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Examining Elementary Mathematics Teachers' Knowledge and Implementation of High Leverage Teaching Practices

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ACCEPTANCE

This dissertation, EXAMINING ELEMENTARY MATH TEACHERS' KNOWLEDGE AND IMPLEMENTATION OF HIGH LEVERAGE TEACHING PRACTICES, by CLIFF CHESTNUTT was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Philosophy, in the College of Education and Human Development, Georgia State University.

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Examining Elementary Math Teachers' Knowledge and Implementation of High Leverage Teaching Practices

by

Cliff Chestnutt

Under the Direction of Dr. Lynn Hart

ABSTRACT

Over the last two decades, significant attention has been given to mathematics teaching and learning as demonstrated by national reform models (e.g. NCTM standards), and national standards changes (e.g. Common Core Standards). This attention generated increased pressure to improve mathematics teaching and learning. As a result, mathematics teacher educators came to identify a set of practices referred to as High Leverage Teaching Practices (HLTP), teaching behaviors that researchers believe improve the teaching and indirectly the learning of mathematics. While there are indications that there is a link between the use of these teaching strategies in mathematics and student achievement, research has focused on pre-service teachers with less attention on the use of HLTP by in-service teachers. To address this gap, this study sought to determine if practicing elementary mathematics teachers identified as 'exceptional' did in fact use HLTP and how they described their use of these practices. Through teacher interviews and classroom observations in-service teachers' knowledge and implementation of HLTP in the mathematics classroom was examined. Results showed that even with limited formal professional learning experiences, these teachers enacted HLTP, albeit to varying degrees, and they described these strategies in their teaching. Additional themes that emerged included the low self-efficacy of the teachers with respect to their knowledge of mathematics and their abilities to teach mathematics.

INDEX WORDS: Elementary math, High Leverage Teaching Practices, HLTP, Mathematics

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Cliff Chestnutt

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1 THE PROBLEM

Background

In 1989 the National Council of Teachers of Mathematics (NCTM) released the *Curriculum and Evaluation Standards for School Mathematics* starting an unprecedented standards-based movement to improve mathematics education systemically in the U.S. (NCTM, 1989, 1991, 1994, 2000). Concurrent to adoption of the last NCTM standards, the National Research Council (2001a, 2001b) published two well-received documents providing recommendations about mathematics teaching. Ten years later national standards emerged in the form of the Common Core State Standards Mathematics (NGA Center & CCSSO, 2010) adopted by forty-five states. However, even with the plethora of standards and recommendations for K12 mathematics education, NCTM acknowledges that the mathematics preparation of students is " far from where we need to be and that much still needs to be accomplished" (NCTM, 2014, p. 2).

High Leverage Teaching Practices (HLTP)

High-Leverage teaching practices are defined as those practices or tasks that are significant to teaching (Teachingworks.org). If carried out skillfully and effectively by the teacher, HLTP will likely result in an increase in student achievement. HLTP are useful across a wide range of subject areas and grade levels and will likely help to meet the academic needs of all students. Ball, Sheep, Boerst, and Bass, (2009), indicate the following set of criteria as necessary for defining and identifying HLTP: support work that is central to mathematics, help to improve learning and achievement of all students, are used frequently when teaching mathematics, apply across different mathematics teaching approaches, and can be practiced by teachers. Lamp, Boerst, & Garziani (2011) assert that HLTP aim to not only teach all students to know mathematics but for students to be able to apply their knowledge to solve authentic, real-world problems. High leverage teaching practices in mathematics focus on the learning that is co-produced by students and teachers in specific contexts, the practices that are central to teaching mathematics, and addresses students differences and equity issues (Ball, 2011).

Ball and Forzani (2011) detailed the development of the Teacher Education Initiative at The University of Michigan to improve teaching practice through the use of 19 research based high-leverage teaching practices. Drawing on best practices research that links specific teaching practices to student achievement, Ball and Forzani (2011) developed a comprehensive list of over 200 items that included videos of teaching, published descriptions of teaching and to teachers' personal experience to develop standards for high leverage teaching practices. Additionally, since few studies identify specific strategies that should be taught during teacher education programs, the authors used existing knowledge of best practices instruction to develop HLTP. As a result, Ball and Forzani (2011) narrowed their list to 19 specific instructional practices designed to increase student achievement. As researchers continued to develop this area of study, it was expected that the list of practices might change.

Research on High Leverage Practices

The National Council for Teachers of Mathematics (NCTM) introduced the initial set of standards as a comprehensive vision for mathematics teaching, learning and assessment (NCTM, 2010). In their publication Curriculum and Evaluation Standards for School Mathematics NCTM set for the first major, cohesive mathematics standards in the United States. In 2000, NCTM 's Principles and Standards for School Mathematics expanded on the 1989 standards by adding principles for school mathematics by four grade level bands; pre-K-second, grades 3-5, grades 6-8, and grades 9-12. Following the development of these grade level bands, NCTM's

Curriculum Focal Points for Pre-K through Grade 8 Mathematics: A Quest for Coherence was developed to identify the most significant concepts and skills that students should be learning at each grade level. As the development of mathematics standards continued to evolve, the National Governors Association released the Common Core Standards for Mathematics in 2010, which were adopted by 45 states, representing an unprecedented opportunity to improve mathematics education in the United States.

Over two decades of research in mathematics education, has indicated that the development of standards alone is not sufficient for achieving the goal of increased achievement in mathematics for all students (NCTM, 2010). Due to this realization, NCTM developed the research-based Principles to Actions: Ensuring Mathematical Success for All, as a guided to continued improvement of mathematics education. Principles to Actions details the structures and policies that must be in place in education in the United States in order for all students to learn. This publication addresses the necessary components for teaching and learning mathematics, which include: access and equity, curriculum, tools and technology, assessment, professionalism. Ultimately, Principles to Actions recommended specific practices for teachers and stakeholders to enact to ensure success in mathematics for all students.

In addition to the work of NCTM to improve mathematics teaching and learning, researchers at the University of Michigan developed Teaching Works professional development, which outlined 19 high-leverage teaching practices addressed to positively impact student learning in mathematics. Teaching Works was developed out of the Teacher Education Initiative (TEI) at the University of Michigan in 2004. The TEI reform was designed with a focus on developing a more practice-oriented teacher-training program, where course instructors have restructured their curriculum to focus on teaching practice and changing the way teachers spend their time in classes and in schools. This research-based reform model lead to the development of Teaching Works. Research from Teaching Works has led to the development of 19 high-leverage teaching practices that are developed and implemented across the teacher-training programs at the University of Michigan in an attempt to develop common approaches to professional development throughout the United States.

In some cases, elementary teachers are unprepared to teach mathematics since they may not have a common set of acceptable teaching practices for entry into the teaching field. Assumptions that quality teachers will learn on the job and ineffective teachers will leave the profession has led to a lack of quality in teaching and in some instances had a negative impact on student learning (Timperley, Wison, Barrar, & Fung, 2008). Some teacher training plans place more emphasis on learning about teaching, rather than practice based teacher training. Throughout the research or HLTP, Teaching Works has aimed to address this challenge by addressing the following components: creating and implementing a new teacher licensure assessment with specific, common, professional requirements for entry into the teaching field based on HLTP and developing a common approach to teacher training based on the HLTP.

High Leverage Teaching Practices (HLTP) in Teacher Education

Research over the last decade on teacher education has focused on factors that impact effective teaching, including teacher's beliefs, teacher's knowledge, teacher thinking and decision making (Grossman & McDonald, 2008). More recently, teaching *practices* are being explored as another crucial component of teacher effectiveness, shifting the focus from what teachers know and think to what they do (Ball & Cohen, 1999; Danielson, 2007; Grace & McDonald, 2008). Rather than simply talking *about* teaching, Sleep (2009) suggests there is a need to focus on what effective teachers actually *do.*

To address this issue of what teachers do to impact student learning, The Teacher Education Initiative at the University of Michigan in their project *Teaching Works* (Ball & Forzani, 2011) began to identify teaching skills necessary to promote learning. The work began as an effort to design a more practice-oriented teacher professional development program at Michigan where course instructors could restructure their curriculum to focus more on teaching practice and change the way teachers spend their time in classes (Davis and Boerst, 2014). They not only wanted to recognize and identify teacher practices that are most likely to support student learning, but they had a goal of putting forth a shared vision in education about these practices.

The Teaching Works project began by isolating practices or tasks that they found were significant to teaching and ultimately learning (Ball & Forzani, 2011). If carried out skillfully and effectively by the teacher, these practices result in an increase in student achievement (Ball & Forzani, 2011). According to the Teaching Works team, the practices help to meet the academic needs of all students and are useful across a wide range of subject areas and grade levels.

Working from existing knowledge of effective instruction, a comprehensive list of over 200 behaviors was identified from videos of teaching, compiled, published descriptions of teaching, and teachers' personal experiences (Ball & Forzani, 2011). From this list the Teaching Works team identified nineteen practices that they came to call High Leverage Teaching Practices (HLTP) that improve student learning. As researchers continue to develop this area of study, it is expected that the list of practices will change and expand to teaching specific grade levels and subject areas.

Principles of Learning

Although there may be a generic collection of effective teaching practices across disciplines (Duit & Treagust 2003; Hlas & Hlas, 2012), each discipline requires focused attention to those teaching practices that are most successful in supporting student learning that is specific to that discipline (Hill et al., 2008; Hill, Rowan, and Ball, 2005). Research from both mathematics education (Donovan and Bransford, 2005; Lester, 2007) and cognitive science (Mayer, 2002) support that learning mathematics is an active process, where each student builds his or her own understanding based on personal experience, feedback from peers, teachers and themselves. This research has recognized several principles of learning that provide the basis for effective mathematics teaching. Specifically, students should have experiences that allow them to engage with challenging tasks that involve meaning making, connect new learning to prior knowledge, acquire procedural and conceptual knowledge, construct knowledge socially, receive descriptive and timely feedback, and develop metacognitive awareness of themselves as learners (Hiebert, 2013).

Effective Teaching Practices for Mathematics

Ball, Sheep, Boerst, and Bass (2009), developed a set of criteria necessary for defining and identifying effective teaching practices in mathematics. These practices must help improve learning and achievement of all students, be used frequently when teaching mathematics, apply across different mathematics teaching approaches, and be practiced by teachers. Lamp, Boerst, & Garziani (2011) assert that these teaching practices must make mathematics accessible to all students, and also help all students apply their knowledge to solve authentic, real-world problems. Effective teaching practices in mathematics focus on the learning that is co-produced by students and teachers in specific contexts, the practices that are central to teaching mathematics, and the issues of student differences and equity. (Ball, 2011).

HLTP in Mathematics

In the *Principles to Actions* NCTM (2014) identifies eight high-leverage mathematics teaching practices that offer a framework to improve the teaching and indirectly the learning of mathematics. The NCTM HLTP framework for mathematics teaching is informed by research from the last few decades. For student achievement to increase in elementary mathematics NCTM believes these practices are "essential teaching skills necessary to promote deep learning of mathematics." (NCTM, 2014, p. 9)

The following eight practices represent HLTP that are believed necessary to help students develop deep mathematical understanding:

1. Establish mathematics goals to focus learning
2. Implement tasks that promote reasoning and problem solving
3. Use and connect mathematical representations
4. Facilitate meaningful mathematical discourse
5. Pose purposeful questions
6. Build procedural fluency from conceptual understanding
7. Support productive struggle in learning mathematics
8. Elicit and use evidence of student thinking

Implementing High Leverage Teaching Practices in Mathematics

Borko and Livingston (1989) suggested that novice mathematics teachers may not have the necessary skills to adopt the complex teaching practices that expert teachers display during instruction. While it is believed that elementary mathematics learners would benefit when teachers implement research informed HLTP, researchers have noted that many preservice teachers struggle with these practices (Davin, 2013; Grossman et. al, 2009; Forzani, 2014; Troyan, Davin & Danato, 2013). For example, Davin (2013) studied four elementary pre-service teachers during their field experience to observe their implementation of the specific HLTP of questioning and increased interaction. He found that preservice teachers consistently had difficulty implementing the specific HLTP that involve important interactions between teacher and student. Davin (2013) suggests that preservice teachers often struggle to move away from their lesson plans and often miss authentic opportunities for learning. Grossman et al., (2009) and Troyan, Davin, and Donato, (2013) echo the assertions of Davin (2013) concerning preservice teachers. It is possible that HLTP may take years of practice to master and teachers may need to be supported as they struggle with implementation. However, with the need for more research on *inservice* teachers' use of HLTP, it may be difficult to develop a solution to assist teachers with implementation. .

Conceptual Framework

The conceptual frame for this study was High Leverage Teaching Practices as identified and described by the National Council of Teachers of Mathematics in their document *Principles to Action: Ensuring Mathematics Success for All* (NCTM, 2014). Research specifically on HLTP was limited and the existing studies primarily focus on the difficulties *preservice* teachers' experience in trying to implement these practices. Limited studies were located that specifically addressed implementation and understanding of the term HLTP with *inservice* teachers. The descriptive study proposed here provided an initial, in-depth look into the use of HLTP with effective, experienced elementary mathematics teachers. This also highlighted how well the general education community's perceptions of effective mathematics instruction maps on to NCTM's vision. Finally, it supported previous research discussing the sometimes-inconsistent link between teachers' espoused versus enacted teaching practices (Cooney, 1995; Polly, 2014). The guiding questions for this study were:

(1) Do effective elementary mathematics teachers with no specific professional development implement high leverage teaching practices?

(2) How do teachers describe their use and knowledge of high-leverage teaching practices in mathematics?

(3) What influences do teachers perceive as impacting their use of HLTP in their classroom instruction?

2 REVIEW OF THE LITERATURE

Introduction

In recent years, there has been a renewed interest in the study of practiced-based teacher education across many academic areas (Ball & Cohen, 1999; Ball & Forzani, 2009; Ball, Sleep, Boerst, & Bass, 2009; Grossman, 2011; Grossman, Hammerness, & MacDonald, 2009; Lampert, 2010; Zeichner, 2010). In particular, researchers and teacher educators have focused on identifying what are referred to as high-leverage teaching practices (HLTP) or practices that when implemented correctly by teachers are believed to support higher levels of student achievement than other teaching practices (Cumming, Hlas, & Hlas, 2012). Currently many researchers have focused on identifying effective teaching practices, decomposing them into micro-practices, and using the information gained to inform teacher education (Grossman, et. al, 2009).

As Zeichner (2012) indicated the focus on teacher practice is not new to teacher education, however, current research has focused on the work teachers do day-to-day during classroom instruction. Many researchers have discussed that identifying high-leverage practices will have an impact on student learning even though the practices may be defined differently from student to student and between classrooms (Ball & Forzani, 2009; Earl, 2012; Lampert, 2009). Once clearly defined and explained, HLTP can be broken into smaller parts so teachers can learn the practices and promote continued learning (Hatch & Grossman, 2007). While many practice-based approaches exist in education, focusing on practices that are most likely to positively impact student learning and be easier for teachers to implement should result in improving teaching and learning in classrooms.

As early as 1975 Lortie discussed the lack of a common technical vocabulary for teaching that could be used to describe the work of teaching and support teacher development. Yet even today research on teaching that provides meaningful ways for analyzing and improving teaching is still limited. Further, most policy recommendations remain far removed from actual educational outcomes. Many policy makers are concerned with employing 'better' teachers and developing new approaches to teacher evaluation and accountability rather than developing the infrastructure and knowledge base that is required for high-quality instruction (Darling-Hammond, 2004). The teaching profession lacks a common, widely agreed upon definition of the characteristics of effective instructional practice. For example, several researchers have identified an important component of instructional practice as teachers' abilities to comprehend, elaborate, respond to, and extend student thinking during classroom discussion (Lampert, Boerst, and Graziani, 2011). Even though this instructional practice is identified as a critical skill, there are not common resources that identify practices such as this, describe the effectiveness of the practices, and provide common strategies for helping teachers develop these skills.

In the following sections, I have shared my search process and discussed several topics that are central to the research on HLTP including Teacher Professional Development, Practice Based Teacher Development, and Teachers' Content Knowledge as well as provide an in-depth look at the research to date on HLTP.

Searching the Literature

The literature review began with a search of terms related to my topic. The researcher used the combined search terms: (a) High Leverage Teaching Practices, (b) elementary teachers, (c) mathematics, (d) implementation, (e) knowledge, and (f) in-service yielded five articles. The various databases used in my search included Galileo, Educational Resources Information Center (ERIC), Psychological Abstracts Index, and Dissertation Abstracts. In addition to these individual databases, these terms were used in a combined search using EBSCOhost. I also used the terms independently and in various combinations. This combination of terms did not result in any additional, relevant articles. I have presented the relevant literature from the review in the following sections: Teacher Professional Development, Practiced Based Professional Development, Teachers' Content Knowledge, High Leverage Teaching Practices, The Evolution of High Leverage Teaching Practices in Mathematics, Meaningful Mathematical Discourse, Posing Purposeful Questions, Supporting Productive Struggle, and Promoting Reasoning and Problem Solving.

