the Delphi II. Fewer panelists strongly agreed that *leaders should have a working knowledge of the school/district's approach to the elementary mathematics program* and *leaders should understand the "why" behind*

math algorithms and rules. The same percentage agreed with the statement pertaining to having an understanding of the district’s approach to the curriculum. Overall, three total statements emerged as critical findings related to content knowledge throughout the entire Delphi process.

Table 10

Results of Delphi III: Content Knowledge

Item	N	M ^a	% Strongly Agree	% Agree
Some understanding of standards	14	3.86	86	14
District’s approach to curriculum	13	3.69	64	29
Ten to one relationship in base ten	13	3.54	64	14
Why behind algorithms	12	3.58	57	21

M^a Rating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Pedagogical Knowledge

The panelists in the third round examined nineteen statements regarding pedagogical knowledge. As a result, three additional statements were added as critical findings of this study. One hundred percent of the panel strongly agreed that *leaders should know that the teacher should act as a facilitator of learning.* Eighty-six percent of the panel also strongly agreed that leaders need to understand the importance of giving students time to wrestle with ideas and maintaining high expectations for academic achievement in mathematics.

In addition to the new findings, the panelists came to a stronger level of agreement on three more statements, however, that level of strong agreement did not meet the 80% benchmark to be considered a consensus. The percentage of the panel who

strongly agreed with statements remained the same for eight statements and dropped for the remaining five ideas. There was a 28% decrease in the percentage of panelists who strongly agreed with the statement: *leaders should understand the NCTM Process Goals*, dropping it to the bottom three statements the panelists felt strongly about.

Four statements fell right on the borderline of meeting a consensus. 79% of the panel strongly agreed with the four items pertaining to feedback, problem solving, student processes, and differentiation. In order for an item to reach a consensus, the statement had to be strongly agreed with by 12 experts. All four statements were met with strongly agree by 11 participants. The statements regarding the importance of viewing problem solving as a vehicle of learning and understanding the power in analyzing student processes rather than mere answers were skipped by one panelist each, while two panelists chose not to rate their level of agreement with the statement that described the importance of differentiation.

Three statements that were highlighted in previous rounds as receiving a notable level of strong agreement did not reach a consensus in the third round. Only 71% of the panel strongly agreed that leaders need to know the importance of using multiple representations and allow time for students to communicate, while 57% felt strongly that leaders should be able to recognize genuine engagement.

Table 11

Results of Delphi III: Pedagogical Knowledge

Item	N	M ^a	% Strongly Agree	% Agree
Teacher as facilitator	14	4.00	100	0
Time to wrestle with ideas	14	3.86	86	14

(continued)

Table 11 (continued)

Results of Delphi III: Pedagogical Knowledge

Item	N	M ^a	% Strongly Agree	% Agree
High expectations	13	3.92	86	7
Student feedback	14	3.79	79	21
Problem solving	13	3.85	79	14
Process vs. product	13	3.85	79	14
Differentiation	12	3.92	79	7
Multiple representations	13	3.77	71	21
Social interactions/communication	12	3.83	71	14
Derailed lessons	14	3.71	71	29
Different work-based configurations	13	3.77	71	21
Math “tricks”	14	3.71	71	29
Common Core Standards of Mathematical Practice	14	3.64	64	36
Lesson structure	13	3.69	64	29
Rich mathematical tasks	14	3.57	57	43
Genuine engagement	14	3.50	57	36
Instilling confidence in students	14	3.50	50	50
NCTM Process Goals	13	3.38	36	57

^a Rating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Knowledge of Teacher Growth

The experts were asked to rate their level of agreement on 17 total statements related to teacher growth. Two new ideas emerged for a total of four critical findings of the study. Ninety-three percent of the panel strongly agreed *leaders should understand that planning requires more than reading the lesson and preparing materials*. Eighty-six percent of the experts believed *leaders should know how to help teachers develop the ability to reflect on their own practice*.

Similar to the results regarding pedagogical knowledge, four additional statements were on the verge of being considered critical findings. 79% of the panel strongly agreed

with the statements regarding the importance of creating relationships, establishing a common vision, providing time for teachers to work through new ideas themselves rather than being told what to do, and knowing that change can take time. Three of the four statements were not rated by one panel member. The only statement on the verge of reaching a consensus that was responded to by all members pertained to the need for teachers to have time to grapple with their own growth.

In addition to the two new critical findings, five additional statements were met with higher levels of agreement. On the other hand, the panel’s level of agreement dropped for four statements and remained the same for six statements.

Table 12

Results of Delphi III: Facilitating Teacher Growth

Item	N	M ^a	% Strongly Agree	% Agree
Planning	13	4.00	93	0
Reflection	13	3.92	86	7
Developing relationships	13	3.85	79	14
Common vision	13	3.85	79	14
Time for teachers to grapple with growth	14	3.79	79	21
Change takes time	13	3.85	79	14
Approaching difficult situations	14	3.71	71	29
Change can be challenging	13	3.77	71	21
Professional development	13	3.77	71	21
Timely feedback	14	3.71	71	29
Small number of high-leverage practices	13	3.69	71	14
Assessing professional development	13	3.69	64	29
Vertical articulation	13	3.69	64	29
Utilizing math specialists	13	3.69	64	29
Effective questioning strategies	14	3.57	57	43
Math resources	13	3.46	50	36
Professional Learning Communities	14	3.43	50	43

^a = Rating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

Summary

A three round Delphi study was conducted to pinpoint what elementary school leaders need to know in order to observe instruction and provide feedback to teachers after an observation. The study was conducted with a 15 member expert panel that included representatives from academics to professionals working in the field.

In the first round, participants were asked to brainstorm a list of items to answer three open ended questions regarding content knowledge, pedagogical knowledge, and knowledge of facilitating teacher growth. The experts were asked to rate their level of agreement with each statement in the following two rounds. Ultimately, at least 80% of the panel strongly agreed with 15 ideas. These are the critical findings of this study (Table 13).