Teacher Professional Development

Quality teacher professional development is essential to improving student success in mathematics (Darling-Hammond, & Richardson, 2009; Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2009). Professional development programs are generally designed to bring about change in teachers classroom practice, in their attitudes and beliefs, and ultimately impact student learning (Darling-Hammond, 2008; Borko, 2004). Cohen & Hill (2000) theorize that professional development is fundamental for enhancing instruction, but despite on-going calls for high quality professional development there are pronounced shortages of excellent programs characterized by enough duration, active learning, focus on content knowledge, coherence, and current instructional reform approaches. The criticism for poor quality programs has focused on the prevalence of single-shot and /or one-day workshops, which often make teacher professional development significantly superficial, fragmented, and disconnected from deep issues about the curriculum and student learning. Professional development can have a powerful effect on teacher skills and knowledge as well as on student learning if it is maintained over time, focused on important curriculum content, and entrenched in the work of professional development communities. When properly designed, these particular opportunities enable many elementary teachers to master content, sharpen their teaching skills, and evaluate their own as well as their students' performance.

However, high quality professional development that leads to positive gains in terms of student achievement also present great challenges (Borko, 2004). Joyce and Showers (2002, 1998) suggested the content of professional development must be selected by a group of teachers and administrators based on teachers specific needs, for student achievement to be impacted. Yoon et al (2007) found that professional development that actually effects student achievement was mediated by teachers' knowledge as well as practice in the classroom. In addition, Loucks-Hornsley and Matsumoto (1999) note that teachers' professional development must take place in within the context of high standards, system-wide accountability, as well as high-stake assessments.

Research points out that professional development is most effective in areas where it addresses the concrete, daily challenges encountered during teaching as well as learning specific academic subject matters, instead of putting significant emphasis on abstract educational principles and teaching methods that are often taken out of context (Edwards, 2002; Jacques & Hyland, 2007). For instance, researchers have established that teachers are more likely to try classroom practices that have been modeled for them within the professional development environments (Fishman et. al, 2003). Similarly, teachers themselves perceive professional development to be the single most valuable component of their learning, especially when it offers opportunities to undertake work that builds their knowledge of the academic content and provides ways to teach to their students (Feiman-Nemser, 2001; McLaughlin &Tolbert, 2006). In addition, teachers also judge professional development as being useful and important when it takes into account their local context, including the specifics of local school resources, accountability issues, as well as curriculum guidelines (Darling-Hammond, Wei, Andree, Richardson, Orphanos, 2009).

Practice-Based Teacher Development

Researchers have characterized teaching as a long-term developmental process that is the result of extended participation in the practices and contexts connected with teaching and learning (Goodnough et. al, 2009; Nolan & Hoover, 2011; Zeichner, 2010; Zembal-Saul, 2009). Along the same lines, curriculum for a practice-based approach needs to focus on preparing teacher candidates “to do teaching” (p. 459) in real life situations and contexts (Ball, Sleep, Boerst, & Bass, 2009). Proponents of a practice-based approach indicate that no amount of teaching about teaching can replace the practice of real life classroom interactions (Ball et. al, 2009; Grossman, & MacDonald, 2008). In some teacher education programs, information is frontloaded where teacher candidates spend several semesters learning theory and practices of teaching without the opportunity to engage in interactive teaching practice (Freeman, 1993; Goldenberg, 2013; Maggioli, 2012). Teachers are then placed in a high-stakes teaching environment for their final year under the guidance of a cooperating teacher. In a practice-based approach, as teacher candidates learn they have the opportunity to plan, implement, rehearse, and reflect on lessons using the methods they are currently learning. Teacher educators create a place where they are able to provide coaching to teacher candidates within the university classroom or field site (MacDonald, Kazemi, & Kavanagh, 2013). For example, in their study of preservice elementary teachers, Lampert, et al., (2013) analyzed the effect of the practice-based pedagogical approach of rehearsals in elementary mathematics methods courses. The goal of this approach was to develop ways in which teacher educators and novice teachers could interact around teaching that is embedded in practice and modifiable. The researchers examined 90 rehearsal-teaching videos from three university teacher education programs. During the videos Lampert et al. specifically focused on the interactional exchanges between teacher educators and new teachers within the rehearsals. Results indicated that the design of rehearsals allowed novice teachers the opportunity to approximate quality teaching, allowing them to learn and adapt lessons while developing their knowledge and skills. The Lampert et al. study provided insight into the importance of a practice-based learning approach to teacher education that will allow novice teachers the opportunity to develop teaching skills while being able to reflect on and revise lessons.

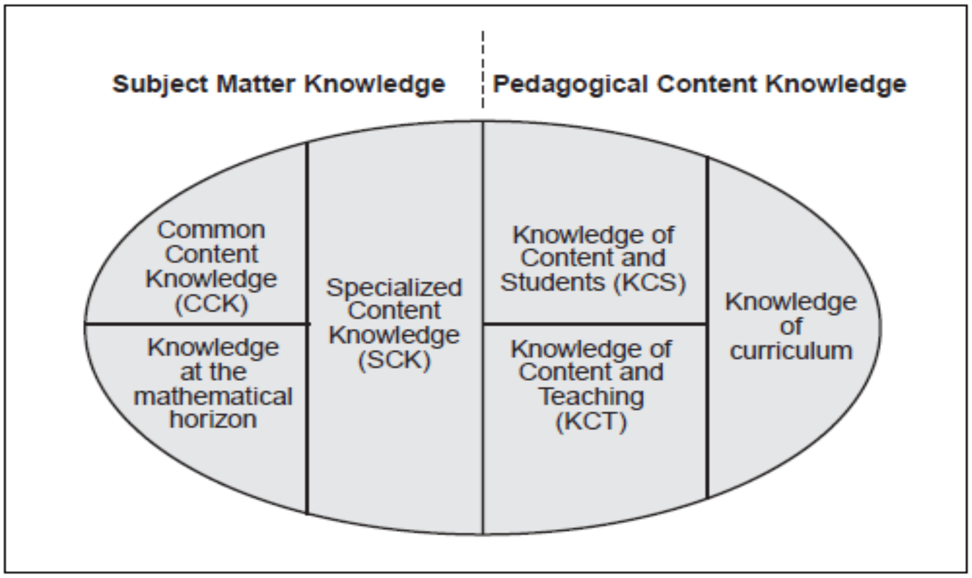
Polly and Hannafin (2014) involved 53 practicing K-5 elementary inservice mathematics teachers in an 84-hour yearlong practice-based professional development program to examine the impact of instructional improvement and increased student achievement. Results from this study indicated that after participation eighty seven percent of the teachers developed more student-centered mathematics lessons. The participating teachers also had higher student outcomes than other teachers in the study. Several other empirical studies involving practicing teachers had similar positive results with practice-based approaches, suggesting the importance of using a practice-based approach to developing elementary mathematic teacher classroom instruction (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). This body of literature suggests that practice-based professional development helps teachers to improve their instructional practice and ultimately increase student outcomes.

Teachers' Content Knowledge

Teachers' mathematical content knowledge is significant in increasing student achievement in mathematics (Hill, Rowan, & Ball, 2005). Research has demonstrated that teachers with a higher level of content knowledge are more likely to implement problem-based instruction in their classroom (Wilkins, 2008). Mathematics content knowledge has been traditionally measured by the degrees teachers' hold, certifications earned, and number of mathematics courses completed (Ball, Thames, & Phelps, 2008). In his pivotal study, Begle (1979) found little relationship between these traditional measures of teacher content knowledge and student achievement. Following this work, researchers have continued to examine the connection between teacher knowledge and student achievement (Hill & Ball, 2004). This shift in focus has resulted in explorations into different types of teacher knowledge, with a particular emphasis on the types of knowledge needed for teaching (Fennema & Franke, 1992; Hill & Ball, 2004).

Hill, Ball, and Schilling (2008) theorized a model of mathematical knowledge for teaching (MKT), the mathematical knowledge necessary for teachers to perform the work of teaching, demonstrating and describing the relationship between subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (see Figure 2). Two types of knowledge found within SMK are: (a) common content knowledge (CCK), the content knowledge used in the work of teaching that is utilized in ways common to other professions that routinely use mathematics; and (b) specialized content knowledge (SCK), the content knowledge specific to the specialized uses that arise in teaching but rarely employed in other professions or occupations. Within the domain of PCK are: (a) knowledge of content and students (KCS), (b) knowledge of content and teaching (KCT), and knowledge of curriculum.

Figure 2
Domain map for mathematical knowledge for teaching



By H. C. Hill, D. L. Ball, and S. G. Schilling, S. G., 2008.

Subject Matter Knowledge. Many scholars acknowledge the need for teachers to develop highly developed mathematical content knowledge. Shulman's (1986) subject matter knowledge (SMK) is a term that is sometimes used interchangeably with content knowledge. Shulman described SMK as knowledge of the discipline, which would also include substantive and syntactic knowledge. Hill, Ball, and Schilling (2008) further described two components of SMK: common content knowledge (CCK), the mathematical knowledge common to most people; and specialized content knowledge (SCK), the particular mathematical knowledge that teachers use when engaging in teaching tasks, such as accurately representing mathematical ideas, providing mathematical explanations for common rules and procedures, and analyzing solution methods for problems (Ball, Hill, & Bass, 2005). Unfortunately, Sowder, 2007 indicated it was common for some teacher preparation programs to place a limited focus on the specialized knowledge required for teaching mathematics, however this has changed over time with more focused research in this area. . This practice has led to a lack of focus on a critical component of teachers' knowledge that is essential to the development of students' achievement. However, with continued research in this area improvements are being made in many programs.

Hill, Rowan, and Ball (2005) conducted a longitudinal study of 700 first- and third-grade teachers examining the teachers' CCK and SCK, with an additional focus on the relationship between teachers' knowledge for teaching mathematics and the amount of student gain on the mathematics portion of the Terra Nova (a series of standardized tests designed to assess K-12 achievement) over the course of a year. The researchers collected survey and student achievement data from teachers and students from 115 elementary schools. Data were collected on two cohorts of students: the first entering in kindergarten and followed through second grade, and the second entered in third grade and followed through fifth. Data on students was gathered through parent interviews and student assessments given in the fall and spring of each academic year. Teacher data were gathered using a log that teachers completed up to 60 times per year and an annual questionnaire completed at the end of each academic year. The questionnaire was used to evaluate measures of teacher qualities such as teacher experience, certification, and undergraduate and graduate coursework, and contained between 5 and 12 items that the researchers designed to measure teachers' content knowledge for teaching mathematics (CKT-M) as opposed to teachers' general mathematical knowledge. The survey items were designed to measure teachers' abilities in providing students with mathematical explanations and representations and their abilities to work with a variety solution strategies related to the content areas of number concepts, operations, patterns, and functions. In addition, the survey items focused on teachers' content knowledge specific to teaching. Results suggested that the participating teachers' performance on the questionnaire incorporating both CCK and SCK questions significantly predicted the size of student gain scores. Researchers concluded that students of teachers who answered more test items correctly had greater gains in scores over the course of the instructional year. Hill et al.'s (2005) study appears to support the idea that increased SCK improves teachers' understanding of how students learn mathematics and is an important factor in developing students' mathematical understanding and increasing mathematics achievement.

Pedagogical Content Knowledge. Even when teachers have significant content knowledge there is no guarantee the knowledge can be taught to students in meaningful ways (Timperely, Willson, Barrar, & Fung, 2008). In his seminal work, Shulman (1986) introduced pedagogical content knowledge and defined PCK as a way of representing the subject in a way that makes it easy for others to comprehend. Researchers agree this particular type of content knowledge is difficult to define and characterize (Hart & Swars, 2009; Rowland, Huckstep, & Thwaites, 2005). Turner and Rowland (2011) asserted that subject matter knowledge (SMK) and PCK respectively involve knowing the content of a subject or discipline and being knowledgeable about the ways in which the content is taught. Turner and Rowland suggest that an assumption exists that pre-service teachers will gain PCK through their professional development and experience with the unfortunate possible result of teachers entering the profession unprepared.

Hill, et al., (2008) conducted a study designed to theorize, measure, and improve teachers' PCK. The researchers attempted to understand and measure the mathematical knowledge needed for teaching that would inform their instruction and ultimately impact student growth. This was conducted through the use of experimental professional development studies where elementary teachers investigated ways in which students learned specific subject matter (Carpenter et al., 1996; Cobb et al., 1991; Franke, Kazemi, & Battey, 2007; Peterson, Fennema, Carpenter, & Loef, 1989). Hill et al. (2008) observed that when participating teachers studied solutions strategies of students the practices of the teachers changed and student learning improved over that of teachers in control or comparison groups. They further indicated that few studies discuss what the typical teacher actually knows about the mathematical thinking of their students, thus suggesting the necessity of additional studies to address the teacher's abilities to understand student mathematical thinking

High-Leverage Teaching Practices

Ball and Forzani, (2011) along with the University of Michigan College of Education faculty, began to develop a common knowledge base for teaching with a thorough analysis of existing research studies and teacher practices. They identified 100 practices that teachers do in their classrooms. As part of this analysis, classroom teachers from all over the Untied States reviewed the list of practices and made additions and revisions. Using a set of pre-identified criteria that the faculty of University of Michigan created, Ball and Forzani began identifying practices that are most high leverage or have the most significant impact on student outcomes. This work is on going in an attempt to further isolate instructional practices that matter most for quality educational opportunities for students.

Ball and Forzani (2011) defined high leverage practices (HLTP) as those practices or tasks that are significant to teaching. If carried out skillfully and effectively by the teacher, HLTP will likely result in an increase in student achievement (Ball & Forzani, 2011). HLTP are useful across a wide range of subject areas and grade levels and will likely help to meet the academic needs of all students.

Although, effective teaching in mathematics may be similar to productive teaching in different disciplines (Duit & Treagust 2003; Hlas & Hlas, 2012), each discipline requires focused attention to those teaching practices that are most effective in supporting student learning that is specific to that discipline (Hill et al., 2008; Hill, Rowan, and Ball, 2005). Research from both mathematics education (Donovan and Bransford, 2005; Lester, 2007) and cognitive science (Mayer, 2002; National Research Council, 2012) support that learning mathematics is an active process, where each student builds his or her own understanding based on personal experience, feedback from peers, teachers and themselves. This research has recognized several principles of learning that provide the basis for effective mathematics teaching. Specifically, students should have experiences that allow them to engage with challenging tasks that involve meaning making, connect new learning to prior knowledge, acquire procedural and conceptual knowledge, construct knowledge socially, receive descriptive and timely feedback, and develop metacognitive awareness of themselves as learners.

From the general work on HLTP, Ball, Sheep, Boerst, and Bass (2009), developed the following set of criteria as necessary for defining and identifying HLTP in mathematics. HLTP

- support work that is central to mathematics,
- help to improve learning and achievement of all students,
- are used frequently when teaching mathematics,
- apply across different mathematics teaching approaches,
- can be taught to others, and
- can be practiced by teachers.

Lamp, Boerst, & Garziani (2011) assert that HLTP aim to not only teach all kinds of students to know mathematics but for students to be able to apply their knowledge to solve authentic, real-world problems. HLTP in mathematics focus on the learning that is co-produced by students and teachers in specific contexts, the practices that are central to teaching mathematics, and address issues of student differences and equity (Ball, 2011).

The Evolution of High Leverage Practices in Mathematics

NCTM introduced the first set of standards volumes as a comprehensive vision for mathematics teaching, learning and assessment (NCTM, 1989, 1991,1994). In their initial publication, *Curriculum and Evaluation Standards for School Mathematics,* NCTM set forth the first major, cohesive mathematics standards in the United States. In 2000, NCTM 's *Principles and Standards for School Mathematics* (PSSM) expanded on the 1989 standards by adding principles for school mathematics and by delineating four grade level bands; pre-K-second, grades 3-5, grades 6-8, and grades 9-12. Following PSSM NCTM produced the *Curriculum Focal Points for Pre-K through Grade 8 Mathematics: A Quest for Coherence* to identify the most significant concepts and skills that students should be learning at each grade level. As the development of mathematics standards continued to evolve, the National Governors Association released the Common Core Standards for Mathematics in 2010, which were adopted by 45 states, representing an unprecedented opportunity to improve mathematics education in the United States.

However, over the two plus decades of research in mathematics education since the development of the first standards, it has become clear that the development of standards alone is not sufficient for achieving the goal of increased achievement in mathematics for all students (NCTM, 2014). In response to this realization, NCTM ultimately developed *Principles to Actions: Ensuring Mathematical Success for All* (2014), as a guide to continued improvement of mathematics education. Principles to Actions: Ensuring Mathematical Success for All detailed the structures and policies that must be in place in education in the United States in order for all students to learn. In addition to outlining HLTP for mathematics, this publication addresses other necessary components for teaching and learning mathematics, including: access and equity, curriculum, tools and technology, assessment, professionalism. Principles to Actions recommend specific practices for teachers and stakeholders to enact to ensure success in mathematics for all students.

NCTM suggests that elementary mathematics teachers would benefit from knowledge and use of HLTP to increase student achievement in their classroom. However, as a relatively new focus area in mathematics education there is limited research to support this position. Existing research on teacher use of HLTP in mathematics found that many teachers struggle with the implementation of HLTP (e.g., Davin, 2013; Grossman et. al, 2009; Forzani, 2014; Troyan, Davin & Danato, 2013). Davin (2013) conducted a study of four elementary pre-service teachers during their field experience and their implementation of the specific practices of questioning and increased interaction. He found that pre-service teachers consistently had difficulty implementing the specific HLTP that involved important interactions between teacher and student. He suggests that teachers often are unwilling to move away from their lesson plans and therefore often miss authentic opportunities for learning. Findings from this study suggest that teacher preparation programs must find ways to prepare teachers to anticipate uncertainty in the classroom and to be able to anticipate and address students' questions as they arise. Grossman, Hammermes, and MacDonald, (2009) and Troyan, Davin, and Donato, (2013) echo the assertion of Davin (2013) that HLTP take years of practice to master and teachers need to be supported in selecting appropriate instructional activities to implement them. Also in these studies, the researchers indicate a resistance from teachers to receiving coaching to implement HLTP during their instruction. Forzani (2014) stresses that the most difficult part of addressing HLTP for teachers is in the classroom implementation due to the fact that teachers are provided little classroom support during the process of learning to teach. Empirical studies that address the specific use of the term HLTP in mathematics classrooms with in-service teachers are limited. Studies that exist are conducted using pre-service elementary mathematics teachers (Ball & Forzani, 2009 & McDonald, Kazemi, & Kavanagh, 2013).

Research related to HLTP

In the following sections I discussed research around four HLTP: meaningful mathematical discourse, purposeful questioning, supporting productive struggle, and promoting reasoning and problem solving. Though not done under the umbrella of HLTP research this work supports the claim of the value of these HLTP.

Meaningful Mathematical Discourse. Effective teaching in mathematics engages students in mathematical discourse to improve mathematical learning of all students in the class (Cobb & Yackel, 1996; Woodward & Irwin, 2005). Mathematical discourse involves the exchange of ideas, through classroom discussion and other types verbal, visual, and written communication. Discourse in mathematics classrooms allows students to create convincing arguments on why and how things work, share ideas, clarify understandings, develop language for explaining mathematics, and see things from the perspectives of other students (NCTM, 2000). Carpenter, Franke, and Levi (2003) indicate that students who learn to express and justify their mathematical thinking, reason through their mathematical explanations and provide rationales for their solutions develop a more in depth understanding of mathematical concepts, that is critical to their further development in math.

In a case study of four in-service teachers, Huffered-Ackles, Fuson, and Sherin (2004) discussed the importance of using mathematics discourse to form math talk learning communities in the classroom. The researchers conducted observations throughout the school year of the teachers as they implemented the research-based mathematics curriculum, Children’s Math Worlds, which contains conceptual support activities for the teachers to promote mathematical discourse.

Based on the data analysis from these observations the teachers' abilities to promote and encourage mathematical discourse communities in their classroom significantly improved from prior to the study. As the teachers' abilities to promote mathematical discourse improved students in the classrooms began to develop and justify their mathematical thinking more confidently and thoroughly. By offering assistance to the teachers in this study and specific components of discourse to create this type of learning community, the researchers offer a framework for others to follow in the creation of such a community.

In another study, Wood, Williams, and McNeal (2006) detail the beneficial nature of students participating in classroom mathematics discourse. The researchers investigated children's mathematical thinking and discourse in five elementary classrooms (4 with a problem solving focus and 1 traditional direct instruction classroom) of 7 and 8 year olds. Children in the reform- oriented classes were encouraged to develop and use mental and invented strategies to solve problems; procedures and algorithms were not specifically taught. Elementary in-service teachers in the study participated in a one-week professional development followed by classroom visits from the researchers. One additional classroom, which was textbook based, was added to the study to be compared to the reform based classrooms. Results from the study suggest a significant increase in the amount and type of mathematical discourse in the reform-based classrooms with much of the talk in the traditional classroom being recall of facts. Additionally, the increase in mathematical discourse led to higher order thinking and problem solving skills. This study conducted by Wood et al., (2006) provides important insight into the differences between classrooms that encourage students mathematical discourse and those that do not. Encouraging and fostering mathematical discourse is critical to students' development in mathematics. For teachers to achieve this goal it will be necessary to foster a classroom community that encourages and allows students to talk about, support and nurture each others learning.

Taken together the results indicate that the HLTP of promoting meaningful mathematical discourse is significant to elementary students' mathematical development. Teachers that are able to foster meaningful discourse tend to see significant improvement in their students' achievement in mathematics and in their abilities to develop a deep understanding. It can be assumed from these studies that the HLTP of meaningful mathematical discourse is a crucial component of elementary students' success in mathematics.

Purposeful Questions. Purposeful questioning that requires students to explain and evaluate their thinking is an essential part of effective instruction in mathematics (Wieland, Hudson, &Amador, 2013). The inclusion of purposeful questioning allows the teacher to evaluate what students know and provides them with the information necessary to adapt the lessons for the varied levels of understanding while making necessary mathematical connections. Asking questions however does not ensure students will develop an understanding. Teachers need to consider the types of questions they are asking students and the pattern of questioning that is being used. Researchers indicate that teachers are often able to ask initial questions in mathematics; however, they struggle to ask follow up questions (Schwartz, 2015; Weiland, Hudson, &Amador, 2013). For the purpose of this study purposeful questioning referred to questions that build on students' mathematical thinking rather than focusing on a teacher-selected response. Purposeful questioning also included asking questions that make the mathematics more visible and accessible to the students.

Franke, Kazemi, and Battey, (2009) examined the classrooms of three elementary mathematics teachers who were involved in algebraic reasoning using the Cognitively Guided Instruction

(CGI) framework. The researchers videotaped and audiotaped the three teachers' classrooms to focus particularly on questions the teachers were asking during instruction that followed up on students initial responses or built on students thinking. Results showed the teachers asked the following three types of questions: (1) teacher directives for students to share their thinking, (2) questions to promote further thinking, and (3) questions to understand students' initial responses. Teachers were often able to address students' initial response with questioning in a variety of ways. Teachers would often ask additional questions of students when their responses were correct to further challenge their thinking. When student responses were incorrect teachers asked additional questions to help students clarify their thinking. These additional questions demonstrated teacher's solid understanding of the mathematical concepts they were presenting to the students. This study provides important information regarding the ways in which teachers can support students to be more explicit in their thinking and more detailed in their explanations through questioning. Additionally, the results show that teachers' questioning can position students thinking in ways to support their mathematical understanding.

In a similar study, Schwartz (2015) observed 56 elementary teachers and their abilities to implement the practice of teacher questioning in their classrooms. Teachers were placed into two groups to participate in either the existing field experience (n=29) or a revised field experience (n=27) focusing more on the development of teacher questioning, with no knowledge of their placement in the particular experiences. Teachers in both sections were evaluated on their abilities to engage in questioning with their students based on the mathematics content, their ability to identify the mathematics being assessed and their analysis of student thinking. Results indicate that there was no difference in the teachers' content knowledge, there was however, significant improvement in the teachers participating in the revised experience abilities to understand appropriate questions to ask, evaluate students thinking, and understand the mathematical goal behind the problem. Schwartz's study provides insight into the need for teachers to use what they know about mathematics and student thinking to pose purposeful questions to their students and also the development of appropriate ways to assess teachers' abilities to purposefully question in mathematics.

Results from these studies indicate that elementary mathematics teachers often have difficulties asking follow up questions that further promote students thinking. Also, these studies indicate the need for elementary teachers to pose purposeful questions to their student that allow for critical thinking and for teachers to evaluate students understanding of mathematics concepts. Finally, these studies imply that using the HLTP of purposeful questioning will positively impact student learning in mathematics.

Supporting Productive Struggle. Supporting productive struggle is essential in supporting student development and understanding in mathematics. Instruction that supports productive struggle embraces students' struggles as opportunities to learn and develop new mathematical connections. Hiebert and Grouws (2007) and Kapur (2014) indicate that a focus on supporting student struggle is essential to students' mathematical learning and understanding and provides students with long-term benefits that will provide them the necessary tools to approach a variety of problems. Teachers can sometimes perceive student struggle as though the teacher failed to reach students. As a result these teachers jump in and "save" their students from developing necessary problem solving abilities (Reinhart, 2010). This action by the teachers lowers the cognitive demand of the problem and takes away the students' opportunities to engage in mathematical sense making (Stein et al., 2009).

Warshauer (2014) used a case study analysis involving 186 classroom opportunities of productive struggle in students in four elementary classrooms as they engaged in problem solving tasks. Students struggles were documented as well as teachers' responses to the struggles and those that were beneficial in supporting students. Results from the study indicate that students often had difficulty choosing a strategy to solve the problems and sticking with that strategy to solve the problem. Students also struggled to examine and explain the solutions strategies they used to address the original problem. Warshauer (2014) describes teachers' responses to student struggle as a fine balance between trying to sustain student engagement and maintaining cognitive demand of the provided tasks. As a result, the researchers developed a Productive Struggle Framework that was used to capture productive struggle experiences of upper elementary students during classroom instruction. Data included transcripts from 39 video recorded class sessions, teacher and student interviews and field notes. Participants were 327 elementary students and their teachers from three different schools. Also, there were varying degrees of teacher guidance throughout the problem solving activities. Results indicate that the teachers' abilities to support the students through allowing more time, asking questions, clarifying and confirming students' solutions, and providing opportunities for discussion with peers contribute significantly to students abilities to problem solve. Posing problems of high cognitive demand gave students the opportunity to think, reason, and problem solve in ways that forced students into situations of productive struggle (Warshauer, 2014). Warshauer's study provide insight into the ways that teachers will need to continue to design high-level cognitive demand tasks and provide students with opportunities for productive struggle for student learning to improve. Embracing productive struggle in the mathematics classroom forces both teachers and students to rethink successful mathematics teaching and learning (Smith, 2000). For students to be successful in the mathematics classroom teachers must embrace productive struggle and effort in problem solving displayed by their students. Teachers must also provide students with meaningful feedback to support their sense making in mathematics.

Promoting Reasoning and Problem Solving

Researchers indicate the importance of selecting tasks that promote reasoning and problem solving and allow access to the problem in many ways. (Stein, et al, 2009; Hiebert, 2004). Major findings from mathematics research over the last several decades has indicated that mathematical tasks do not provide the same opportunities for all students thinking and learning (Hierbert, et al, 1997; Stein et al, 2009); students learning is highest in classrooms that consistently encourage higher level thinking and problem solving (Boaler and Staples, 2008; Stein & Lane, 1996), and that many tasks with high cognitive demand are often scaled down to be less challenging for students (Stigler and Hiebet, 2004).

In their 2012 study, Kisker, et al., used the Mathematics in Cultural Context (MCC) supplemental mathematics problem solving curriculum in an attempt to improve the reasoning and problem solving abilities of native Alaskan second grade students. This study included 25 intervention schools that had no previous experience with the MCC curriculum and 25 control schools. The schools were randomly assigned to either the treatment or control groups and there was little variation the basic mathematics curriculum used by both groups. Using the Picking the Berries and Going to Egg Island problem based units in the MCC the researcher were able to observe significant increases in the treatment group's abilities to problem solve and reason mathematically from pre test to post test in the units. Results from the study indicate that the use of problem solving based mathematics activities were more meaningful to students and in turn promoted higher levels of achievement, mathematical reasoning, and long term retention of mathematical knowledge. In addition, this study demonstrated that teachers using a problem based approach and encouraging mathematical reasoning had a positive impact on both rural and urban students, suggesting the significance of this approach to student learning.

Bailey and Taylor (2015) conducted a study of nine novice teachers as they attempted to learn about HLTP and implement a problem based teaching approach to explore teaching and learning mathematics in their classrooms. The teachers participated in a 12-week mathematics education course with modules focusing on problem solving and working with students on problem solving. Teacher often had opportunities to work on problems in small groups and work with small groups of students on problem solving. Analysis of the data indicated that 8 of the 9 teachers had no experience with a problem solving approach prior to the study. Additionally, teachers also reported the benefit of using a problem solving approach to meet the needs of diverse mathematics learners. Teachers also indicated being able to understand the importance of using a problem solving approach to help them to become problem solvers and critical thinkers. Results from the study revealed that teachers participating in problem solving activities led to shifts if their thinking about how to "do" mathematics and understanding how they might help their students become problem solvers. Bailey and Taylor's study provides important insight into the needs of elementary teachers to experience problem-solving activities to help their students become problem solvers and increase student achievement in mathematics.

The purpose of this review was to view the movement in teacher education to a more practice-based approach and the implementation of HLTP to improve academic achievement in students. It is clear from the research reviewed that much has been done to investigate teacher education with a focus on practice based teacher education. This research has led to significant improvements in teacher education across the United States and the beginning of the development of HLTP. Most of the research found, however, was conducted on pre-service teachers' understanding or use of HLTP in teacher preparation programs. More research is required to determine in-service teachers' knowledge and implementation of HLTP to increase student achievement in mathematics. It is important to see how experienced teachers are using HLTP in their classrooms and how all teachers can learn to implement these effective strategies.

3 METHODOLOGY

The purpose of this study was to describe elementary mathematics teachers' knowledge and implementation of high leverage teaching practices (HLTP). I used a case study design to examine teachers' knowledge of high leverage instructional practices in mathematics and subsequent classroom instructional implementation of these practices. Merriam (1998) asserts the appropriateness of selecting case-study methodology to complete a holistic and intensive analysis of a single, delimited object of study. In addition, Yin (2003) concluded that when an investigation takes place in a real-life context and theory development is a goal of the study, case study is the correct choice.

Qualitative research is often defined by the fluid nature of the inquiry. As a result, qualitative research cannot be completed in a prescriptive, systematic format (Denzin & Linkin, 2005). However, most researchers agree to a certain level of consistency when it comes to effective methods of data collection, data analysis, and reporting (Creswell, 2003). Following these recommendations, this chapter began with the research design, followed by a description of the context of the study, including the study setting and participants. Finally, the methods used to collect and analyze data are explained, while adding a description of the measures taken to assure trustworthiness of the study.

Case Study

Qualitative case study served as the methodology for this study. Merriam (1988) describes case study methodology as a means of in depth inquiry where the researcher explores an event or activity of one or more individuals. Cases are constrained by activity and time, and researchers collect detailed information using various data collection methods (Stake, 1995). For this study, the case was three elementary mathematics teachers from the same K-3 elementary school teaching math lessons and being involved in observations over a period of two months.. Additionally, elementary mathematics teachers' knowledge and classroom implementation of high-leverage teaching practices was investigated. For this study, I collected data through in-depth interviews of the three participating teachers, audio recordings of two elementary mathematics lessons taught by each of the participating teachers, administration of the Classroom Observation Instructional Protocol (CIOP) (Leinwand, 2009), and field notes made during and after observations and interviews. Specifically, interviews and lessons were audiotaped and transcribed verbatim and field notes made during (or after) the lessons were transcribed. All data were first coded using previously determined *a priori* codes followed by coding of additional emergent themes.

Yin (2009) details five components of an effective case study research design: research questions, purpose of the study, unit of analysis, logic that links data to the purpose of the study, and criteria for interpreting findings. According to Yin (2009), the how and why questions are the most effective for case study research. For this study, my research questions were:

(1) Do effective elementary mathematics teachers with no specific professional development implement high-leverage teaching practices in mathematics?

(2) How do teachers describe their use and knowledge of high leverage teaching practices in mathematics?

(3) What influences do teachers perceive as impacting their use of HLTP in their classroom instruction?

The second component of case study research design is to clearly define the purpose of the study. My purpose in this case study was to describe elementary mathematics teachers' knowledge of and implementation of high-leverage teaching practices (HLTP). As previously discussed, use of HLTP enhances student learning. The knowledge gained in this study might lead to better understanding of learning and support that elementary teachers need to develop these high practices to improve student learning. Waddell (2014) indicated that while important research on HLTP is being conducted with pre-service teachers, there is less of a focus in research on HLTP with experienced classroom teachers.

The third component of case study research design is the unit of analysis, which Yin (2009) describes as the area of focus that a case study will analyze. Yin (2009) asserts that when research is accurately specified an appropriate unit of analysis will occur and the unit of analysis is directly related to the research questions the research has developed. The unit of analysis for this case study was the group of three elementary mathematics teachers from an elementary school in a large southeastern city that participated in this study.

The fourth component of case study design is to connect data to the purpose of the study. The connection of data to the purpose of the study begins after data collection, when themes begin to emerge. As data were analyzed, I coded initially for *a priori* HLTP, followed by emergent themes in the data that matched the stated purpose of the study. The aim was to identify themes that address the research questions posed in the study.