Table 13

Critical Findings of the Delphi II and III

Item	% Strongly Agree	Domain
Effective questioning	100	Pedagogical Knowledge
Process of reasoning	100	Content Knowledge
Student-centered classrooms	100	Pedagogical Knowledge
Teacher as facilitator	100	Pedagogical Knowledge
Formative and summative assessments	93	Pedagogical Knowledge
Planning	93	Facilitating Teacher Growth
Classroom environment	86	Pedagogical Knowledge
Focus on learner and teacher	86	Facilitating Teacher Growth
High expectations	86	Pedagogical Knowledge
Messy math	86	Pedagogical Knowledge
Procedural vs. conceptual knowledge	86	Content Knowledge
Reflection	86	Facilitating Teacher Growth
Respect and trust	86	Facilitating Teacher Growth
Some understanding of standards	86	Content Knowledge
Time to wrestle with ideas	86	Pedagogical Knowledge

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Chapter Five contains a summary of the study and critical findings of the Delphi as they relate to existing literature. It also examines surprises that surfaced throughout the process, implications for action and recommendations for further research.

Summary of the Study

School leaders are responsible for ensuring high-quality mathematics learning for all students. In order to lead this teaching and learning, school leaders must observe instruction and provide teachers with informed feedback. If school leaders can help teachers become better practitioners in the classroom, leaders can have a real impact on raising student achievement. As a result of minimal research and contradictory recommendations guiding school leaders towards mathematics leadership, many school leaders are not effectively fostering growth in mathematics instruction. The purpose of this study was to provide clarity to school leaders by pinpointing what elementary school leaders need to know in order to effectively observe mathematics instruction and provide teachers with feedback. More specifically, the study examined what school leaders need to know in terms of content knowledge, pedagogical knowledge, and knowledge of facilitating teacher growth.

The study was conducted using the Delphi Method. Throughout the process, a panel composed of 15 experts in mathematics leadership contributed ideas in a three round process. The study concluded with 15 guidelines regarding what school leaders need to know in order to effectively observe elementary mathematics instruction and provide informed feedback to teachers.

Critical Findings

Throughout the process of the Delphi Study, 15 total guidelines emerged as critical findings of this study. Key findings reveal that leaders should:

1. understand that elementary mathematics is a process of reasoning rather than just facts, rules and procedures
2. know how to distinguish between procedural and conceptual teaching
3. have SOME understanding of national/state/district elementary mathematics standards
4. know that mathematics classrooms need to be student-centered, where student exploration and conversations precede formal presentation
5. understand the use of effective questioning to engage students in developing mathematical understandings and connections
6. understand how to utilize formative and summative assessments
7. understand how to set up a safe, respectful classroom where students are comfortable taking risks
8. understand that a truly student-centered lesson may be 'messy'
9. know that the teacher should act as a facilitator of learning
10. know that students need time to wrestle with their own confusion when solving a problem
11. understand the importance of high expectations for all students
12. know that respect and trust are essential in supporting teacher growth
13. use observation techniques that focus on the learner as well as the teacher

14. understand that planning requires more than reading the lesson and preparing materials

15. know how to help teachers develop the ability to reflect on their own practice

Before delving into each recommendation and connecting it to existing literature, it is imperative to reiterate that the critical findings were established when at least 80% of the panel *strongly* agreed with the statement. Ninety-eight of the 100 original ideas shared by the experts were met with *some* level of agreement by about 80% or more of the panel. Therefore, just because a statement did not emerge as a critical finding of the study, one cannot conclude that the recommendation is not valid or important. Such statements simply were not met with a *strong* level of agreement as established by the level of consensus required in this study. A table listing all of the findings can be found in Appendix F. In the following sections, I will discuss the critical findings as they compare to existing literature.

Findings Related to the Literature

The Math Wars remind us that the mathematics pendulum has been swinging for decades, fluctuating between emphasizing the importance of basic facts, to focusing on problem solving and exploration (Kilpatrick 2001, 2009a; Herrera & Owens, 2001). The first finding of this study, of which 100% of the participants strongly agreed, suggests that leaders should look for and encourage methods that support learning as a process in which the learner actively explores and invents knowledge on a personal level rather than being given procedures and rules to follow (Molina, 2014; Fox, 2001). Students must learn mathematics with an understanding and become actively engaged in the process to build new knowledge from experiences (www.nctm.org, 2014).

Supporting the need for leaders to view mathematics as a process, experts strongly agreed that: (a) *mathematics classrooms need to be student-centered, where student exploration and conversations precede formal presentation* where (b) *the teacher should act as a facilitator of learning*. The idea of student-centered classrooms supports constructivist theories, suggesting that learning is a process in which the learner actively invents knowledge, making sense of the world by exploring and working with other students to create their own understandings (Fox, 2001). In a student-centered classroom, the teacher must not act primarily as a transmitter of knowledge, rather a facilitator who leads students through exploration, investigation, and discovery (Herrera & Owens, 2001).

As the facilitator, experts strongly agreed that *leaders should understand the use of effective questioning to engage students in developing mathematical understandings and connections*. Also supporting constructivist views, leaders must watch for teachers listening to students and asking effective questions to guide students through potential discourse while helping students make connections between understandings (Molina, 2014; Nelson, 1999). Some opponents of constructivism believe that too little guidance throughout a lesson can have a negative impact, as students could potentially create misconceptions from disorganized thinking (Kirschner et al., 2006). Therefore, teachers must use questioning that stimulate students' thinking, challenge them to make sense of what they are doing, and guide them towards targeted understandings (Kanold, Briars, & Fennell, 2012).

Next, the panel concluded that leaders should *understand the content well enough to distinguish between procedural and conceptual teaching*. Leaders must be able to

distinguish between traditional methods that rely on procedural knowledge, or the mastery of computation skills, rote knowledge of procedures, algorithms, and definitions, (Kirschner et al., 2006; Eisenhart, et al., 1993) and constructivist methods that facilitate an understanding of mathematical relationships and connections within numeracy (Molina, 2014; Whitehurst, 2003). The panel did not conclude, however, that direct instruction should never be implemented nor should leaders necessarily solely look for “socio-constructivist” teaching. Although many of the critical findings of this study support constructivist theories, the lack of consensus can lead us to believe that neither direct instruction nor sheer constructivism should dominate 100% of the time (Whitehurst, 2003; Stein & D’Amico, 2000). Instruction in today’s classrooms, however, does not reflect the balance of methods and tends to lean more towards traditional means of instruction (Silver, 2010; Kazemi, Franke, & Lampert, 2009). In response, school leaders must be able to distinguish between the two approaches to teaching and understand when to incorporate components of each theory successfully (Molina, 2014; Ball et al., 2005).