The fifth component of case study design research consists of the standards for interpreting findings. Most often, the case study researcher codes the data before identifying emergent themes (Yin, 2009). For this study, I looked specifically for themes related to HLTP that have been previously grounded in research. Additionally, after I reviewed current literature and implemented an open coding process to the data, I discovered emerging themes related to teachers use of HLTP. I used these themes.to carefully determine meaning from the findings to develop recommendations for future research

Study Setting and Participants

This study took place at a public elementary school (grades K-3) located in a metro area in the southeastern U.S. Oakwood Elementary School (a pseudonym) is in a rapidly changing, affluent in town community. Over the last 8 years the district has seen a significant decrease in the diversity within it schools. The district serves over 5000 students across the 8 schools.

The school district commitment to inquiry-based instruction is evident in all schools with the K-3 school implementing the Expeditionary Learning instructional model and the middle and high schools implementing the International Baccalaureate instructional model. Additionally, the districts' commitment to instructional technology is evident across all schools have interactive whiteboards in every classroom, a minimum of 10 classroom student computers and 1 to 1 Ipads for grades 4-12.

Oakwood Elementary School had 452 students and 46 certified teachers. The student body was 71% White, 14% Black, 5% Hispanic, 3% Asian, and 7% Multiracial. The percentage of students eligible for the federally funded free and reduced lunch program was 14%. Additional student demographics include: students with disabilities at 10%, and students with limited English proficiency at 2%. The school had two administrators, one principal and one instructional coach. The teaching faculty consisted of 44 female and 2 male teachers. Of these teachers, 38 were White and 8 were Black, with years of teaching experience ranging from 2 to 33 years. The teachers' academic degrees included, 15 Bachelors, 23 Masters, 8 Ed Specialists, and no doctoral degrees. The school was chosen as a sample of convenience. I was teaching in the school district and had access because the district allows teachers to conduct research at other schools within the district. Additionally, this study took place during the final month of the school year and several observed lessons appeared to be review or an extension of a previous lesson. Finally, pseudonyms were used throughout the study for all teachers and students.

Description of Participants

The participants (3 teachers) in this study were purposefully selected because of their experience with teaching elementary mathematics and were recommended by their principal and instructional coach as effective mathematics teachers. Both the principal and instructional coach were asked to provide their definitions of an effective teacher of mathematics and the characteristics they expected to observe during classroom instruction. The school principal indicated that an effective mathematics teacher is a teacher that focuses on questioning students to help them understand the mathematics being taught throughout the lesson. Also, effective teachers should encourage and allow students to solve problems in a variety of ways using different solution strategies. The principal also stated that when he is observing a lesson, students should be talking and defending their solutions and explaining their thinking in relation to their solutions. The principal also explained that during an effective mathematics lesson he should observe differentiation of the lesson using problem solving and collaboration between students and teachers. The principal discussed at length that effective elementary mathematics teachers focus more on developing the learning process of mathematics over the final product or solution.

Similarly, the instructional coach discussed the importance of effective mathematics teachers using questioning and problem solving to engage students in meaningful, authentic learning. The instructional coach defined an effective mathematics teacher as someone who, first and foremost understands the developmental progression of mathematical reasoning for their target grade and age group and how it flows from previous grades and into following grades (knows and understands the standards). Having a deep understanding is more powerful than being able to relay and provide instruction and practice on discreet skills as they pertain to the specific standards of the teacher's grade level. They need to understand why they are being asked to teach specific concepts such as number sense, composing and decomposing numbers. He also indicated, “I look for teachers who provide learning experiences that build on concrete to symbolic to abstract reasoning skills for students to approach, practice and master mathematical concepts. Effective teachers foster mathematical dialogue. They do not just teach finding answers or only using classic algorithms.”

Additionally, all participants were selected as effective mathematics teachers based on the achievement scores of the students in the classrooms. The principal indicated that criteria for student achievement was based on having over 80 percent of the students in the classroom consistently scoring proficient (3) or exceeding standards (4) on classroom assessments. This is based on the scoring system the district used to evaluate student performance: (1) Developing, (2) Meeting, (3) Proficient, (4) Exceeding. Student achievement was also determined through performance on the Georgia Milestone Assessment (GMAS). The principal and instructional coach used data provided by the district in this study to define an effective teacher as a teacher that has 65 percent or more of students achieving proficient or distinguished status on the GMAS assessment. Students in the classrooms of all three participant teachers met this criteria.

The three teachers were teaching in the same elementary school and were observed teaching math lessons over a period of two months. They ranged in age from 25-43 years old (Shannon 43, Jessica 41, and Sarah 25) and all were female. Participants had an average of 10 years teaching experience. Shannon reported having 14 years experience, while Jessica reported having 13 years, and Sarah reported 3 years. The teachers reported teaching Kindergarten (Sarah), First

Grade (Jessica), Second Grade (Shannon), and also indicated that they teach mathematics in addition to other subjects. Each participant is described below.

Shannon. Shannon (pseudonym) was a white female teacher holding and Educational Specialist degree. She was near the end of her 14th year of teaching during this study. Shannon was in her 4th year at this particular school, teaching 2nd grade. Shannon, a second grade teacher, expressed that she had to work really hard to be what she perceived as an effective mathematics teacher. Shannon expressed that she always had difficulty in math and did not develop a better understanding of concepts until adulthood. She indicated that her background was in Language and Literacy and she was much more comfortable teaching those subjects. Shannon also expressed significant motivation to increase her knowledge in mathematics and become a more effective teacher by seeking out and participating mathematics professional development on her own. She stated that she would attend NCTM workshops and organized a staff development specialist from another school district in the state to work with her team for the school year. Shannon also discussed how she signed up for any mathematics staff development that the school system would offer and in her opinion many of them were not applicable to her teaching.

Jessica. Jessica (pseudonym) was a white female with 13 years teaching experience. Five of those years were spent teaching 1st grade in the school in the study. Jessica held a bachelor's degree in Early Childhood Education, a master's degree in Reading and Literacy, and an Educational Specialist degree in Educational Leadership. Jessica also reported receiving a K-5 mathematics endorsement that was offered by the school district. Jessica expressed always having difficulty in math and remembering that she was frequently told she was not good at math. Jessica indicated that her motivation to become and elementary teacher stems from her difficulties in mathematics and hoping to provide a different, more positive experience for her students. With the exception of the mathematics endorsement offered by her school system, Jessica stated that she had little opportunity for mathematics professional development and the opportunities she pursued were outside of the school district.

Sarah. Sarah (pseudonym) was a white female with 5 years teaching experience and 3 years teaching kindergarten in the school in this study. Sarah held both bachelor's and master's degrees in Early Childhood Education. She also obtained the K-5 Elementary Mathematics Endorsement. Sarah indicated that she believes that she is very competent in mathematics and also views herself as a strong mathematics teacher. She explained how math concepts came to her very naturally and how this had always been her strongest subject area both in school and in her classroom. Sarah also discussed her many positive experiences in mathematics throughout her life and the importance she places on teaching children to think and communicate mathematically, starting in kindergarten.

Data Collection

I collected data for this study by conducting (a) individual, semi-structured initial interviews of the three participating teachers on their knowledge of HLTP, (b) classroom observations using the Classroom Instructional Observation Protocol (CIOP) instrument (described below), (c) audio recording of the 2 mathematics lessons taught by each participating teacher, and (d) field notes. Data collection occurred in a variety of ways to strengthen the design of the study. Data triangulation involves the cross checking of multiple data sources in order to ensure construct validity. Multiple sources of evidence provide valid results (Schensul et al., 1999). Yin (2003) advises that triangulation is not achieved by simply including multiple data sources, but rather when the events of the case study are supported by multiple data sources. As codes and categories were constructed during data analysis, all data sources were explored with the goal of supporting *a priori* codes and emergent interpretations of the data. As previously mentioned, I looked carefully for both agreement and disagreement across data sources. An additional strength of the study design was that I was able to compare interpretations of individual teachers' implementation of high-leverage teaching practices (through the use of the CIOP during mathematics lesson observations and audio recordings of the lessons), with those of their knowledge of the practices (through individual teacher interview data).

Data Sources

Audio Recorded Semi-structured Interviews. All teachers participating in this study engaged in an initial semi-structured interview (Merriam, 2009). The interview is a critical method of data collection in qualitative research. DeWalt and DeWalt (2002) state that the semi-structured interview serves two purposes: (a) as a instrument for gathering rich, deep understandings of a human experiences; and (b) as a means for developing a conversational relation with the participant about the meaning of their experience. There were several convincing reasons for using interviews as a primary data source for this study. First, qualitative interviewing is appropriate when the researcher is studying individuals understanding of meaning within their personal experience (Kvale, 1996). The second reason for interviewing is to learn what is in another persons mind. Patton (1987) indicated that the reason for interviewing is to find out information about people that we are unable to observe. The third purpose of interviewing is that interviews allow the researcher to develop thick descriptions of the subjects being studied, enabling the study reader to make decisions about the transferability of study results (Merriam, 2002). Finally, interviews allow for triangulation of information obtained from other data sources, which increases the credibility of the study (Emerson, Fretz, & Shaw, 1995; Merriam, 2002).

Three participants were interviewed for this study using semi-structured interviews. The semi-structured interviews were used to develop a deep understanding of each participant's knowledge of HLTP. Each semi-structured interview lasted approximately thirty minutes and was conducted immediately following the second lesson observation in the teachers' classroom. Each interview began with a series of questions to determine relevant demographic data from the participants (See Appendix B). Next, teachers were asked a series of open-ended questions related to the participant's knowledge of and experience implementing HLTP in their elementary mathematics classroom (See Appendix C). With participant approval, I audio-recorded the interviews to ensure accurate transcription (Merriam, 2002). The interview explored teachers' knowledge of high-leverage teaching practices. For example, I asked, "Have you heard of High Leverage Teaching Practices?" If the participant was aware of HLTP from previous professional development, I asked "Do you implement high leverage teaching practices in your mathematics instruction?" "Can you give me some specific examples?" If the teacher was not aware of the term HLTP I asked, "Ok, then can you describe your understanding of best practices in mathematics?" When appropriate, I used the interview to gain information regarding the factors that led to the development of knowledge of high-leverage teaching practices, including questions about previous professional development. A copy of the interview protocol is in Appendix C.

Classroom Instructional Observations. Marshall and Rossman (1989) describe participant observation as an opportunity to gather anecdotal data that will add additional information to deepen the understanding of the study. I observed participating teachers teaching two mathematics lessons during the last few months of school (6 observations in all). The observations of the mathematics lessons lasted approximately 45 minutes each or the duration of the lesson.. The Classroom Instructional Observation Protocol (CIOP) (Leinwand, 2009) was used with permission to identify the HLTP the teachers were implementing in their classroom The instructional observation protocol details the nine specific high-leverage practices that are research affirmed to increase student achievement and that need to be included in every mathematics lesson. The COIP was a two- column instrument that listed the specific high-leverage practices teachers should be implementing during their mathematics instruction along with examples of the practices. The second column of the COIP is designed for the observer to take field notes and make comments on the observation of the high-leverage practices during classroom instruction. Reliability of the COIP was attained through triangulation and inter-rater reliability (Leinwand, 2009). Also multiple researchers used the instrument and achieved the same results prior to its implementation and distribution (Leinwand, 2009). A copy of the COIP is in Appendix A.

Audio Recorded Lessons. The lessons were also audio recorded using a handheld Sony recorder that was placed in the front of the classroom near the teacher. When the teacher moved to a different location in the classroom she moved the recorder with her. Additionally, I audio recorded the lessons with an IPhone located in the back of the classroom as a back up. In each, classroom, teachers discussed the recordings with their students prior to lesson to try and limit the distractions. While students were aware of the audio recording equipment, no one appeared to be distracted by its use during the lesson. Audio recordings were used to make certain that all data and information from the lessons were captured. Audio recordings are very useful as a check for any gaps in data, any errors that may occur, and quality control of the data. The audio recordings were used for analysis only and will not be used for public use or presentations.

Field Notes. Field notes were taken during the interviews and in the second column of the COIP to supplement the audio recorded data. For this study, I took jotted notes during the interviews and observations and immediately following I recorded the field notes as completely as possible Field notes are detailed notes of observations or conversations taken during qualitative research. Depending on the study, the notes taken can be full verbatim transcripts of conversations taken by hand or audio recording or brief notes that can be expanded later in the research process. Bell and Bryman (2007) identify three classifications of field notes based on recommendations by Lofland (1995) and Sanjek (1990). These are: mental notes when it may be inappropriate to take notes; jotted or scratch notes, taken at the time of observation or discussion and consisting of highlights that can be remembered for later development; and full field notes written up as immediately and as completely as possible.. Keeping quality systematic field notes was an essential part of this research as reactions to visual observations that are not captured in audio recording are only useful to the extent that the researcher can remember them.

Defining *A Priori* Codes

Initial data for this study were collected based on four *a priori* codes (a) posing purposeful questions, (b) supporting productive struggle, (c) promoting reasoning and problem solving, (d) and encouraging mathematical discourse.

Purposeful Questioning. Purposeful questioning that requires students to explain and evaluate their thinking is an essential part of effective instruction in mathematics (Weiland, Hudson, &Amador, 2013). The inclusion of purposeful questioning allows the teacher to evaluate what students know and provides them with the information necessary to adapt the lessons for the varied levels of understanding while making necessary mathematical connections. Effective mathematics instruction encourages students to reflect on their thinking as an important part of mathematical discourse. Purposeful questions allow teachers to figure out what students know and adapt lessons to meet individual students needs (NCTM, 2014). Purposeful questions are those that assess and advance students' reasoning and sense making of mathematical ideas (NCTM, 2014). Teachers using purposeful questioning in the classroom should ask questions that build on student thinking, go beyond gathering information and require justification, make the mathematics visible, and allow sufficient wait time for students to respond. The identifiers from the COIP instrument for PQ were teachers of mathematics responding to most student answers with why?, How do you know that?, or Can you explain your thinking?

Supporting Productive Struggle. Productive struggle in mathematics is defined as the students ability to make sense of a problem and persevere in solving the problem. NGA Center for Best Practice, 2010) Research suggests that students out of school experiences influence their motivation and perseverance in solving difficult mathematical tasks (Taylor, 2015). Productive struggle is also impacted by students' perceptions of their own mathematical ability in relation to their classmates (Middleton, Tallman, Hatfield, and Davis, 2015). Factors that affect a student's ability to productively struggle include the students' mathematical self-image, whether or not the student finds the task interesting, whether or not the student feels he or she knows enough mathematics to solve the problem, and if the student believe the problem is worth the effort (Star, 2015). Supporting productive struggle is essential in supporting student development and understanding in mathematics. Instruction that supports productive struggle embraces students' struggles as opportunities to learn and develop new mathematical connections. NCTM (2014, p. 11) states, "An effective teacher provides students with appropriate challenges, encourages perseverance in problem solving, and supports productive struggle in mathematics." Walshaw (2015) indicated that teachers can do the following four thing to support students in productive struggle: ask questions that focus their thinking and identify their struggle, encourage student reflection on their work, give time for students to struggle and not step in too soon, and acknowledge that struggle is an important part of mathematics. The identifiers from the COIP instrument for Supporting Productive Struggle were teachers of mathematics taking every opportunity to develop number sense by asking for, and justifying, estimates, mental calculations and equivalent forms of numbers.

Promoting Reasoning and Problem Solving. Researchers indicate the importance of selecting tasks that promote reasoning and problem solving by allowing access to the problem in many ways and providing opportunities for multiple solution strategies (Stein, et al, 2009; Hiebert, 2004). According to NCTM (2014) teachers that promote reasoning and problem solving should motivate students' learning of mathematics through providing opportunities for exploration and problem solving, select tasks that provide multiple entry points, pose tasks that require a high level of cognitive demand, and encourage students to use varied approaches to problem solving. The COIP indicated that effective teachers of mathematics elicit, value, and celebrate alternative approaches to solving mathematics problems so that students are taught that mathematics is a sense-making process for understanding why and *not* memorizing the right procedure to get the one right answer.

Mathematical discourse. involves the exchange of ideas, through classroom discussion and other types verbal, visual, and written communication. Discourse in mathematics classrooms allows students to create convincing arguments on why and how things work, share ideas, clarify understandings, develop language for explaining mathematics, and see things from the perspectives of other students (NCTM, 2000). Effective mathematics teaching engages students in mathematical discourse that will increase the mathematical learning of the whole class (NCTM, 2014). Teachers encouraging mathematical discourse should engage students in purposeful sharing of ideas and reasoning, facilitate students' explanations and defense of their mathematical ideas, and ensure progress towards mathematical goals by making connections to students' approaches and reasoning (NCTM, 2014). The identifiers from the COIP instrument for Support

Mathematical Discourse were teachers of mathematics creating language-rich classrooms that emphasize terminology, vocabulary, explanations and solutions.

Data Management

In order to prepare the data for analysis, I maintained a binder with color-coded dividers indicating each form of data. Schensul and LeCompte (1999) suggested developing data instrument logs for organizing and managing data. To complete this, and Excel spreadsheet was used to manage each data source (e.g., lesson transcripts, interview transcripts, field notes, and researcher memos), date recorded, and a brief description of the data contents. All data were organized in chronological order within the binder to demonstrate the natural progression of the data collection. Chronological order also helped improve the process of reading through and reviewing the data.

During the data analysis phases, data were physically sorted into emergent themes reported on index cards with category names written on the top. The data were then sorted into groups of interrelated themes and ideas by physically positioning them on chart paper, while actively engaging in memo writing. This process helped me to identify relationships between emergent categories and themes.

Data Analysis

One of the initial goals in qualitative research is to reduce data into manageable parts for additional synthesis and interpretation (Lecompte and Schensul, 1999). The process of identifying and interpreting meaning from qualitative data usually begins with coding. Saldana (2009) indicated that coding is primarily interpretive and not always precise. Since data interpretation is filtered through the researchers lens, it is necessary that reporting data analysis is transparent as to how the codes were developed (Yin 2003). In the following sections, examples are given at each step in the coding process to clearly demonstrate the process by which data were analyzed.

For this study, data were analyzed in two separate phases, First Cycle coding (open coding) and Second Cycle coding. The difference between the purposes of First and Second Cycle coding is defined as First Cycle coding being primarily for data reduction and Second Cycle coding for the purpose of classifying, synthesizing, interpreting data (Saldana, 2009).

Open Coding. At the conclusion of data collection, I began a more in-depth analysis using open coding. This process was used to develop as many possible promising themes related to the research questions without overlooking any of the data. Since, I was exploring the data for emergent themes and only had a vague idea about themes that would, I followed the suggestion of Auebach and Silverstein, (2003) to keep a copy of the research questions, and goals of the study close by to make focused decisions about coding. I referred to this regularly during the data coding process.

Open coding involved several continuous steps. First, I wrote summarized phrases in the margins of the lesson transcripts, interview transcripts and field notes. Bogden and Bilkin (1998) detailed the importance of summarizing early in the data analysis process to avoid making advanced inferences, which can impact the trustworthiness of the study. Once I labeled the data physically, I entered each code into an electronic coding manual. As suggested by Saldana (2009), I included the code phrase, the location and a description of the data (which included a copy of the specific data). This organizational tool was important for me to maintain consistency between data interpretations. Some of the codes and categories from the First Cycle coding are included in Table 3.1.

Table 3.1
Codes and Categories from First Cycle Coding

Categories	Shannon	Jessica	Sarah
Lack of Confidence in Math	WORK HARD TO FEEL GOOD	UNCOMFORTABLE BAD FEELING	CONFIDENT IN K
Limited Math PD	NONE PROVIDED	ALL READING PD	NO MATH PD
Difficulties Knowing Questions to ask	PLANS OUT Q'S UNSURE ABOUT EFFECTIVENESS	PURPOSELY IN-CLUDES QUES-TIONS DIFFICULTY WITH FOLLOW UP Q'S	PRE-PLAN Q'S
Not Being "Good" at Math	STRUGGLED IN SCHOOL	GOOD READER AND WRITER	LANGUAGE AND LITERACY BACK-GROUND
Comfort Level with Problem Solving	IMPORTANT, TRIES TO IN-CLUDE	SPENDS A LOT OF TIME WORKING ON THIS	INCLUDES PS WHEN POSSIBLE
Allowing students to struggle	TRIES NOT TO JUMP IN	DIFFICULT TO GIVE UP CONTROL	WANTS TO HELP

Second Cycle Coding. Codes that emerged from First Cycle coding were grouped into new categories through the process of Second Cycle coding. These categories were constantly refined by ongoing analysis, which was achieved by continuously referring back to the original data sources for interpretation and developing statement about the relationship between the individual units of data and the emergent themes

To help place the codes into the various categories, printouts of the coding manual were cut into pieces by coded data units. These data units were then grouped by placing them on index cards with the title at the top. All the index cards were then placed on large poster paper so connections could be made between categories and codes with a marker. Once a theme had emerged, I went back through the data to look for statements confirming or disconfirming the evidence (Stake, 1995). In some cases disconfirming evidence caused me to reorganize the emergent themes. For example, after observing Shannon teach problem-based lessons that included purposeful questioning, I began to attribute this to high self-efficacy and knowledge of HLTP. However, interview data appeared to disconfirm this initial thought:

> Int: It seemed like you were comfortable with questioning in Math and using HLTP during your lessons? Like, when you asked Johnny, "What information do you have that you can use?, instead of giving him a strategy.
>
> Shannon: "I don't feel that I am very good at teaching math. I have to work really hard to feel like I know what I am doing. Math has always been really difficult for me."

Because Shannon displayed what was initially perceived as characteristics of an effective mathematics teacher, implementing HLTP, with high self-efficacy, her knowledge of HLTP and apparent high self-efficacy could not be attributed to any of the emergent categories.

After each interview and observation, audio recordings were transcribed verbatim and I wrote any additional memos connected to further ideas or questions that emerged during the transcription process. Data analysis involves the process of making meaning from data, a process involving the consolidation, reduction, and interpretation of what has been said and observed (Merriam, 2009). Data analysis involved a two-step process, initially applying *a priori* codes using content analysis, followed by a constant comparison method.

All data found from the *a priori* coding of the interviews and field notes were analyzed using the process of content analysis (Cole, 1988) in an attempt to observe the frequency of themes related to high-leverage teaching practices. Content analysis is a method of analyzing written or verbal communication messages (Cole, 1988; Harwood & Garry, 2003). Additionally, content analysis as a research method is a systematic and objective way of quantifying phenomena with the goal of developing a condensed and broad description of the phenomena (Downe-Wamboldt, 1992; Sandelowski, 1995). For this study, the following *a priori* HLTP were identified as observable behaviors from the full list of HLTP and were used for initial coding: (1) meaningful mathematical discourse (MMD), (2) purposeful questions (PQ), (3) support productive struggle (SPS), and (4) promoting reasoning and problem solving (PRPS). When I observed what I believed to be one of the HLTP during the lesson I included a tally mark on the COIP recording sheet and jotted the question down in the margin of the form. At the conclusion of the observations, I wrote memos about why I believed the particular question belonged in the chosen category. After the data was transcribed, I carefully checked the lesson transcripts for agreement with my initial determination. Throughout this process, I consistently referred back to the research-based definition of each HLTP to confirm or disconfirm my initial thoughts.

After *a priori* coding, a constant comparison analysis occurred. Constant comparison allowed previously unidentified themes and categories to emerge through a repetitive process of coding, collapsing, and verifying codes. Data were analyzed using line-by-line open coding, generating many units of meaning (Lincoln & Guba, 1985), that was included in a coding manual. Data from the themes was then compared across teachers and additional data reduction took place to form smaller groups. The process of renaming, combining, and collapsing continued until shared themes emerged across the participant's knowledge and implementation of high leverage practices and the data categories represented the observed experiences found in the data (Strauss & Corbin, 1998).

This qualitative procedure allowed new themes to emerge and allowed the researcher to develop an understanding of teacher's knowledge and implementation of high leverage teaching practices.

Trustworthiness

Qualitative validity was determined by using several strategies to check the accuracy of the findings. Triangulation from different data sources was used to justify the themes that emerged in the study (Creswell & Miller, 2000). Credibility is when the researcher analyzes the data through a process of reflecting, exploring, judging its relevance and meaning and ultimately developing themes that accurately represent the experience. Credibility was established by member checking and sending participants their transcript for review and verification. Each participant was asked to agree with his or her transcript. Maintaining and preserving all transcripts, notes, and audiotapes established dependability in the study. Authenticity refers to the reporting of each participant's experiences in such a way that it maintains respect for the context of the data and presents all perspectives equally so that the reader can develop their own conclusions.

Bracketing

In qualitative research, the researcher sets aside his potential prejudices and biases in a technique called bracketing (Bogdan, 1979; Creswell, 2007; Taylor &Bogdan, 1984). Creswell (2007) states that bracketing is completed in qualitative research to allow the researcher to set aside preconceived experiences to gain a more in depth understanding of the participant's experiences. Moustakas (1994) also refers to this as the epoche, which is where the researcher is mindful of information that is really there and avoids the familiarity of everyday events and people. The epoche is a reflective-meditative technique that allows preconceived notions to be addressed and written down or bracketed when the researcher is ready to do so (Mustakas, 1994). However, Crotty (1996) pointed out that it is not humanly possible for qualitative researchers to be totally objective. If the researcher is unaware of their own preconceptions or beliefs about a subject it is impossible to put them aside. The process of bracketing allowed me to be aware of my interest, beliefs, knowledge, and thoughts before beginning the research process. Our knowledge hinders our ability to thoroughly research a topic when we unknowingly bring assumptions about the topic into the research process (Whall, Sinclair, & Parahoo, 2006). It became a challenge for me the researcher, as an elementary mathematics teacher, to conduct a study to explore the experiences of other elementary mathematics teachers in their classroom settings. My previous knowledge and assumptions could limit my ability to understand participants' perspectives because I already knew a significant amount about the topic. This could introduce bias to the research. In order to address this bracketing was used. I used several strategies to acknowledge and address my researcher influence throughout the research process.

I first focused on achieving reflexivity through the use of a reflexive journal, where I wrote down my feelings, thoughts, and perceptions during all stages of this study. This allowed me to re-examine my ideas related to teachers' use of high leverage practices when issues arise that may affect the study. Next, I limited the scope of the literature review to achieve bracketing. Since any additional information I learned through the literature review could cause a potential bias, I limited the scope of the literature review so that I have an understanding of HLTP but that I was still able uncover new information about how teachers are implementing these practices. Finally, to achieve bracketing during the data collection phase of the study, I used semi-structured interviews. The use of semi-structured interviews allowed me to be guided by the participants' responses rather than by predetermined questions. During these interviews I asked focusing questions rather than guiding questions to achieve bracketing. My ultimate goal was to gain an in-depth understanding of teachers' knowledge and use of high leverage teaching practices in mathematics and the use of bracketing allowed me to minimize any potential bias or influence I had on the study. Since this report is fulfilling a doctoral research requirement, the data analysis portion of this report was scrutinized and validated by the researcher's doctoral committee.

The Role of the Researcher

As the researcher, I carried out this study with the goal of describing teachers' knowledge of and implementation of high-leverage teaching practices in an elementary mathematics classroom. Kilbourn (2006) indicated that researchers need to review their own biographical experiences as they relate to the studied topic.

One important difference between qualitative and quantitative research is the role the researcher plays in the process. It is clear that the primary instrument for data collection and analysis in case study research is the researcher. As a researcher moves through the research process, the researcher must acknowledge he or she is a human instrument and the primary research tool. As such, it is necessary for researchers to consider their own biases and limitations throughout data collection, analysis, interpretation, and the reporting stages of the process. Qualitative research assumes that the researcher's biases and values impact the outcome of any study (Merriam, 1998). However, Peshkin (1993) submitted that, "one's subjectivities could be seen as positive, for bias is the basis from which researchers make a distinctive contribution, one that results from the unique configuration of their personal qualities, and joined to the data they have collected" (p. 18). To allow any audience of qualitative studies to evaluate the validity of conclusions inferred from data, researchers should, as part of the study, neutralize or bracket their biases by stating them explicitly to the full extent possible (Altheide, 1990). For this study, in the interest of full disclosure and of safeguarding against unethical or unintentional influences on my interpretations of elementary teachers' knowledge and implement high-leverage teaching practices, the following discussion outlined my personal experiences relevant to this study.

For the last 16 years, I have been teaching in a K-5 elementary classroom. For this study, I conducted research in the school district where I was teaching and was in a mathematics teacher leadership role. During this time I have had the opportunity to work with many teachers in a mentoring role, where I have observed their classroom instruction. During this experience, many teachers expressed a belief that they had knowledge of high-leverage teaching practices (or best practices) and were implementing them in their classroom. This experience presents a potential bias because based on my teaching and mentoring experiences, I believed that there are many experienced in-service elementary mathematics teachers that believe they are implementing high-leverage teaching practices, however, when classroom instruction is observed minimal implementation occurs.

In addition to my teaching experience I was also pursuing a Ph.D. in Elementary Education with a focus on Mathematics. During my experience in a doctoral program, I believed that I received more than adequate professional development related to the implementation of high-leverage teaching practices. As a part of the program, I completed an elementary mathematics endorsement that included four mathematics courses along with a teaching internship. Throughout this program my classroom instruction was observed and evaluated for implementation of high-leverage teaching practices. Through participating in the doctoral program focused on mathematics education and he mathematics endorsement, I feel that my knowledge and implementation of HLTP was greatly improved. Simultaneous to these experiences, I participated in numerous professional development activities in my school that covered a variety of mathematics topics with varying quality. However, throughout professional development in my school system experience, I did not receive any professional development specifically related to high-leverage teaching practice. Those programs that prepare pre-service teachers may introduce high-leverage teaching practices, but offer minimal (if any) follow-up support in the classroom. Practicing teachers often receive significantly less professional learning to address the knowledge and implementation of high-leverage teaching practices. My experience with this doctoral program provided me with the expertise to assess understanding and implementation of HLTP, but could also potentially constituted a bias.

4 RESULTS

The purpose of this research study was to examine elementary mathematics teachers' knowledge of high leverage teaching practices (HLTP) and how they implemented high-leverage teaching practices in their classroom. The following research questions informed this study: (a) Do effective elementary mathematics teachers with no specific professional development implement high leverage teaching practices? (b) How do teachers describe their use and knowledge of high-leverage teaching practices in mathematics? (c) What influences do teachers perceive as impacting their use of HLTP in their classroom instruction?

During the observations of classroom mathematics lessons, teachers were observed in order to document the ways in which they implement HLTP. Also, during in-depth interviews teachers were asked to describe their knowledge of HLTP and their perceptions of and experiences with implementing them in their classrooms.

The research findings that this chapter reports were based on the analysis of the following data sources: classroom observations, in-depth interviews, and the researchers field notes and analytic memos.

Summary

The participants of this study were three elementary mathematics teachers from a small, urban PK-12 school district in a Southeastern state. They ranged in age from 25-43 years old (Shannon 43, Jessica 41, and Sarah 25) and all were female. Participants had an average of 10 years teaching experience. Shannon reported having 14 years experience, while Jessica reported having 13 years, and Sarah reported 3 years. The teachers reported teaching Kindergarten (Sarah), First Grade (Jessica), Second Grade (Shannon), and also indicated that they teach mathematics in addition to other subjects.

Participants contributed different amounts of information to support the themes that comprise the narrative. Some participants talked at length on one or two themes; some participants made nearly equal contributions across all the themes. Thus, all participants' voices and views were represented in this study. The unit of analysis was the group of three participating teachers. .

When asked about their knowledge of HLTP, all the participants indicated they were not familiar with the term HLTP. They each asked if HLTP referred to or were related to Best Practices professional development they remember from their undergraduate teacher professional development program. Shannon, for example, stated, "I am very familiar with Best Practices from years ago but I don't know anything about current practices." She also indicated that she would assume HLTP had something to do with using mathematical practices in her classroom and using strategies that would encourage problem solving and having students explain their thinking.

Similarly, Jessica described that she was aware of the term HLTP in classroom instruction. She stated that she thought they would have something to do with differentiated instruction or small groups of students. She went on to explain that she had heard of Best Practices in teaching but was not clear on what those were.

Jessica also explained how she had never heard of the term HLTP and she was not sure how to use them in the classroom. She then wondered if they were similar to best practices in teaching, which she mentioned she had some experience with previously as a pre-k teacher.

Interestingly, although all three participants explained not being familiar with the term HLTP ,after a brief discussion of HLTP they all felt as though they used them in their daily instruction. Each of the three teachers stated, "Yes, I definitely do that in my class. I would call that good teaching."

Classroom Instructional Lessons

This section describes each of the observed classroom instructional lessons. Each lesson was coded with the teachers' name (a pseudonym) and the number 1 or 2 for lesson #1 or lesson #2. All observed lessons from each teacher began with a problem-solving activity (including a class discussion), concept development, and an exit ticket (closing to the lesson).

Shannon lesson #1, Grade 2. Shannon began this lesson with a short warm up as she organized materials for the lesson. She then introduced the problem: *There are 24 penguins sliding on the ice. There are 18 whales splashing in the ocean. How many more penguins than whales are there?* Each of the students had a math notebook where they copied the problem, which was projected on the interactive whiteboard. Shannon also gave the students access to a variety of manipulative if they wanted to use them. Shannon then read the problem to the group and provided students the opportunity to solve the problem on their own, then talk with a partner at their table, and finished with a group discussion of solutions and mathematical ideas. During the table discussions Shannon moved around listening to group discussions. This was followed by a group discussion facilitated by Shannon.