Findings of this study also reveal a leader must understand that (a) *a truly student-centered lesson may be 'messy'* and (b) *students need time to wrestle with their own confusion when solving a problem*. Student discourse is often associated with a successful and sometimes unpredictable mathematics classroom (Frykholm, 2004). Lesson derailment, or veering from one’s original objectives to explore and clarify student discourse, is not only acceptable, but potentially powerful, as confusion is something from which students and teachers can learn (Nelson, Benson, and Reed, 2004). Although cognitive dissonance and discourse can make math unpredictable and messy, school

panelists and existing research agree that leaders must understand that it is essential to a mathematics classroom (Frykholm, 2004). It is through this time and exploration that students have the time to grapple with the discourse and build their own understanding (Nelson & Sassi, 2000).

Panelists also strongly agreed that *leaders should understand how to set up a safe, respectful classroom where students are comfortable taking risks*. Current research describes a reformed classroom as one where students respect each other's thinking, trust in one another to withhold judgments regarding their thinking, and the commit to support and investigate each other's thinking (www.nctm.org, 2014; Nelson & Sassi, 2006). Within this safe environment, the experts also concluded that *leaders should understand the importance of high expectations for all students*. It is critical to provide access to students without lowering the cognitive demand of the task (Jackson, Garrison, Wilson, Gibbons, & Shahan, 2013).

As in setting up a safe student environment, experts strongly agreed that *leaders should know that respect and trust are essential in supporting teacher growth*. This finding does not reveal anything new, rather it adds to the depth of existing research that emphasizes the importance of respect and trust in the workplace (Kouzes & Posner, 2012; Louis, Dretzke, and Wahlstrom, 2010).

One way of building this respectful and trust worthy climate is by adhering to another critical finding: *leaders should use observation techniques that focus on the learner as well as the teacher*. Teachers are more apt to grow if they experience authentic conversations directed towards improving student learning, rather than judgmental interactions that focus only on teacher behaviors (Fulmer, 2006). Successful leaders also

pose open-ended questions focused on student learning, allowing teachers to feel comfortable participating in the conversation rather than posing questions that target a teacher's actions. Only pinpointing a teacher's actions can negate a sense of trust between leader and teacher, quickly stifling the conversation (Nelson, 1999).

Experts also strongly agreed that *leaders should know how to help teachers develop the ability to reflect on their own practice*. Effective school leaders ask questions to stimulate deep reflection and encourage teachers to think about current practices and construct their own meaning of effective instruction (Nelson, 1999). This finding supports the idea that school leaders should not necessarily be defined as assessors of teacher competence, rather as individuals who facilitate discourse and teacher growth through self-reflection (Reitzug, West, & Angel, 2008).

In terms of the actual content school leaders must possess, 86% of the panel strongly agreed that leaders should have *some* understanding of the standards. This finding somewhat supports the idea that elementary leaders need to possess subject specific knowledge, (McConachie & Petrosky, 2009; Spillane, 2005; Burch & Spillane, 2003; Stein & Nelson, 2003), however, the depth of it remains undefined. The experts agreed, under the stringent criteria of this study, that some knowledge of the standards is needed. A majority of the panel thought that a deep understanding is required, but not enough agreement was reached to make that statement a critical finding.

In addition to the standards, the panel concluded that *leaders should understand how to utilize formative and summative assessments*. Some researchers agree that assessment practices may be the most important factor a leader should consider when observing instruction as they can have a significant impact on student achievement

(Hattie, 2012; Wiliam, 2007b). The experts agree with recent literature supporting the importance of each type of assessment. Leaders need to understand that high-quality assessment practices combine formative assessment for learning with summative assessment of learning (Kanold, Briars, & Fennell, 2012).

Lastly, the panel reached a consensus regarding the statement: *leaders should understand that planning requires more than reading the lesson and preparing materials.* More specifically, leaders must help teachers understand that planning is an important time for teachers to understand how an individual lesson advances the mathematical goals of the unit and identify the important goals for the lesson (Ball et al., 2005). It is a time to brainstorm high levels of questions to ask students, anticipate student responses and misconceptions, plan how to address different learning needs (Molina, 2014; Ball, Thames, & Phelps, 2008). Lastly, planning should be used to create multiple assessment strategies to determine if the goals of the lesson are being achieved (Kanold, Briars, & Fennell, 2012).

Unintended Outcomes

A couple of unintended outcomes surfaced as I was conducting my research. First, in terms of technicalities of the study, I was not expecting panelists to skip responding to a statement. After receiving feedback from a couple of panelists, however, it became clear that my definition of a leader might have hindered participants from responding to all questions. Two of the 15 panelists reflected that my definition of a leader made it difficult to answer some questions. I defined a leader as a principal, assistant principal or school-based math coach. The two experts who voiced their concern indicated that the responsibilities do and should radically differ between administrators and content leaders

in a school. Therefore, they were unable to answer some of the questions, which could have potentially led to fewer critical findings of the study.

I was also surprised that a few particular statements did not surface as critical findings. First, only 57% of the panelists strongly agreed that *leaders should be able to distinguish between students actively following directions versus students actively thinking about a problem*. Also known as genuine engagement, almost half of the original panel mentioned the importance of being able to recognize this in classrooms as they replied to the first round questionnaire. Active engagement, a criteria included as an important Common Core Standard of Mathematical Practice, is also considered a meta-strategy, or an instructional practice that leaders should look for when observing any mathematics classroom, regardless of its projected learning outcomes or targeted standards (Kanold, Briars, & Fennell, 2012). Perhaps if the statement would have included the term ‘genuine engagement’ more panelists would have strongly agreed.

Lastly, the panel did not reach a strong consensus regarding either statement about using multiple representations to solve mathematics problems. Both the NCTM Process Goals and the Common Core Standards for Mathematical Practice state the importance of using multiple representations. Eight of the original 15 panelists mentioned the idea of multiple representations in response to the open ended content knowledge question and nine participants mentioned the importance of multiple representations when thinking about study pedagogy. The two statements that did not meet the criteria as critical findings were: (a) *leaders should be able to solve problems observed in a classroom in multiple ways* and (b) *leaders should understand the importance of using multiple representations when working with a mathematical concept*. While I understand

that it might not be critical for leaders to be able to represent problems in multiple ways themselves, I would at least expect that they should understand the importance of and look for teachers and students working with multiple representations.

Perhaps the study would have yielded different results if I defined leader only as a principal or assistant principal. Similar statements with different and perhaps more clear wording, may have also provided different conclusions.