Shannon lesson #2, Grade 2. Shannon began this lesson with a subtraction fluency warm up. She then introduced the problem*: Mr. Thompson's class raised a total of 96 dollars for a field trip. They need to raise a total of 120 dollars. (A). How much more money do they need to reach their goal? (B). If they raise 86 more dollars, how much more extra money will they have?* For this lesson the students were given the problem on a piece of paper in groups of 3. Shannon gave each of the groups poster paper and markers to solve and show their solutions. She told the students they needed to discuss the problem and agree on an answer before transferring the information to the poster. She also encouraged the students to show different solution strategies on the poster. Shannon moved around and asked questions of the different groups, clarified any misunderstanding, and encouraged the groups to continue working. This was followed by a class discussion facilitated by Shannon.

Jessica lesson #1, Grade 1. Jessica called all the students to the carpet and began the lesson with the following problem: *Ben played 9 songs on his banjo. Joe played 3 more songs then Ben. How many songs did Joe play?* For this lesson all the students had a marker and whiteboard with them to solve the problem. As the students were solving the problem, Jessica asked them to write a number sentence that matched the problem on their boards. After the students solved the problem she called several students to the front of the class to share their strategies for solving the problem. She then asked the students to write a statement the showed the answer. The class discussion and students sharing continued until the end of the lesson.

Jessica lesson #2, Grade 1. Jessica began this lesson introducing the problem: *Lisa was reading a book. She read 6 pages the first night, 5 pages the next night, and 4 pages the following night. How many pages did she read?* Jessica read the problem to the class and it was projected on the whiteboard and all the students had their math notebooks. For this lesson, after Jessica introduced the problem she met with a small group and had two groups working independently. Jessica gave the independent groups the following problem to complete when they were finished: *If she read a total of 20 pages by the fifth night, how many pages could she have read on the fourth and fifth nights? Jessica continued working with the small group and facilitated a class discussion with the whole class at the end with the first problem. She planned to check in on the second problem with the independent groups the next day.*

Sarah lesson #1, Grade K. Sarah began this lesson with a brief counting warm up to get all the students settled after coming in from recess. After the warm up she introduced this problem to the students: *We are going to be talking about shapes again. Draw things you saw this past* *week that looked like shapes you know. What are the different shapes called?* When the students finished they had to share their picture with a partner and discuss the name of the shape and how the knew the name. Sarah also had the students check with their partner for agreement about the shapes. During this time Sarah walked around the room reviewing definitions of different shapes and asking students questions about the drawings they made. She also asked two groups to describe shapes that could be combined to make other shapes. The lesson concluded with the students drawing a new picture with different objects from their week.

Sarah lesson #2, Grade K. Sarah began this lesson with a skip counting activity warm up again to focus the class on mathematics after recess. She had the students sit on the carpet and the following problem was introduced: *Ms. Garcia is panting her fingernails. She has painted all the nails on her left hand except for her thumb. How many more nails does she need to paint? How many does she have left to paint after she paints her thumb? Draw a picture to help you.* Shannon read the problem to the class and it was displayed on the interactive white board in front of the class. Sarah moved around checking the students' white boards and asked questions of several students. When all the students finished, Sarah facilitated a whole class discussion and asked for several students to share their solutions.

Study Findings

Four *a priori* codes were examined for this study. They were: teachers use of purposeful questioning, teachers supporting productive struggle, teachers promoting reasoning and problem solving, and teachers encouraging mathematical discourse. Additionally, three additional themes emerged from the data: (1) teacher's confidence in mathematics, (2) teacher's confidence in teaching mathematics, and (3) teacher's having limited opportunities for professional development.

For each of the four *a priori* themes I first provided data for the number of times the theme was observed in both lessons for each of the three teacher participants. I then provided quotations from the transcripts as examples of evidence of the theme. These results addressed my research question: Do effective elementary mathematics teachers with no specific professional development implement high leverage teaching practices? Following the examples, I provided quotations from the interviews of how each teacher described her use of particular HLTP. These quotations were provided to answer research question number two: How do teachers describe their use and knowledge of high-leverage teaching practices in mathematics? After providing these results, I presented the other themes that emerged during the interviews.

Theme 1: Teachers' use of purposeful questioning

This section detailed teachers' use of purposeful questioning in their elementary mathematics classroom to help students develop a deeper understanding of mathematical concepts. Purposeful questioning was defined earlier as an instructional practice allowing the teacher to evaluate what students know and providing them with the information necessary to adapt the lesson for varied levels of understanding while making necessary mathematical connections. Asking questions however does not ensure students will develop understanding. The types of questions they are asked students and the pattern of questioning that is being used must be considered. For the purpose of this study purposeful questioning referred to questions that build on students' mathematical thinking rather than focusing on a teacher-selected response. Purposeful questioning also included asking questions that make the mathematics more visible and accessible to the students (NCTM, 2014).

After analyzing the lesson transcripts and field notes from the lesson observation, the researcher found all participants used purposeful questioning during their lessons, although with varying frequency. Raw Data in Table 4.1 indicates the frequency that each teacher was observed using purposeful questioning during her lesson.

Table 4.1
Frequencies of Teachers use of Purposeful Questioning

Purposeful Questions	Shannon	Jessica	Sarah
Lesson 1	27	23	18
Lesson 2	25	17	11

When observed during instruction, all participants asked questions of their students with the purpose of guiding them to develop understanding of a mathematical concept or encouraging them to think more deeply about their solution. All the participants in this study used purposeful questioning.

Shannon, an experienced teacher with 14 years experience, used purposeful questioning the most of the three participants. Across the two observed lessons she asked 27 questions in the first lesson and 25 questions in the second lesson to encourage her students to think deeper and to analyze solutions to mathematical problems. For example, in one lesson during a discussion, she asked, " How do you know that if you subtracted you would get 600?" Shannon continued on to ask a student, "If I only have six, can I take away 10 from it? In Lesson 1 Shannon asked the following questions.

- How does your picture relate to addition and subtraction?
- What does your solution have to do with the party time task?
- What might happen here taking 100 and subtracting?
- How can you prove that 100 is the solution?
- How do you know that your sum will be greater than your first amount?

- Why does group A get more than Group B in this problem?

An example from Shannon's second lesson is as follows.

- Jennifer, what do you think about what Henry said?
- How does this relate to our first problem? Can you explain?
- Does 100 seem reasonable for this problem?

As with most teachers, Shannon was not limited to only asking purposeful questions. She also asked questions of the students that would be considered good questionning, but not considered examples of *purposeful questions* for this study. For example, she asked, "Can you explain that in a different way, " and "Can someone please explain what Jennifer said in another way."

In her interview Shannon said, "it is important for me to ask my students questions with a purpose in mind so that I can guide them to develop a deeper understanding of the mathematical concepts we are studying." She also stated, "I usually try to guide them with questioning and give them a chance to tell me more about their thinking?"

Jessica, an experienced first grade teacher with 13 years of teaching, used purposeful questioning during her mathematics lessons too, however less frequently than Shannon. During observations of Jessica's lessons she asked 23 purposeful questions in lesson one and 17 purposeful questions in lesson two. In her first lesson Jessica asked the following series of purposeful questions:

- Can you explain to us why you chose to use a number line to solve this problem?
- How can you be sure the 79 is the correct solution?
- Is there a different way you could solve this problem?
- Does your answer make sense for this problem?

- What did you learn about math today?

During her interview, Jessica stated, "I think I am getting better at questioning and being purposeful about the words and vocabulary I am using to help the students better understand math." Jessica further explained that she does not only use purposeful questioning in her lessons. She stated, "I always try to focus on asking my students questions instead of just giving them the equation or the solution. Sometimes my questions are just to make sure they understand what they are doing. I often use my questions as a way of assessing my students." She also mentioned that questioning is an area that she has continued to work on and feels as though she has improved in over the last five or six years of teaching. Jessica stated, that she tries to plan her daily lessons with questioning in mind so that she can try to deepen her students understanding. For example, she stated that, "The wording I use and the questions I use are open-ended to see what the students will say and then I can guide them with additional questions."

Sarah, a kindergarten teacher who was the least experienced in this study with 3 years experience, also used purposeful questioning in her lesson but less frequently than the other teachers. During her first lesson, 18 purposeful questions were observed with 11 during her second lesson. Sarah talked about how she was comfortable asking questions during her lessons and stated that she felt that this was the most important part of her lessons. Many of the purposeful questions she asked during the lessons were directly related to helping her students understanding the concept being studied, place value. For example, she asked, "How many groups of tens are in the number 33?" Additionally she asked, "What number is that, can you break the number down in tens and ones using place value?" Sarah also indicated that she tries to give her students questions to help them develop their understanding of math and to help them dig deeper into the problems. During Lesson 1, Sarah asked the following questions with a small group:

- Can you explain how you know this is a rectangle?
- How do you know that it will be odd or even?
- How does your picture help you solve this problem?
- Is there a different way to find a solution other than making dots?

In her interview, Sarah indicated, “Yeah, I definitely try to use questions in my lesson. It is something that I focus on when I plan my lessons.” She talked about how she was comfortable asking questions during her lessons and stated that she felt that this was the most important part of her lessons.

Consensus among all three participants was summed up by Jessica when she said, “We as teachers try to make sure we are asking our students as many open-ended questions as we can during a lesson and try to let them talk to give us solutions. We also try not to give them answers but help guide them to understand through questioning.

Purposeful questioning was used in all the lessons and was described by all the teachers in the interviews. Even though the teachers stated little formal knowledge of the term HLTP, they unanimously engaged in it with some understanding of its purpose.

Theme 2: Teachers’ support of productive struggle

This section described teachers’ abilities to support productive, developmentally appropriate struggle in their classrooms. Supporting productive struggle involves instruction that supports productive struggle embraces students’ struggles as opportunities to learn and develop new mathematical connections. Hiebert and Grouws (2007) and Kapur (2014) indicated that a focus on supporting student struggle is essential to students’ mathematical learning and understanding and provides students with long-term benefits that will provide them the necessary tools to approach a variety of problems.   Further, this sections detailed specific instances where teachers provided these opportunities for productive struggle.

All three participants in this study provided some opportunities for their students to struggle and grapple with difficult problems although seen less frequently than the previous theme. Data in Table 4.2 shows the number of observed incidents in each of the observations.

Table 2
Frequencies of Teachers Supporting Productive Struggle

Supporting Productive Struggle	Shannon	Jessica	Sarah
Lesson 1	5	7	0
Lesson 2	3	2	2

Shannon began both of her lessons with a problem of the day where students were given the opportunity to work individually on a problem and encouraged to try solutions on their own for several minutes before talking with a partner. After working with a partner the students discussed their solutions with the teacher and the whole class. The following were questions Shannon asked with a small groups of students during the intial problem solving activity.

- Sammy, have you tried more than one strategy?
- Can you think of another way to explain your solution to the group?
- Eve, can you offer a suggestion to Sammy for a possible way to solve this problem?

During these activities I observed students trying different solutions while Shannon moved throughout the group asking questions to support their problem solving. Evidence of Shannon encouraging productive struggle is seen in the first lesson when she was working with a student who appeared to be having difficulty. Shannon stated, “You will need to do more math, what strategies have you tried to solve this problem?" During her second lesson, a small group of students was working on a problem-solving task. One student sat by himself, not attempting to solve the problem. Shannon sat with him individually asking him questions. She asked, "What strategies do you think will work? Have you tried to solve the problem?" After working with the student for a few minutes, Shannon offered a strategy for the student who went on to successfully solve the problem. Working with another student Shannon asked the following questions.

- Keri, is there another way you could try to represent that?
- Do you think a different strategy would work better?
- How would you explain your understanding of this problem right now?

In her interview Shannon also said, "I try to let the students guide the questioning and try to let them guide the questions and support them in their thinking. I also ask them to tell me more about that and ask them to explain why they think a certain way about a problem." Shannon further explained that, "I try to allow them to experience struggle in the classroom. I find it difficult sometimes because I want to help and give them a way to solve the problem or the answer but I know it's best if I support them while they figure it out."

Similar to Shannon, **Jessica** also began each of her lessons with a problem solving activity that the students were expected to grapple with as she supported the development of their mathematical understanding. During Jessica's lessons much of her support of the students struggle involved giving verbal encouragement for them to continue trying solutions or encouraging them by reminding other group members to give students time to think and formulate their solutions. For example, during her first lesson she stated several times, "Let Ellie finish, we need to give her time to think." She also stated that, " I know math is hard, but I know you can solve this problem, what do you need to do next?" Additionally, Jessica supported productive struggle in her classroom during the following mini-lesson by asking the following questions:

- Walker, I know it is hard. Have you tried another way to solve it?
- Can you thinking of a different strategy to use?
- Does anyone have another way to solve it that they can share that might help the group understand?
- Could tally marks be a way to solve this problem? Is using tally marks the best way to solve or should we try something else?

During her interview Jessica indicated that she tries to support productive struggle but finds it difficult to give up control and let her students struggle. She stated, "I want to support my students in their struggle by I find it really difficult.. I just really want to jump in and help them. . I think it takes me having the ability to give up control to allow them to work through the problems and I am working on this in my lessons."

Sarah also supported productive struggle in her classroom, however, during the first lesson, there were no occurrences observed where productive struggle was supported. During this lesson observation, students were not provided opportunities for productive struggle as this lesson appeared to be a review of a previously taught lesson. Students were observed being asked clarifying questions with little need to struggle through development of mathematical understanding.

During her second lesson, Sarah encountered one student that seemed to be having a particularly difficult time with a problem and she spent several minutes asking the student the following series of questions to help support his understanding. She asked,

- So what could help you find this?

- Can you think about strategies to solve word problems that we've used in the past?
- Do you want to do circles? Would that be helpful?
- Do you want to draw a picture?
- Don't forget, what it the question asking you to do?

Sarah briefly described how productive struggle was supported in her classroom when she stated that, "I give my students a chance to think and figure it out on their own. I don't just want to tell them how to solve problems."

Theme 3: Teachers' promotion of reasoning and problem solving

This section described teacher's use of problem solving activities in their classroom. Further this section discussed the ways that teachers promoted mathematical reasoning and student justification of their chosen solution strategies. Promoting Reasoning and problem solving was previously defined as using mathematical tasks that motivate students learning and help students build new mathematical knowledge through problem solving (NCTM, 2014). Additionally, these selected tasks must encourage reasoning and access to mathematics through a variety of entry points and allowing for a variety of representations and solution strategies. Raw data in Table 4.3 details the frequency of incidents that occurred during classroom observations.

Table 3
Frequencies of Teachers Promoting Reasoning and Problem Solving

Promoting Reasoning and Problem Solving	Shannon	Jessica	Sarah
Lesson 1	11	14	12
Lesson 2	13	17	5

All participants in this study discussed the importance of promoting reasoning and using problem-solving based lessons in their classrooms. Each of the participants began each lesson with a problem solving activity and continued with problem solving during small group instruction.

Shannon, the most experienced teacher in the group, provided many opportunities for reasoning and problem solving in her class. The following is an interaction between Shannon and several of her students during a problem solving discussion:

- Adam, can you explain what you think won't work with Henry's solution?
- Kate, is there another way to solve this problem?
- Is there another possible answer to this problem?
- Do we think that this answer is reasonable based on the problem?

Shannon continually provided students with problem solving task and opportunities to communicate their reasoning both written and orally. Additionally, she asked for alternative solution strategies to have students further explain their reasoning. Shannon was also observed asking students that were not immediately volunteering to explain their reasoning during the problem solving activity. She asked Sammy, a boy who sat by himself and would not look up from his whiteboard, "What do you think might be a possible solution, can you explain to us your thinking in the way you solved the problem." Additionaly Shannon asked a group of students,

- Anna, what didn't work with your data?
- What have you tried so far?

- Michael do you see any other possible solutions?
- Michael what do you think you should do next?

In her interview, Shannon stated, "Yes, I try to do this a lot during my lessons. I focus on problem solving and having the students explain how they solved the problem. I want them doing the work and the thinking." She also indicated, I always try to focus my questioning so my students will have the opportunity to problem solve and communicate their thinking. I really think this helps them become better mathematicians."

Jessica also began each of her lessons with a problem solving activity where the students were given a problem and expected to work on their own for a few minutes and then explain their solution and reasoning with a partner before discussing with the whole class. When students began to share their reasoning with each other Jessica was observed moving around to the pairs of students asking them to further explain their reasoning for their solutions. Additionally, Jessica was observed during both lessons providing her students with several different problem solving tasks and each time asking student to explain their reasoning. Each time that Jessica gave the students a problem solving task she asked one or more students to, "Please explain your reasoning to the class to help us all better understand your thinking." For example in her first lesson:

- Does anyone see a pattern in the numbers on the board?
- What are some other possible patterns?
- Could we solve this using a model or picture?
- Eli, can you explain the strategy you used to solve the problem?

She also stated during her interview that she has become much better at focusing on students' reasoning and providing problem solving activities in the last few years because she has intentionally made it a focus in her lessons. She stated, "I have really focused on problem solving and making my students explain the reason for their solution. In my planning and preparation because I know it is important." Jessica was consistently observed asking for multiple solution strategies during problem solving and expecting students to justify their thinking and reasoning throughout. During her interview, Jessica stated, "I try to always give my students problem solving activities in class. It is important for me to allow them to discuss their reasoning and solutions so they can develop a better understanding of math."