Implications for Action

Many school leaders are uncomfortable as instructional leaders in mathematics and see mathematics improvement as the responsibility of someone other than themselves (Nelson, Stimpson, & Jordan, 2007; Spillane, 2005; Brenninkmeyer & Spillane, 2004). The results of this study add to the minimal and outdated research that exists regarding how school leaders can influence effective instruction (Robinson, Lloyd, & Rowe, 2008). Adding to the depth of research, specifically addressing how school leaders can impact improvements in mathematics through observing and providing feedback, is an important step in giving school leaders the information they need to become comfortable with and take ownership of leading mathematics improvement.

Overall, the findings from this study validate existing research and can equip leaders with more information in terms of observing mathematics instruction and providing feedback to teachers. Principals, assistant principals, and school based math coaches can use the guidelines as a place to start when delving into classroom observation practices and facilitating teacher growth.

Districts and other organizations can use this information to create professional development opportunities for school leaders. Workshops can be created to target the 15

understandings allowing time for school leaders to experience, observe, and reflect on the critical findings as they apply to the classroom. Lastly, the findings in this study can provide guidance to leadership preparation programs at the university level as they work to build solid instructional leaders who will ultimately help raise student achievement.

Recommendations for Further Research

Strengthening mathematics leadership is a monumental task that will take time, commitment, and knowledge. Additional research in the field may benefit the forward momentum of helping leaders become and remain highly effective in terms of mathematics instruction. One idea for further research is the possibility of replicating this study with a completely different set of panel members with a variety of backgrounds. If replicated, response sets could potentially tighten if the definition of school leaders only included principals and assistant principals.

If the study is replicated, I would caution the researcher as s/he decides how many open ended questions to include in Round One of the Delphi study. It could be beneficial to choose only one domain of Leadership Content Knowledge to explore. Analyzing the data from three open-ended questions and creating a forced choice instrument for the second two rounds was difficult in terms of finding the balance between capturing the depth of participants' thoughts, and creating a questionnaire that was realistic in size. The richness of the specificity of responses was somewhat lost as I tried to keep the questionnaires a respectable length, therefore, it would be helpful to narrow the focus from the start.

Another seemingly natural next step in the research could be to compare the recommendations from this study to the reality of what school leaders actually know

about content, pedagogy, and facilitating teacher growth. One study could be done to analyze what leaders know, while another could study staff perceptions on leaders in terms of their mathematics leadership. A third study could compare leader beliefs with staff perceptions. Regardless of the study, once the current state of leaders' knowledge is examined, professional development could be implemented to build on any deficits.

A similar Delphi study could also be conducted to investigate what essential knowledge school leaders need to know in terms of language arts, social studies, or science instruction. The results could be analyzed across the other subjects in order to gain an understanding of what knowledge may be universal to all classrooms versus knowledge that is content specific.

Lastly, a researcher could take the 15 recommendations and dig further into the meaning of each statement. For example, what are specific characteristics of a student-centered classroom? What does it look like? This would create a more solid understanding of the recommendations as they apply to the elementary classroom.

Concluding Remarks

School leaders are faced with a myriad of responsibilities of which observing instruction and providing feedback is only one small sector. When beginning to process and implement these findings, it is important to remember that this is not an exhaustive list of critical ideas to consider when observing mathematics instruction and providing feedback to teachers after an observation. It is, however, a good place to start.

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APPENDIX A

IRB Approval Letter



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0969
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: February 6, 2014
TO: William Joseph Glenn, Lindsay Erin Elliott, Walt Mallory
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)
PROTOCOL TITLE: What Elementary Leaders Need to Know in Order to Observe Mathematics Instruction and Provide Feedback to Teachers Effectively: A Delphi Study
IRB NUMBER: 13-974

Effective February 6, 2014, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Exempt, under 45 CFR 46.110 category(ies) 2**
Protocol Approval Date: **October 31, 2013**
Protocol Expiration Date: **N/A**
Continuing Review Due Date*: **N/A**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

APPENDIX B

Letters to Participants

Lindsay E. Elliott
Doctoral Candidate
Virginia Tech

Phone: 703.201.7407
Email: psulee117@gmail.com

Potential Participant's Name
Title
Location
Email Address

Dear (Potential Participant),

I am a doctoral student at Virginia Tech. I am conducting research regarding the knowledge elementary school leaders must have in order to effectively observe mathematics instruction and provide informed feedback to teachers. As an assistant principal in a Title I school for the past five years and a mathematics teacher six years prior, I am passionate about facilitating teacher growth in order to raise student achievement. I found that existing research regarding this topic is somewhat contradictory, therefore, the purpose of this study is to provide clarity to school leaders by pinpointing what elementary school leaders need to know in terms of mathematics content knowledge, student pedagogical knowledge, and knowledge of how teachers learn to teach mathematics.

The study will be conducted using the Delphi technique. The methodology is an iterative process consisting of a series of sequential questionnaires or rounds, completed by a selected panel of experts. The members of the panel are confidential throughout the process. Typically, there are three rounds to the process. Round one is open-ended and will contain three questions. Rounds two and three will include the information collected from the previous questionnaires and participants will be asked to complete rating scales concerning the items. The end-result will be a consensus of opinion regarding what school leaders need to know in order to effectively observe elementary mathematics instruction and provide informed feedback to teachers.

I identified you as a strong potential candidate as a member of my panel. I feel that your experiences in the field of education would provide invaluable information for my study. Please reply via email to let me know if you would be willing to participate. I will send an official Consent Form with the Round 1 Questionnaire. I anticipate that this study will begin in with Questionnaire 1 in November and conclude with the final questionnaire in January.

In addition to your decision to participate in this study, I am also interested in any names of other individuals you feel might be qualified, interested participants to contact. These individuals may include researchers, principals, assistant principals, or math specialists that you feel have a deep understanding of mathematics leadership, particularly at the elementary level.

I appreciate your time, and hope to hear back from you!

Sincerely,
Lindsay E. Elliott
Lindsay Elliott
Doctoral Candidate

Lindsay E. Elliott
Doctoral Candidate
Virginia Tech

Phone: 703.201.7407
Email: psulee117@gmail.com

Potential Participant's Name
Title
Location
Email Address

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I am a doctoral student at Virginia Tech. I am conducting research regarding the knowledge elementary school leaders must have in order to effectively observe mathematics instruction and provide informed feedback to teachers. As an assistant principal in a Title I school for the past five years and a mathematics teacher six years prior, I am passionate about facilitating teacher growth in order to raise student achievement. I found that existing research regarding this topic is somewhat contradictory, therefore, the purpose of this study is to provide clarity to school leaders by pinpointing what elementary school leaders need to know in terms of mathematics content knowledge, student pedagogical knowledge, and knowledge of how teachers learn to teach mathematics.