Sarah included problem-solving tasks throughout the observed lessons. She began each of the observed lessons with a problem that students had to spend a few minutes coming up with solutions and then explaining their reasoning to a partner and then with the class. She began her first lesson with the following questions to promote reasoning and problem solving:

- John, what was your estimate?
- Class is there another possible answer?
- Alan, is there another way to solve this problem?
- Alan, how confident are you in your answer?

During her second lesson, Sarah, asked a student,

- What strategy did you use to build that number?
- How many groups of ten do you have in that number?
- Can you please explain to the group how you know how many tens you have?

Later during this lesson when Sarah worked with a another student, Sarah stated, "Ryan, I heard you counting by tens and then asked the following questions:

- Why were you counting by tens and not ones?
- Will you please show your friends the way you counted?"

During her interview, Sarah indicated that she used problem-solving as often as possible to challenge her students. She stated, "I try to give them problems to solve everyday if I can. We definitely have problem solving activities every week." When asked about promoting reasoning in her lessons, Sarah stated that she did not believe that she did this well and this was and area that she was planning to focus on moving forward.

Participants in this study were all observed promoting reasoning and problem solving during their lessons. Each of the participants also indicated some level of knowledge of reasoning and problem solving during their interviews. The use of problem solving and the expectation of students' use of reasoning were evident throughout the lessons and lead to improved mathematical understanding of each teacher's students.

Theme 4: Teachers' encouragement of mathematical discourse

This section described teacher's encouragement of the use of mathematical discourse in their classrooms. Further I discuss specific examples of the ways in which teachers promoted mathematical discourse. Mathematical discourse involves the exchange of ideas, through classroom discussion and other types verbal, visual, and written communication. Discourse in mathematics classrooms allows students to create convincing arguments on why and how things work, share ideas, clarify understandings, develop language for explaining mathematics, and see things from the perspectives of other students (NCTM, 2000, p.29). Data in Table 4 indicates the frequency of teachers' encouragement of mathematical discourse during observed lessons.

Table 4
Frequencies of Teachers Encouraging Mathematical Discourse

Encouraging Mathematical Discourse	Shannon	Jessica	Sarah
Lesson 1	27	23	15
Lesson 2	25	17	7

When asked about the use of mathematical discourse, all the teachers described that they try to encourage their students to "talk" mathematically about the math they are working on. During the interviews all participants detailed that they do use it but not all were certain that mathematical discourse is meaningful to further developing students' understanding of the math concepts. During the classroom observations, all teachers were observed encouraging mathematical discourse in their classrooms with the frequency varying by teachers. Interestingly, during the classroom observations a majority of the discourse was teacher to student focused or teacher directed with little opportunity for student-to-student discourse provided by the participants.

Frequently during lesson observations, **Shannon** was heard, responding to students with questions like, "Can you explain this a different way," or "Can anyone add any additional information," to encourage more students to communicate mathematically. When working with a small group Shannon asked the following questions:

- So, Michael can you explain your model to me?
- Can you please explain it to the group?
- Michael, can you talk us through your thinking and say how you decided to solve this problem?
- John, can you explain your different strategy?

Throughout the observations, Shannon had many conversations similar to this one where she asked questions and had students explain their thinking to each other even when it appeared to be uncomfortable for the student. For example, Shannon engaged in the following discussion with a group of students:

- Ally, How else could you explain your answer?
- Noel, what do you think did not work with Ally's answer?
- Ok, Ellie, do you have another way to solve the problem?
- Keri, can you explain your strategy to the group?
- Alright, class is there anything we overlooked with this problem?

She continuously asked questions and allowed the students to think and explain their thinking to the group. For example,

- Susan, can you explain how you knew to subtract?
- Ally, at first you thought the answer was 802, can you explain what happened whey you went back to check?
- Kinsey, do you have another way to explain this problem?
- Ana, what strategy did you use to get your solution?

Shannon explained during her interview that she tries to have the students discuss their math with her and with each other every day throughout the lesson. During the two lesson observations, she was observed encouraging mathematical discourse 52 times. She detailed that she intentionally plans problems and activities that she believes will provide her students opportunities for mathematical discourse. Shannon stated, "We have many great student conversations about math. Every math class involves the students talking about math. "When I listen to their conversations it lets me know how much the know about math." Shannon also discussed the importance of allowing students to "vocalize" their thinking. She mentioned that when her students are given the chance to talk everyone in the class benefits mathematically.

Shannon further explained the importance of mathematical discourse in her class. She said, "Having the students use mathematical discourse gives them the opportunity to teach and learn from each other. I do recognize though that the conversations are greater with some students than others. This is one of the reasons I choose to focus on discourse, so that everyone feels comfortable doing it."

Jessica was observed encouraging mathematical discourse 40 times between the two lessons. During her first lesson she asked the class,

- How can I represent 79?
- Does anyone think they know what it means?
- What do you think, Gabriel?
- Greta can you give me your example?
- Does anybody have a different way to solve this? Turn and talk with your partners.

In her second lesson she asked the following series of questions to promote mathematical discourse:

- Greta, could you solve this problem using a number line or a picture?
- John, can you please explain your solution?
- Does anyone else have a different strategy?
- Samantha, what have you tried, what steps did you take?
- How reasonable is our solution?

She asked questions of the students and have them communicate their mathematical thinking with partners and the whole group.

Jessica also described in her interview how she encourages students to talk about math and the strategies they used to problem solve. She mentioned that, "I try really hard to make sure that I give my students the chance to think and communicate mathematically. "Sometimes I catch myself wanting to give them the answer or tell them if they are right or wrong, but I know how important it is for them to talk about math so they can better understand. I usually find that when students make mistakes and I ask them questions and let them discuss to find their mistakes."

Similarly to the first two participants **Sarah** was also observed encouraging mathematical discourse during her lessons. Sarah was observed encouraging mathematical discourse 15 times during her first lesson and 7 times during her second observed lesson. For example, she asked one student,

- What do you think you could do to solve this?
- Could you use a number line?
- Can you explain to the group how a number line can help you solve this problem?

Additionally, she asked another student,

- How did you solve this problem?
- Can you use a picture?
- How does a picture help us solve the problem?

During Sarah's lessons she was most often observed using her students responses to encourage mathematical discourse. She frequently asked students additional questions about their thinking or asked if someone had an additional solution allowed students to mathematically communicate. For example, "Can you explain your thinking about that solution?" or "How do you know that solution will work?"

During her interview, Sarah mentioned of using or encouraging mathematical discourse in her classroom. She stated, "Yeah, I definitely do that in my classroom, having my students explain their thinking is really important. It is something I always focus on in my planning and lessons. I always go back and make sure that I am incorporating students talking about math in my lessons."

The key points outlined in this section related to *a priori* codes established prior to data collection. There were four specific codes that were observed and reported by participants in this case study: (1) Purposeful Questioning, (2) Supporting Productive Struggle, (3) Promoting Reasoning and Problem Solving, and (4) Encouraging Mathematical Discourse. Participants indicated or where observed including all of these themes during their classroom instruction.

In addition to the *a priori* codes several additional themes emerged from the data. The additional themes that emerged from the data included: Teacher's confidence in Mathematics, confidence in Mathematics teaching, and teacher's having limited opportunities for professional development.

Theme 5: Teachers' Confidence in Mathematics Content Knowledge

All the participants expressed not having complete confidence in mathematics during their interviews. Shannon and Jessica expressed the greatest lack of confidence by discussing their difficulties with math when they were in school, which they reported led to their uncertainty about the math they are teaching. Additionally, they both reported that they felt they were very strong in Language and Literacy and felt this may contribute some to their difficulties and lack of interest in learning mathematics.

Shannon reported that she struggled significantly with math when she was in school and quickly lost interest by middle school. Shannon said, "Math made no sense to me in school and I don't remember feeling like my teachers were able to help me understand. They would just give me a procedure to follow and I couldn't understand what was happening. I would try to make sense of what I was supposed to do with the problems and after a while I just gave up and realized that I wasn't good at math." She also indicated that this was still a concern for her now as a teacher, to try and make sure she is comfortable with the math she is teaching to her students so she can help them understand. Shannon stated, "I have to work really hard to be sure what I am teaching makes sense to me before I present it to my students. I want them to have a different experience than I did."

Jessica also reported that her experiences as a student impacted her confidence in math. She detailed how her experiences in math were very negative and she always felt she was "bad" at math. She also discussed that the adults in her educational experience would tell her that it was all right that she was not good at math because she was such a strong reader and writer. She stated, "I get such a negative feeling when I think about math. I was always told that I wasn't good at math by all my teachers. I was told you are such a great reader and writer." During her interview, Jessica stated six times that she is not good at math and has negative feelings anytime she thinks about math.

Sarah reported having similar experiences with math as the other participants but indicated being somewhat comfortable with math. During her interview, she stated, "I think I am ok at math. It is not my favorite subject but I understand elementary mathematics enough for the grade I teach." She discussed never enjoying math and she felt it was boring and she personally preferred any other subject.

In summary, all the participants expressed some level of discomfort about mathematics based on their personal experiences with math. Additionally, at different levels the participants expressed that they felt they were not good at math and this had an impact on their abilities to teach math to their students.

Theme 6: Teachers' Confidence in Mathematics Teaching

During their interviews all the participants expressed different levels of confidence in teaching mathematics. All the participants detailed how they had a background in Language and Literacy and felt much more comfortable teaching Literacy related subjects. Two of the participants indicated that they get a negative feeling anytime they have to teach math.

Shannon indicated that she really has to try hard to teach math and does not believe that her lessons are very strong. She stated, "Teaching Math has been a really big focus for me. I work really hard to try and create good lessons, but I don't really feel like I am that good at it." She also mentioned that she tries to focus a majority of her lessons on student questioning and problem solving but after the initial question she is unsure about how to respond next. Shannon stated, "I try hard to get better at questioning, I focus on this during my planning and always try to include them in my lessons." Shannon expressed the most lack of confidence of the teachers is this study.

Similar to Shannon, Jessica also expressed a lack of confidence in teaching math. When asked about teaching Math, Jessica stated, "I get a really anxious feeling about it every time I have to teach. It is definitely my weakest area to teach." She also stated, "The other subjects seem to come naturally to me, but I really have to try hard to figure out how to teach math to my students." Jessica also detailed how she often attempts to focus on questioning the students but does not feel confident that her questioning is effective in helping to develop her students understanding. Additionally, she mentioned that during her lessons she is trying to not focus so much on telling the students that they got a right or wrong answer, but she struggles to not just give the kids an algorithm and make sure they know the answer.

During her interview, Sarah, expressed more confidence in teaching math than the other participants, particularly when talking about the math for the grade level she teaches. She stated, "I am fine with teaching math for kindergarten since that is the grade I teach but I don't really focus much on any other math." Sarah discussed several times that she felt it was important to understand the math at the grade level she teaches and she did not really see the benefit of worrying about math beyond her grade level. Additionally, Sarah stated, "If I was able to choose, I wouldn't teach math, but that is part of teaching in an elementary classroom. You have to teach all subjects."

All participants in this study expressed difficulties with teaching elementary mathematics. During the interviews, the participants expressed the desire to teach any other subject than mathematics.

Theme 7: Limited Mathematics Professional Development for Teachers

All participants indicated receiving limited or no professional development in mathematics from their school or district. During the interviews the teachers detailed receiving significant, ongoing professional development in reading and writing with no professional development related to math. The participants all recognized the importance of and need for mathematics professional development as a first step in improving mathematics instruction in the school and district. Shannon, for example, identified the need for an ongoing yearlong mathematics professional development with a focus on math fluency, mathematical problems solving, and math workshop. Jessica also expressed the need for mathematics professional development focusing on developing problem solving and vertical alignment of curriculum across grade levels. She stated, "Math instruction in our district is not as strong as it should be and we need to focus on professional development to address this issue." Similarly, Sarah detailed the lack of professional development in math. She stated, "As a district, we have a lot of professional development, just never focused on math. We need to work on learning more about number talks and other forms of communicating in mathematics." Participants in this study all agreed that professional development is occurring in the district just not in math.

Summary

In this chapter, I presented the findings of the study. These findings were based primarily on an analysis of transcripts from two observed classroom lesson of each participant, an analysis of interview transcripts, and supported by reviewed memo notes and classroom observations. Findings were discussed based on four *a priori* codes along with additional themes that emerged from the data. Data in the *a priori* section focused on teachers' implementation of the following four HLTP: teachers use of purposeful questioning, teachers supporting productive struggle, promoting reasoning and problem solving, and encouraging mathematical discourse. In the area of data collection participants were observed during two mathematics lessons using the COIP recording instrument to understand their use of the HLTP.

The themes that emerged from the data were the teacher's confidence with math content knowledge, their confidence with math instruction, and lack of available professional development for teachers in mathematics. Additionally, the participants described a lack of professional development in their school district to assist teacher development in mathematics teaching and learning. Teacher experiences and support vary, which can make it difficult for the participants to develop as teachers of elementary mathematics. To that end, Chapter 5 discusses the results of this study and recommendations for future research.

5 DISCUSSION

The purpose of this study was to examine elementary mathematics teacher's implementation and knowledge of high leverage teaching practices. Data were collected through two classroom observations and one interview with each of three elementary mathematics teachers. This chapter reviews, analyzes, and discusses the findings of this study. The chapter also outlines implications for elementary level mathematics teachers and illustrates the potential impact on student achievement when teachers implement HLTP in their classroom. The chapter concludes with suggestions for further research.

The research questions that guided this study were "Do effective elementary mathematics teachers with no specific professional development implement high leverage teaching practices?" "How do teachers describe their use and knowledge of high-leverage teaching practices in mathematics?" and "What influences do teachers perceive as impacting their use of HLTP in their classroom instruction?

Analysis was done for the following HLTP used as *a priori* codes: (1) teachers use of purposeful questioning, (2) teachers supporting productive struggle, (3) teachers promoting reasoning and problem solving, and (4) teachers encouraging mathematical discourse. Results revealed that all three teachers' implemented these HLTP in their mathematics instruction albeit at varying degrees. Throughout the interviews, however, teachers expressed little formal knowledge of the term HLTP, but with continued discussion all teachers were able to describe using these practices during their classroom mathematics instruction. One emerging theme from the interviews was that all three teachers reported low self-esteem related to their mathematics content knowledge and their ability to teach mathematics. This raises questions about both the possible rigor of the mathematical discussion in these classrooms and the criteria used by administrators to identify excellence in mathematics teaching. Current literature has examined the effect of teacher's mathematical content knowledge of on quality and rigor of mathematics instruction (Cady, Meier, Lubinski, 2006; Engeln, Euler, & Mass, 2013; Lui & Bonner, 2016). Teachers with low self-efficacy in their mathematical knowledge and teaching may have limited power to orchestrate powerful mathematical discussions. Additionally, administrators may be limited in their ability to notice rigorous mathematical discussions when identifying excellent teaching. All three teachers indicated having a background in Language and Literacy. Two of the teachers indicated having negative feelings when they are expected to teach mathematics. Finally, the teachers expressed the lack of mathematics professional development opportunities presented challenges to their ability to improve their mathematics instruction and increase their use and knowledge of HLTP.

Summary of Findings

Research Question One: Do effective elementary mathematics teachers with no specific professional development implement high leverage teaching practices?

The findings from this study suggested that effective elementary mathematics teachers did in fact implement HLTP in their classrooms, however in different amounts. For the lessons observed with each teacher, Shannon asked 52 purposeful questions, Jessica asked 42 purposeful questions, and Sarah asked 29. For example, a common question asked during the lessons was, "How does this answer relate to our first problem? Can you explain?" Also during the lessons, Shannon was observed supporting productive struggle 8 times, while Jessica was observed 9 times and Sarah 2 times. Additionally, Shannon was observed promoting reasoning and problem solving 24 times, Jessica was observed promoting reasoning and problem solving 31 times and, Sarah 17 times. Finally, during the lesson observations Shannon was observed encouraging mathematical discourse 52 times, while Jessica was observed 40 times and Sarah was observed encouraging mathematical discourse 22 times.

Criteria for inclusion in this study were that the school administrator must have identified the participant as an excellent mathematics teacher and although use of HLTP was not identified as a specific criterion for selection, it appears, that at least in this case, the use of HLTP was perceived as providing excellent mathematics instruction. All three mathematics teachers were observed implementing HLTP and all reported having little formal professional development in the use of these practices. The primary difference across the three teachers was that the more experienced teacher used HLTP more frequently, which suggested that with experience some teachers may develop more flexible questioning strategies and increase the use of student-centered practices. Shannon, the most experienced teacher in the study, was observed using HLTP a minimum of 10 more times than the other teachers. This is consistent with previous studies that found a higher frequency of productive teaching behaviors in more experienced teachers , i.e., more Mathematical Knowledge for Teaching (Borko & Livingston, 1989; Leinhardt, 1989; Ball et al., 2008; Hill et al., 2005).