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You have been identified as a strong potential candidate by another professional in the field. S/he feels that your experiences in the field of education would provide invaluable information for my study. Please reply via email to let me know if you would be willing to participate. Then, I will send an official Consent Form with the Round 1 Questionnaire. I anticipate that this study will begin with Questionnaire 1 in November and conclude with the final questionnaire in January.

I appreciate your time, and hope to hear back from you!

Sincerely,

Lindsay E. Elliott

Lindsay Elliott
Doctoral Candidate

APPENDIX C

CONSENT FORM

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY INFORMED CONSENT FORM FOR PARTICIPANTS OF INVESTIGATIVE PROJECTS

Study Title: What Elementary Leaders Need to Know in Order to Observe Mathematics Instruction and Provide Feedback to Teachers Effectively: A Delphi Study

Investigators: William Glenn, Ph.D. Walter Mallory, Ph.D. Lindsay Elliott
wglenn@vt.edu wmallory@vt.edu psulee117@gmail.com
703.538.8493 703.538.8496 703.201.7407

I. PURPOSE OF THE PROJECT

Improving mathematics instruction is an essential issue many school leaders are encountering as they feel increased pressure to ensure high-quality learning for all students. Key responsibilities of school leaders in leading mathematics improvement include observing instruction and providing teachers with feedback. If school leaders fulfill these responsibilities effectively and help teachers become better practitioners in the classroom, they can have a substantial impact on raising student achievement. As a result of minimal research and contradictory recommendations guiding school leaders towards mathematics leadership, many school leaders are not effectively fostering growth in mathematics instruction. The purpose of this study is to provide clarity to school leaders by pinpointing what elementary school leaders need to know in order to effectively observe mathematics instruction and provide teachers with feedback. The study will be conducted using a three-round Delphi technique with an expert panel composed of approximately 15 stakeholders with diverse perspectives in the area of mathematics leadership. The Delphi technique is an iterative process consisting of a series of sequential questionnaires or rounds, completed by a panel of experts. After each round is completed, feedback regarding participants' responses is given back to the panel, and new questionnaires based on their input are generated. The end-result will be a consensus of opinion from a group of individuals knowledgeable about mathematics leadership.

II. PROCEDURES

You are asked to participate in this study by completing three rounds of questionnaires. The first round will consist of three open-ended questions. The second and third rounds will be formatted as a forced choice instrument based on the responses from the previous rounds. The questionnaires will be administered via www.survey.vt.edu. The expected time commitment required should not exceed a total of 2 hours. Participants will have two weeks to respond to each questionnaire.

III. RISKS

There are no risks involved in this study.

IV. BENEFITS OF THIS PROJECT

Participants will be providing information regarding necessary information elementary school leaders must have in order to effectively observe instruction and provide informed feedback to teachers. This information may be beneficial for school districts as they form professional development opportunities, and for universities who are preparing future mathematics leaders. When research is completed and results compiled, you are welcome to contact the investigator for the results.

V. EXTENT OF ANONYMITY AND CONFIDENTIALITY

The results of the study and the participants will be kept strictly confidential. Participants will be given a code which will be used during the entire research process and Lindsay Elliott, the researcher, and Dr. William Glenn & Dr. Walter Mallory, faculty advisors, are the only individuals who will have access to the code. Questionnaire responses and codes will be secured in the home of the researcher. All analysis will be conducted by Lindsay Elliott, and reviewed by Dr. William Glenn and Dr. Walter Mallory. All data will be destroyed after a period of three years. It is possible that the Institutional Review Board (IRB) may view this study’s collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research.

VI. COMPENSATION

There is no compensation for participating in this study.

VII. FREEDOM TO WITHDRAW

You are free to withdraw from the project at any time. You reserve the right to refuse to answer any item on any of the questionnaires.

VIII. SUBJECT’S RESPONSIBILITIES

I voluntarily agree to participate in this study. I have the responsibility of completing three questionnaires.

IX. Subject’s Permission

I have read and understand the Informed Consent and conditions of this project and have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project. If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project. Should you have questions or concerns regarding your participation, feel free to contact Dr. David Moore, Institutional Review Board Chair, at (540) 231-4991 or moored@vt.edu.

X _____
Signature of Study Participant

X _____
Date

APPENDIX D

The Delphi I

What Elementary Leaders Need to Know in Order to Observe Mathematics Instruction and Provide Feedback to Teachers Effectively: A Delphi Study Round 1

Email Content:

Hi, [participant]!

Thank you for agreeing to serve as a panel member for my study regarding elementary mathematics leadership. Please use the following link: <https://survey.vt.edu/> to access the questionnaire for the first round. The password is XYZ. As mentioned, Round 1 will consist of three open-ended questions. Please provide as many responses as appropriate and **use phrases if possible**. I do not necessarily need complete sentences!

Ideally, I would like to have these responses by December 22. That way, I can compile the data and get the second round out in January. All survey responses will be anonymous; therefore you may receive a reminder email from me close to that date if I haven't heard from all 15 panel members by that time.

Lastly, please sign the attached consent form and return via email.

If you have any questions, please do not hesitate to reach out!
Take care and THANK YOU so much for taking the time to complete this during such a busy time of year.

Lindsay Elliott
Doctoral Candidate
Virginia Tech

Questionnaire Items (via www.survey.vt.edu):

1. What should elementary school leaders know about **mathematics content** in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?
2. What should elementary school leaders know about **student pedagogy** in order to observe mathematics instruction knowledgeably and provide effective feedback to teachers after an observation?
3. What should elementary school leaders know about **facilitating teacher growth** in order to provide effective feedback to teachers after an observation?

APPENDIX E

Delphi II

What Elementary Leaders Need to Know in Order to Observe Mathematics Instruction and Provide Feedback to Teachers Effectively: A Delphi Study Round 2

Email Content:

Thank you for responding to the Round 1 questionnaire regarding elementary mathematics leadership. We had 100% participation. That is exciting!

Please use the link: www.linktosurvey.com to access the questionnaire for the second round. Round 2 will consist of a series of statements. In response, you will choose your level of agreement. I anticipate the survey to take no more than 30 minutes of your time. This time – there is no writing!