Research Question Two: How do teachers describe their use and knowledge of high-leverage teaching practices in mathematics?

During the interviews, all teachers expressed not being familiar with the term HLTP when using the formal label, but when prompted as to what these practices involved they all expressed having a significant amount of understanding about these instructional practices and their use. Sarah, for example indicated, “Yes, I would say that asking questions is just good teaching in math.” Sarah also stated, “I think that using HLTP in the classroom provides a framework for teaching. I feel like I can always go back and use the strategies in my planning and instruction.”

Shannon agreed with Sarah in stating, “I always try to focus my questioning so my students will have the opportunity to problem solve and communicate their thinking. I really think this helps them become better mathematicians. When I am using these practices, I feel that it helps me to ask the students a lot of how and why questions to further develop their thinking. I always try to let my students guide the question and having them communicating mathematically, so I feel that they are understanding the math better.” Jessica, also stated, “Yes, I believe that the HLTP help me to focus my instruction on the types of questions and problems I wanted to give to my students. Teaching using these types of practices has helped me to use more open-ended questions with my students to help them understand math better. Also teaching like this has made me be more purposeful with the types of questions and activities I use.”

The HLTP that were presented in the Principles to Action (NCTM, 2014) identified teaching skills necessary to promote deep learning in mathematics. All three participants in this study who were identified as exceptional mathematics teachers described using HTLP in their mathematics instruction and exhibited these behaviors in their instruction, which provided confirmatory evidence of NCTM's position.

Research Question Three: What influences do teachers perceive as impacting their use of HLTP in their classroom instruction?

During interviews, teachers expressed several factors they perceived to be limiting their use of HLTP in the classroom. All the participants expressed a lack of self-efficacy in mathematics content knowledge and mathematics teaching. For example, Shannon stated, “Math made no sense to me in school and I have to try really hard to make sure I understand the math I am teaching my students.” In regards to self-efficacy in teaching mathematics, all participants also indicated not being confident in their abilities. For example, Jessica indicated, “ I don’t think I am very good at teaching math, in fact, I wouldn't teach it if I didn't have to." In addition, all the participants expressed the need for ongoing, mathematics professional development to help them improve mathematics instruction. Consistent with the findings of Joyce and Showers (2002), teachers need quality professional development opportunities that are closely aligned with the desired outcomes to improve their teaching practice and impact student achievement..

Conclusions

In this section, several conclusions are presented based on the findings of this study and how they relate to the existing literature, followed by a discussion of the implications this study's findings hold for teachers who want to improve their classroom mathematics instruction. The discussion of implications focuses primarily on how classroom mathematics instruction can be improved. Finally, several limitations of this study are acknowledged followed by recommendations for future research.

Teachers' Use of HLTP. The findings from this study support previous studies indicating that effective elementary mathematics teachers do implement HLTP during their classroom instruction (Feiman-Nemser, 2001; Sabean and Bavaria, 2005). However, contrary to the results of Davin (2013) and Grossman et al. (2009) teachers did not struggle with implementation of HLTP, even though participants indicated no specific professional development. With regard to the significant use of HLTP in classroom instruction this study suggests that teachers with more experience implement HLTP more frequently than their less experienced peers (Borko and Livingston,1989; Leinhardt, 1989; Ball et al., 2008; Hill et al., 2005). For example, Shannon the most experienced teacher was observed implementing HLTP in her classroom more than the other participants. Consistent with findings Borko and Livingston (1989), more experienced teachers may have the ability to develop more flexible questioning strategies and student-centered practices. Also, consistent with the results of (Johnson, 2004) while the teachers engaged in HLTP in their classrooms, many of the interactions were teacher directed with little opportunity for student generated discourse or student to student discourse.

Teachers' Familiarity with HLTP. In this study all participants were familiar with strategies found in HLTP, although they were not familiar with the specific language of HLTP. After discussion about the meaning of HLTP they all expressed understanding of the practices. In fact, one of the significant findings of this case study was that elementary mathematics teachers with no specific professional development were familiar with and implemented HLTP in their classrooms. These findings are confirmed by many similar studies (Schwartz, 2015; Troyan et al., 2013). While discussing HLTP during the interviews the participants did not initially recognize the term HLTP, but when prompted indicated having knowledge of best practices in teaching mathematics. Since the participants in this study were all experienced mathematics teachers these findings resonate with the results of Borko and Livingston (1989) who discussed how more experienced teachers' have increased knowledge and use of more specific instructional practices. Contrary to the findings of Weiland, Hudson, &Amador (2013), teachers did in fact have knowledge of HLTP even if it was not using this term.

Factors Influencing Teachers' Use of HLTP. Findings from this study presented several factors that influence teachers' use of HLTP in their mathematics instruction. Findings from this study indicated teachers display low self-efficacy in regards to mathematics content knowledge and mathematics teaching ability, which can impact instructional choices and student achievement. According to Charlambous and Phillipou (2010) teachers' self-efficacy had a significant impact on their ability to implement appropriate mathematical tasks and can have and impact on student achievement. Bandura (1997) discussed that teachers' self-efficacy can limit their willingness to experiment with new teaching approaches. Alternatively, Ghaith and Yaghi (1997) indicated that teachers with high self-efficacy are more willing to adopt more student-centered instructional approaches.

Another factor influencing teachers' implementation indicated in this study was the lack of mathematics professional development for teachers. In fact, one of the most significant findings from this study is the teachers' need for specific mathematics professional development. For the most part the teachers in this study indicated a need for ongoing mathematics professional development that would help them implement HLTP in their classrooms. Similar to the findings of Lampert et al., (2013) professional development for teachers needs to be practice-based and have a specific focus on instructional strategies. Also according to Ball, Sleep, Boerst, & Bass, (2009) professional development for teachers needs to have a specific curriculum focused on the practices teachers will engage in to support their students learning.

Implications

The findings from this study hold several implications for researchers and practitioners interested in teachers' knowledge and implementation of HLTP in classroom instruction. In this section, several practical recommendations, based on the study's findings, for improving teachers' knowledge and implementation of HLTP are discussed and questions are raised about the support that teachers may need to address this area.

Improving Teachers' Self-Efficacy. Results from this study suggested that improving teachers' use of HLTP in elementary mathematics can be impacted by increasing teachers' self-efficacy related to mathematics content and mathematics teaching. Tunks and Weller's (2009) claimed that teachers' self-efficacy can be improved when they are continuously and significantly supported with content and instructional implementation is important to consider to assist teachers. School districts therefore must find ways to provide teachers with ongoing support with regards to mathematics content and instructional practices. This study echoes the findings of previous research that ongoing, consistent support for teachers can improve their self-efficacy, thus positively impacting student achievement (Anderson, 1997; Bandura, 1997; Charlambous and Phillipou, 2010).

Professional Development for Teachers.

Similar to Cohen and Hill's (2000) study the teachers in this study indicated a lack of mathematics professional development. When teachers were planning and implementing lessons they would attempt to incorporate HLTP in their instruction but did not appear confident in their understanding of how to do so. Joyce and Showers (2004, 1996) indicated the need for professional development to be teacher selected and based on their needs, rather than district selected. Therefore to improve teachers' use of instructional practice, we first need to evaluate the quality of the professional development being offered to teacher and the content of the professional development. Districts will need to implement or increase the mathematics content and instructional professional development opportunities for teacher and ensure they are ongoing and specific to the teachers' goals.

Teachers' Need for Instructional Coaching.

The study findings question the need for teachers to be provided with ongoing, instructional coaching in mathematics. This was apparent in all the interviews with teachers as they indicated the need to have a coach provide purposeful classroom coaching during their mathematics lessons. Jessica was openly discussed the importance of having a coach come in to her classroom to help her use HLTP more effectively. For instance, researchers have established that teachers are more likely to try classroom practices that have been modeled for them within the professional development environments (Fishman et. al, 2003). Similarly, teachers themselves perceive professional development to be the single most valuable component of their learning, especially when it offers opportunities to undertake work that builds their knowledge of the academic content and provides ways to teach to their students (Feiman-Nemser, 2001; McLaughlin &Tolbert, 2006). For student achievement to increase in mathematics it will be necessary to provide teachers with mathematics specific instructional coaches that can model effective instructional practices and provide ongoing support for as well for mathematics content.

Limitations

As with most small sample, qualitative studies, there are limitations. Limitations were provided here to allow the readers to evaluate the usefulness of these results. This study focused on three elementary mathematics teacher's implementation and knowledge of high leverage teaching practices. Since this study was conducted during the last two months of the school year and some of the observed lessons appeared to be review, which could have impacted the teachers' use of HLTP in their lessons. Considering the focus of this study was on *implementation* of HTLP during instruction, I did not address the overall rigor of the mathematics that resulted from use of the practice in the lesson. For example, purposeful questioning was observed in all the lessons but the resultant dialogue was not studied and without further analysis of the exchanges between the students and teacher the researcher is unable to assess the depth of mathematical content and exploration. A second example is that while the practice of encouraging discourse was found in the discourse that occurred in the lessons, it was not studied. Each teacher was observed encouraging mathematical discourse, however simply allowing discourse does not indicate that students experienced significant mathematical exploration and discovery. Several previous studies indicated the importance of the teacher's role in facilitating meaningful mathematical discourse (Turner, Meyer, Midgely, & Patrick, 2003; Yackel and Cobb, 1996). Chazan and Ball (1995) also indicated the complexity of the role the teacher plays in facilitating classroom discourse. Without in-depth analysis of the discourse that emerged as a result of the high leverage practice the quality of the exchange was not evident. Further, the mathematical discourse in the observed lessons was almost always teacher to student discourse and almost never student-to-student, which raises the question of whether significant mathematical ideas were generated by the students or only by the teacher. Johnston (2004) indicated that for students to be engaged teachers must foster a classroom discourse that happens not only with the teacher, but also between students. He also stated that the language that teachers and their students use in mathematics is very important and should be present among all members in the learning community. Additionally, teachers all reported encouraging mathematical discourse and since mathematical discourse is process that takes a significant amount of time and practice to develop it can be difficult for teachers to assess the amount and quality of discourse. Understanding the difficulty of assessing classroom mathematical discourse, Hufford-Ackles, Fuson, and Sherin (2004) developed a framework to describe and evaluate the process a class goes through when introduced to the use of mathematical discourse. The framework evaluates the areas of mathematical questioning, explanation of mathematical thinking, source of mathematical ideas, and responsibility for learning. Although this framework was a positive indicator of classroom discourse it did not account for individual students, which teachers will need to be aware of. As a result, teachers will also need to focus on individual student discourse to ensure their participation so they can encourage and scaffold students that are not participating in the discourse.

Another limitation was in the nature of the HLTP. Some behaviors displayed by the teachers had multiple interpretations, i.e., a single behavior may qualify as evidence on more than one

HLTP. When using HLTP as the rubric for analyzing teaching, the researcher was left to interpret the teacher's intention for a specific behavior as evidence of a specific HLTP. For example, asking a student if they can solve a problem in a different may be an example of purposeful questioning, purposefully asking the student to think about the problem in a different way. However this question may also support productive struggle by asking a student to work outside his or her comfort zone.

As is the case with many studies the context plays a significant role in the findings of this study. Since data were collected in an affluent, primarily white suburban school the findings of this study may be different if conducted in a different context. Students and teachers in this school have access to a variety of mathematical resources that peers in more urban or rural schools may not have. This difference in resources can limit the opportunities that students have for mathematical learning and can also present a challenge for other schools in being able to attract and retain high quality mathematics teachers. Additionally, a majority of the students attending Oakwood Elementary were able to attend a Pre-K program prior to starting school, which may not always be the case in other school districts. Students and teachers at Oakwood also have a significant access to technology both at home and in the school to help support mathematical learning.

Finally, as with many studies that involve participant observation in a research setting, the potential for observer influence on the findings can be expected and in turn must be acknowledged. For instance, in this study, the extent to which teacher's behaviors were changed by their knowledge of being participants in this study is a real possibility. How did the presence of the researcher who was unknown to them and not a regular evaluator impact their classroom behaviors?

Future Research

Previous research identified HLTP as behaviors used by excellent mathematics teachers (Ball and Forzani, 2011; Heibert & Grouws, 2007). Additional studies are needed to investigate the quality and rigor of the mathematics experience beyond simply the implementation of HLTP. A potential misuse of HLTP could be observers making the assumption that quality mathematics instruction is taking place when in reality the mathematics may not be in depth. This area of study will be necessary to ensure that quality mathematical exploration and discourse is taking place and rigorous mathematics content is being presented. Further studies are needed to explore the use of HLTP in the context of rural and urban, lower socioeconomic schools. Comparisons of schools resources, teacher quality, and student access to mathematical support may help to determine the effectiveness of using these strategies.

Finally, while it has been noted that elementary mathematics teachers would benefit from specific professional development targeting HLTP and mathematics content, the professional development literature advises us that teachers will also need hands on coaching and support to assure improved teaching that supports rich mathematical interactions in the classroom. Joyce and Showers (2002, 1996) indicated a significant increase in teacher classroom instructional implementation and also an increase in student achievement through the use of consistent coaching as a method of professional development.

Summary

In conclusion, this study was a preliminary examination of the use of HLTP in the elementary classroom. Perhaps the greatest contribution of this study was the exposure of the additional research needed on HLTP to determine their effectiveness when implemented in a larger setting or in a different school context. There is no doubt that the use of HLTP as a framework for instructional practice in mathematics provided a useful perspective for the development of professional development for elementary teachers. However, even with these behaviors in place, the teachers in this study all expressed low self-efficacy in teaching mathematics. This contradiction raises questions on whether simply using these practices assure valid, rigorous mathematics in the classroom. Going forward it will be important for teacher evaluators to not only look for evidence of implementation of HLTP during classroom instruction but also to assess the rigor and depth of the mathematics content being explored to ensure deep mathematical learning. Finally, this study's findings assert that for teachers to implement HLTP and increase student achievement in mathematics it will be necessary that they be provided with mathematics professional development and ongoing coaching to improve their self-efficacy and instructional practice.

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APPENDICES

Appendix A

High Leverage Mathematics Instruction Practices

These are nine research-affirmed instructional practices that correlate with high levels of student achievement and that should be incorporated into all mathematics instruction at all levels.

Practices	Comments/observations
1. Effective teachers of mathematics respond to most student answers with "why?", "how do you know that?", or "can you explain your thinking?"	
2. Effective teachers of mathematics conduct daily cumulative review of critical and prerequisite skills and concepts at the beginning of every lesson.	
3. Effective teachers of mathematics elicit, value, and celebrate alternative approaches to solving mathematics problems so that students are taught that mathematics is a sense-making process for understanding why and *not* memorizing the right procedure to get the one right answer.	
4. Effective teachers of mathematics provide multiple representations – for example, models, diagrams, number lines, tables and graphs, as well as symbols – of all mathematical work to support the visualization of skills and concepts.	
5. Effective teachers of mathematics create language-rich classrooms that emphasize terminology, vocabulary, explanations and solutions.	
6. Effective teachers of mathematics take every opportunity to develop number sense by asking for, and justifying, estimates, mental calculations and equivalent forms of numbers.	
7. Effective teachers of mathematics embed the mathematical content they are teaching in contexts to connect the mathematics to the real world.	
8. Effective teachers of mathematics devote the last five minutes of every lesson to some form of formative assessments, for example, an exit slip, to assess the	

degree to which the lesson's objective was accomplished.	
9. Effective teachers of mathematics demonstrate through the coherence of their instruction that their lessons – the tasks, the activities, the questions and the assessments – were carefully planned.	

Appendix B

Participant Survey

Participant Code: _____

1. Gender: ____________
2. Number of years teaching experience: ___________
3. Number of years teaching in this school: __________
4. Ethnic Identity:

   ___ African American or Black (Not of Hispanic Origin)

   ___ American Indian or Alaskan Native

   ___ Asian or Pacific Islander

   ___ Hispanic (Mexican, Puerto Rican, Cuban, Central or South American)

   ___ White (Not of Hispanic Origin)

   ___ Multiracial
5. What is your highest degree earned?

   ___ Bachelors

   ___ Masters

   ___ Ed. S

   ___ Ph.D. or Ed. D.

   ___ Other ____

6. Have you had any formal or informal professional development related to High Leverage Teaching Practices in Mathematics? If so please describe.

   ____
   ____
   ____

7. What is the total number of hours of High Leverage Teaching Practices in Mathematics professional development you have received?

   ____

Thank you for completing this survey!

Appendix C

Interview Protocol Questions

1. What grade level do you teach? How long have you been teaching?

2. What have you heard about High Leverage Teaching Practices?

A. If yes, what have you heard about HLTP?

B. If no, have you heard of best practices in teaching mathematics?

3. Do you think high leverage teaching practices affect your everyday mathematics instructional practice?

4. Do you implement any high leverage teaching practices in your mathematics instruction?

5. Have you participated in professional development have you participated in related to high leverage teaching practices in mathematics instruction?