Please submit this survey within the next two weeks and remember that the survey will time out after a period of inactivity.

If I can answer any questions or provide any additional information, please let me know. Thank you so much for your continued participation.

Lindsay Elliott
Doctoral Candidate
Virginia Tech

Follow-up Email:

Hello panel member! This is a friendly reminder that the Round 2 survey will close in x days on month, date. I look forward to your response and hope that we can reach the 100% participation mark again!

Take care,
Lindsay Elliott
Doctoral Candidate
Virginia Tech

Round 2 Delphi (via www.survey.vt.edu)

[Participants were asked to respond to each statement using the Likert Scale: Strongly Agree, Agree, Disagree, or Strongly Disagree].

Content Knowledge

Leaders should have a DEEP understanding of national/state/district elementary mathematics standards.

Leaders should have SOME understanding of national/state/district elementary mathematics standards.

Leaders should know the content deeply enough to understand the overall development of mathematical concepts across grade levels.

Leaders should have a working knowledge of the school/district's approach to the elementary mathematics program.

Leaders should understand the mathematics students will encounter in middle and high school.

Leaders should know the sequence of instruction for the four operations from the concrete to the algorithm.

Leaders should know how to teach the strategies for basic facts so students move from understanding to instant recall.

Leaders should understand how math ideas articulate across the curriculum outside of mathematics.

Leaders should know how mathematics standards and lessons within a grade level connect to one another.

Content Knowledge: Leaders should understand how to help students decompose numbers when working with operations.

Leaders should know that elementary mathematics is a process of reasoning rather than just facts, rules and procedures.

Leaders should have a solid understanding of the ten to one relationship of our base ten system.

Leaders should understand the "why" behind math algorithms and rules.

Leaders should know the content well enough to know how mathematical concepts can be taught through problem solving.

Leaders should be able to solve problems observed in a classroom in multiple ways.

Leaders should understand the content well enough to distinguish between procedural and conceptual teaching.

Leaders should understand the importance and role of vocabulary within the development of mathematics.

Leaders should understand the stages of conceptual development students move through to reach proficiency.

Pedagogy

Leaders should understand the NCTM Process Goals.

Leaders should understand the Common Core Standards for Mathematical Practice.

Leaders should know that the teacher should act as a facilitator of learning.

Leaders should know that mathematics classrooms need to be student-centered, where student exploration and conversations precede formal presentation.

Leaders should know that it's important for students to make estimations.

Leaders should know how to use manipulatives effectively for instruction.

Leaders should know how to incorporate rich mathematical tasks that have high levels of cognitive demand into daily instruction.

Leaders should understand the use of effective questioning to engage students in developing mathematical understandings and connections.

Leaders should understand the effective use of wait time.

Leaders should know how to instill confidence in students to become enthusiastic math learners who persevere.

Leaders should understand and look for “socio-constructivist” teaching.

Leaders should understand the need for teachers to help students self-monitor their progress in terms of learning goals and the criteria for successful mastery.

Leaders should recognize it is often useful to have students propose incorrect solutions,

as it is an opportunity to have the class analyze erroneous reasoning.

Leaders should be able to identify and recognize effective curriculum materials.

Leaders should know how to take advantage of different work-based configurations (whole group, small groups, individual) at different points in a lesson.

Leaders should be able to address issues related to providing interventions.

Leaders should be able to distinguish between students actively following directions versus students actively thinking about a problem.

Leaders should recognize that problem solving is a vehicle for learning mathematics as opposed to an end goal.

Leaders should understand that a truly student-centered lesson may be 'messy'.

Leaders should understand that a truly student-centered lesson may not be carried out as initially planned.

Leaders should understand what successful differentiation looks like in a mathematics classroom.

Leaders should be able to do error analysis of student work in order to make instructional decisions for that child.

Leaders should understand how teachers use students' thinking to facilitate guided classroom discourse.

Leaders should understand that direct instruction will fail to reach all students.

Leaders should know that students need time to wrestle with their own confusion when solving a problem.

Leaders should know that you can tell more about a child's thinking by examining his/her process rather than the product.

Leaders should know that students need many opportunities to have social interactions with each other to explain and justify their ideas and discoveries.

Leaders should understand the importance of using multiple representations when working with a mathematical concept.

Leaders should understand how to set up a safe, respectful classroom where students are comfortable taking risks.

Leaders should understand how to sequence shared student strategies so all students can follow the mathematics and see connections between strategies.

Leaders should understand the importance of moving from the concrete to the pictorial to the abstract in the development of a mathematical concept.

Leaders should understand how to utilize formative and summative assessments.

Leaders should understand the importance of high expectations for all students.

Leaders should understand that students should see each other as resources for developing mathematical thinking.

Leaders should understand the importance of effective, frequent feedback from teacher to student.

Leaders should be able to anticipate student responses and misconceptions.

Leaders should be able to recognize age appropriate tasks for elementary school students.

Leaders should understand that teachers need a clear, focused learning target for each lesson specific enough that students know exactly what they should know or be able to do.

Leaders should understand that students do not benefit from learning "tricks" to solve problems.

Leaders should understand how to use contextual situations to anchor students' thinking.

Leaders should know that effective lessons include all of the following: activation of prior knowledge, time for students to work on a task(s), and a closing to synthesize findings.

Leaders should know how to use technology to strengthen students' mathematical understandings.

Teacher Growth

Leaders should know that effective feedback must be timely.

Leaders should know that effective feedback must be geared towards a long term goal that supports key elements of a common vision.

Leaders should know that effective feedback must not include value judgments.

Leaders should understand the theories of engaging adult learners.

Leaders should understand when to utilize coaching versus mentoring versus consulting roles with teachers.

Leaders should know how to develop relationships with teachers.

Leaders should know how to approach difficult situations and conversations.

Leaders should know that teachers grow when they have the opportunity to work through ideas themselves, rather than being expected to alter a teaching practice because they were told to.

Leaders should be able to pick a small number of high-leverage practices to focus on when facilitating teacher growth.

Leaders should be able to use effective questioning strategies in order to understand and advance teachers' thinking regarding a lesson.

Leaders should be able to ground debriefing discussions on specific events in the lesson.

Leaders should understand teachers' phobias in mathematics.

Leaders should know how to utilize lesson studies.

Leaders should know how to foster Professional Learning Communities, or groups of teachers who can collaborate regularly.

Leaders should base teacher feedback on 3 components of a lesson: student and teacher knowledge of the math content, learning and pedagogy, and the facilitation of an intellectual community.

Leaders should know how to assess growth (student or teacher) in order to monitor progress.

Leaders should work with teachers to establish a common vision of effective mathematics instruction.

Leaders should know how to help teachers develop the ability to reflect on their own practice.

Leaders should know how to utilize math specialists effectively.

Leaders should understand that following up on recommendations made to teachers is critical.

Leaders should know that change is a process that takes time.

Leaders should understand that change can be challenging.

When providing feedback, leaders should describe positive aspects of the lesson before providing constructive criticism.

Leaders should conduct multiple, short observations of a classroom throughout the year rather than only 1 or 2 lengthy observations.

Leaders should model best practices in mathematics instruction.

Leaders should understand the need to work with receptive teachers who want assistance before working with resistant staff.

Leaders should provide professional development opportunities.

Leaders should know how to assess the effectiveness of professional development opportunities.

Leaders should have a working knowledge of the range of mathematics resources available to teachers.

Leaders should have a working knowledge regarding the stages of teacher development.

Leaders should know that a small amount of humor can be productive when facilitating teacher growth.

Leaders should know that respect and trust are essential in supporting teacher growth.

Leaders should use observation techniques that focus on the learner as well as the teacher.

Leaders should know how to use video recording methods to facilitate teacher growth.

Leaders should keep feedback anchored in student learning and evidence of that learning.

Leaders should know that kindness is necessary when supporting teacher growth.

When conducting a post-observation conference, leaders should ask the teacher to describe all of the following: lesson objectives, lesson strengths, lesson weaknesses, and potential next steps.

Leaders should understand that vertical teams of teachers need to meet periodically to gain a greater awareness of mathematical progressions and standards.

Leaders should master knowledge of student pedagogy first, followed by facilitating

teacher growth, and content last.

Leaders should understand that planning requires more than reading the lesson and preparing materials.

APPENDIX F

Delphi III

What Elementary Leaders Need to Know in Order to Observe Mathematics Instruction and Provide Feedback to Teachers Effectively: A Delphi Study Round 3

Email Content:

We are almost there - only 1 more round to go! Thank you so much for responding to Rounds 1 and 2 of my Delphi Study. We had 100% participation in Round 1 and 93% participation in Round 2.

Please use the link: <https://survey.vt.edu/survey/entry.jsp?id=1391563003158> to access the questionnaire for the third and final round. The password is Delphi3. Round 3 will consist of a series of statements you have already seen. Included will be the percentages of how the panel (including you) responded to each statement. You will find the percentages in parenthesis beside each possible response. Some of the original statements have been removed, as they either already met or did not meet criteria I defined in my study.

I am asking that you select your level of agreement one more time in response to each statement. The number of items has been pared down to about 40 total statements. This should not take longer than 15 minutes of your time. Please remember that for the purpose of this study, school leaders are defined as elementary principals, assistant principals, and school-based math coaches.

Please submit this survey within the next two weeks and remember that the survey will time out after a period of inactivity.

If I can answer any questions or provide any additional information, please let me know. Thank you so much for your continued participation.

Lindsay Elliott
Doctoral Candidate
Virginia Tech

Follow-up Email:

Hello panel member! This is a friendly reminder that the Round 3 survey will close in x days on month, date. I look forward to your response and hope that we can reach the 100% participation mark again!

Take care,
Lindsay Elliott
Doctoral Candidate
Virginia Tech

Round 3 Delphi (via www.survey.vt.edu)

Teacher Growth: Leaders should know how to develop relationships with teachers.

- Strongly Agree (79%)
- Agree (14%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should know that the teacher should act as a facilitator of learning.

- Strongly Agree (79%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should understand the importance of effective, frequent feedback from teacher to student.

- Strongly Agree (79%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know how to approach difficult situations and conversations.

- Strongly Agree (79%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know that teachers grow when they have the opportunity to work through ideas themselves, rather than being expected to alter a teaching practice because they were told to.

- Strongly Agree (79%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should work with teachers to establish a common vision of effective mathematics instruction.

- Strongly Agree (79%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should know that students need time to wrestle with their own confusion when solving a problem.

- Strongly Agree (71%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should know that students need many opportunities to have social interactions with each other to explain and justify their ideas and discoveries.

- Strongly Agree (71%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should understand the importance of using multiple representations when working with a mathematical concept.

- Strongly Agree (71%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should understand what successful differentiation looks like in a mathematics classroom.

- Strongly Agree (64%)
- Agree (21%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (14%)

Content Knowledge: Leaders should have a working knowledge of the school/district's approach to the elementary mathematics program.

- Strongly Agree (71%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should know how to take advantage of different work-based configurations (whole group, small groups, individual) at different points in a lesson.

- Strongly Agree (71%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should recognize that problem solving is a vehicle for learning mathematics as opposed to an end goal.

- Strongly Agree (79%)
- Agree (14%)
- Disagree (7%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should understand that a truly student-centered lesson may not be carried out as initially planned.

- Strongly Agree (71%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should understand the importance of high expectations for all students.

- Strongly Agree (71%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should be able to use effective questioning strategies in order to understand and advance teachers' thinking regarding a lesson.

- Strongly Agree (71%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should understand that planning requires more than reading the lesson and preparing materials.

- Strongly Agree (71%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Content Knowledge: Leaders should have a solid understanding of the ten to one relationship of our base ten system.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should know how to instill confidence in students to become enthusiastic math learners who persevere.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Teacher Growth: Leaders should know how to help teachers develop the ability to reflect on their own practice.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Teacher Growth: Leaders should have a working knowledge of the range of mathematics resources available to teachers.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should understand the NCTM Process Goals.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should understand the Common Core Standards for Mathematical Practice.

- Strongly Agree (71%)
- Agree (21%)
- Disagree (7%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should know that you can tell more about a child's thinking by examining his/her process rather than the product.

- Strongly Agree (71%)
- Agree (21%)
- Disagree (7%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should understand that students do not benefit from learning "tricks" to solve problems.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should know that effective lessons include all of the following: activation of prior knowledge, time for students to work on a task(s), and a closing to synthesize findings.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know that effective feedback must be timely.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know how to foster Professional Learning Communities, or groups of teachers who can collaborate regularly.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know that change is a process that takes time.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should understand that change can be challenging.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should provide professional development opportunities.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know how to assess the effectiveness of professional development opportunities.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should understand that vertical teams of teachers need to meet periodically to gain a greater awareness of mathematical progressions and standards.

- Strongly Agree (64%)
- Agree (36%)
- Disagree (0%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should know how to incorporate rich mathematical tasks that have high levels of cognitive demand into daily instruction.

- Strongly Agree (71%)
- Agree (14%)
- Disagree (14%)
- Strongly Disagree (0%)
- No Answer (0%)

Pedagogy: Leaders should be able to distinguish between students actively following directions versus students actively thinking about a problem.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (7%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should be able to pick a small number of high-leverage practices to focus on when facilitating teacher growth.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (7%)
- Strongly Disagree (0%)
- No Answer (0%)

Teacher Growth: Leaders should know how to utilize math specialists effectively.

- Strongly Agree (64%)
- Agree (29%)
- Disagree (7%)
- Strongly Disagree (0%)
- No Answer (0%)

Content Knowledge: Leaders should understand the "why" behind math algorithms and rules.

- Strongly Agree (64%)
- Agree (14%)
- Disagree (14%)
- Strongly Disagree (0%)
- No Answer (7%)

Pedagogy: Leaders should understand that direct instruction will fail to reach all students.

- Strongly Agree (64%)
- Agree (14%)
- Disagree (14%)
- Strongly Disagree (0%)
- No Answer (7%)

Content Knowledge: Leaders should have SOME understanding of national/state/district elementary mathematics standards.

- Strongly Agree (64%)
- Agree (21%)
- Disagree (7%)
- Strongly Disagree (7%)
- No Answer (0%)

Additional Comments:

	 
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APPENDIX G

Full Findings of the Delphi

Item	N	M ^a	% Strongly Agree	% Agree
Effective questioning	14	4.00	100	0
Student-centered classrooms	14	4.00	100	0
Teacher as facilitator	14	4.00	100	0
Process of reasoning	14	4.00	100	0
Planning	13	4.00	93	0
Formative and summative assessments	14	3.93	93	7
Reflection	13	3.92	86	7
High expectations	13	3.92	86	7
Focus on learner and teacher	14	3.86	86	14
Respect and trust	14	3.86	86	14
Classroom environment	14	3.86	86	14
Time to wrestle with ideas	14	3.86	86	14
Procedural vs. conceptual knowledge	14	3.86	86	14
Some understanding of standards	14	3.86	86	14
Messy math	14	3.79	86	14
Differentiation	12	3.92	79	7
Developing relationships	13	3.85	79	14
Common vision	13	3.85	79	14
Change takes time	13	3.85	79	14
Problem solving	13	3.85	79	14
Process vs. product	13	3.85	79	14
Time for teachers to grapple with growth	14	3.79	79	21
Student feedback	14	3.79	79	21
Social interactions/communication	12	3.83	71	14
Change can be challenging	13	3.77	71	21
Professional development	13	3.77	71	21
Multiple representations	13	3.77	71	21
Different work-based configurations	13	3.77	71	21
Approaching difficult situations	14	3.71	71	29
Timely feedback	14	3.71	71	29
Derailed lessons	14	3.71	71	29
Math “tricks”	14	3.71	71	29
Small number of high-leverage practices	13	3.69	71	14
Assessing professional development	13	3.69	64	29
Vertical articulation	13	3.69	64	29
Utilizing math specialists	13	3.69	64	29
Lesson structure	13	3.69	64	29
District’s approach to curriculum	13	3.69	64	29

Common Core Standards of Mathematical Practice	14	3.64	64	36
Direct Instruction	13	3.54	64	14
Ten to one relationship in base ten	13	3.54	64	14
Students as resources	12	3.67	57	29
Classroom discourse	13	3.62	57	36
Concrete to pictorial to abstract	13	3.62	57	36
Estimations	13	3.62	57	36
Vocabulary	14	3.62	57	36
Stages of conceptual development	14	3.62	57	36
Why behind algorithms	12	3.58	57	21
Effective questioning strategies	14	3.57	57	43
Following up	14	3.57	57	43
Rich mathematical tasks	14	3.57	57	43
Effective curriculum materials	14	3.57	57	43
Incorrect solutions are ok	14	3.57	57	43
Wait time	14	3.57	57	43
Feedback anchored in student learning	13	3.54	57	29
Clear learning target	13	3.54	57	29
Socio-constructivist teaching	13	3.54	57	29
Lessons and standards build	13	3.54	57	29
Theories of engaging adult learners	14	3.50	57	36
Genuine engagement	14	3.50	57	36
Solve problems in multiple ways	13	3.46	57	21
Deep understanding of standards	14	3.43	57	19
Assessing growth	13	3.54	50	43
Model best practices	13	3.54	50	43
Specific events	13	3.54	50	43
Providing interventions	13	3.54	50	43
Instilling confidence in students	14	3.50	50	50
Math resources	13	3.46	50	36
Manipulatives	13	3.46	50	36
Professional Learning Communities	14	3.43	50	43
No value judgments	14	3.43	50	43
Progressions between grades	14	3.43	50	43
Problem solving	13	3.38	50	29
Stages of conceptual development	13	3.38	50	29
Humor	12	3.50	43	43
Teacher stages of development	12	3.50	43	43
Age appropriate tasks	12	3.50	43	43
Contextual situations	14	3.43	43	57
Student self-monitoring	14	3.43	43	57
Coaching vs. mentoring vs. consulting	13	3.38	43	43
Error analysis	13	3.38	43	43
Sharing student strategies	14	3.36	43	50
Decomposing numbers	13	3.23	43	36

Three components of feedback	12	3.42	36	50
NCTM Process Goals	13	3.38	36	57
Basic facts: understanding to recall	13	3.38	36	57
Feedback towards goal/common vision	14	3.36	36	64
Lesson studies	12	3.33	36	43
Kindness	13	3.31	36	50
Video recording methods	14	3.31	36	50
Anticipating responses and misconceptions	13	3.08	36	29
Conducting post conference	13	3.31	29	64
Teacher phobias	14	3.21	29	64
Mini observations	13	3.15	29	57
Positive before negative feedback	13	3.15	29	50
Middle and high school content	14	3.14	21	71
Technology	14	3.07	21	64
Work with receptive teachers first	13	2.92	14	64
Across the curriculum outside of mathematics	13	3.08	7	86
Pedagogy, growth, then content	12	2.42	7	29

^aRating scale used was: 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree
