A CASE STUDY OF SENSE-MAKING OF THE COMMON CORE STATE STANDARDS FOR MATHEMATICS BY ELEMENTARY GENERALISTS

A thesis presented by Terry Langton to The School of Education in partial fulfillment of the requirements for the degree of Doctor of Education in the field of Education

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Abstract

Forty-five state departments of education have adopted and implemented the Common Core State Standards for mathematics. The standards contain reform mathematics language that is abstract and ambiguous resulting in substantial interpretive duty for elementary teachers who as generalists commonly do not have deep understanding of mathematics education. Further, teachers who must gain a strong understanding of a curricular reform in order to implement it well frequently do not. This instrumental case study explored how three third grade generalists learned about and perceived the Common Core State Standards for mathematics. The research used a sense-making framework that holds teacher learning of a reform message is dependent upon: the teacher’s experiences, beliefs, knowledge, and attitudes; their social contexts; and how the reform message is represented. Data were collected with: semi-structured interviews of three generalists, one retired teacher, and three administrators; professional development observation; and document collection. The major themes that emerged from data analysis included: (a) the generalists’ experiences with reform mathematics during professional development have equipped them with a developing understanding of what the standards are asking them to do, (b) the teachers received few and basic messages that have helped them understand the standards, (c) the professional development that the teachers received was inadequate and insufficient for helping them understand the standards, and (d) the foreign terminology used in the standards blocked their sense-making efforts leaving them with a superficial understanding of the curriculum reform. This report concludes with limitations of the research; implications for policy makers, administrators, and teachers; and recommendations for future research.

Keywords: Common Core State Standards for mathematics, reform mathematics, elementary generalist, curriculum reform, professional development, sense-making
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“When we cannot use the compass of mathematics or the torch of experience . . . it is certain that we cannot take a single step forward” (Voltaire as cited in Gaither & Cavazos-Gaither, 1998, p. 249).

CHAPTER I: INTRODUCTION

The well-being of a nation is, in part, related to the abilities of its people to understand and use mathematical ideas (U. S. Department of Education, 2008). Mathematical capacity can bring countries advances in healthcare, commerce, finance, science, exploration, national defense, and all forms of technology (U. S. Department of Education, 2008). In an interdependent world economy our students must compete against their American and international peers in the workforce (ASCD, 2012; Schmidt, 2012a). One’s K-12 education forms the foundation of their preparation for the workforce. Further, high level mathematics standards are needed to prepare our students to be college and career ready (Schmidt, 2012a). However, in the United States student achievement in mathematics education needs improvement as evidenced by national and international standardized test scores (Schmidt, 2012a; Schmidt & McKnight, 2012).

About one quarter of grade twelve students achieved proficiency in mathematics on the 2009 National Assessment of Educational Progress (National Center for Education Statistics, 2010). Internationally, American eighth grade students scored below average on the 2009 Programme for International Student Assessment (PISA) (Schmidt & Burroughs, 2013a). The average score of 487 by American 15-year-olds on the mathematics scale for the 2009 PISA put the U. S. in 25th place among 34 participating countries (Organisation for Economic Co-operation and Development [OECD], 2010, p. 8). In 2012 the U. S. achieved an average score of 481 on the PISA mathematics assessment (OECD, 2013). Finally, on the 2011 Trends in
International Mathematics and Science Study (TIMSS) American eighth grade students placed 24th in mathematics among 56 education systems (National Center for Education Statistics, 2011, para. 3).

The dissatisfaction with America’s level of student achievement, the need to prepare students for college and careers, and a desire for more progressive mathematics education has led to the adoption of a rigorous mathematics curriculum framework called the Common Core State Standards (CCSS) for mathematics (CCSSM) in 45 states, the District of Columbia, and three U.S. territories (CCSSI, 2010, 2012c; Schmidt & Burroughs, 2013). There is a high degree of similarity between the curricula used in the countries with the highest levels of student achievement on international mathematics tests and the CCSSM (Schmidt & Houang, 2012). Researchers who have compared the CCSSM to previous state standards have stated that the CCSSM are as or more rigorous than all the states’ former curricula for mathematics (including those of the state where this study was based) (Carmichael, Martino, Porter-Magee, & Wilson, 2010).

The standards-based CCSSM seeks to promote changes in mathematics instruction which in turn will advance student achievement (Cohen & Ball, 1990a; Common Core State Standards Initiative [CCSSI], 2012d; Editorial Projects in Education Research Center [EPERC], 2013). Thus, teachers’ instructional practices have been identified as the problem and the solution.

Cuban (1993, 2003) identified the paradox of policymakers viewing teachers’ instruction as the problem and solution for reforming schools. Cuban (1993) noted that teachers have traditionally used teacher-directed instruction to teach math as a group of rules for students to remember and apply. Conversely, the CCSSM requires teaching for deeper learning with computational fluency combined with conceptual understanding (CCSSI, 2010). Therefore, the
reform (the CCSSM) requires that most teachers learn to think and act in unfamiliar ways (Jennings, 1996). The instructional and student learning potential of this reform policy cannot be realized without teacher learning that supports and enables understanding of the CCSSM (Cohen & Ball, 1990a; Elmore & McLaughlin, 1988; Hall & Hord, 2011; Jennings, 1996; Remillard & Bryans, 2004). Reform policies require teacher learning since the policies either contain new ideas or are a reorganization of old ideas (Cohen & Barnes, 1993). Thus, the success of a reform policy is determined by what teachers learn from it (Jennings, 1996).

**Statement of the Problem**

The CCSSM are a considerable change from the curriculum frameworks that states previously used (Porter, McMaken, Hwang, & Yang, 2011). In the state (henceforth referred to as the State) that the Euler School District (pseudonym) is in (a state that has used standards-based mathematics for about 15 years prior to the adoption of the CCSSM) the adoption of the CCSSM means teachers must understand new goals for student learning and correspondingly, new methods of instruction. The State Commissioner of Education, identified the CCSSM as a resource for changing and improving curriculum, teaching, and assessment.

Teachers must engage in learning about the CCSSM in order to transform the reform message into an understanding of what is to be taught (i.e., content), the methods of instruction and student learning practices that the CCSSM implies, and the guiding principles that underpin the curriculum (Elmore & McLaughlin, 1988; Fullan, 2007; Lawrenz, Huffman, & Lavoie, 2005). Teachers must build implementation of the reform based upon their understanding on these three parts of the innovation (Cohen & Ball, 1990a; Fullan & Stiegelbauer, 1991; Weatherly & Lipsky, 1977). However, a perpetual problem, and the research problem for this study, is that teachers who are expected to implement curricular reform frequently misunderstand
or do not gain a sufficient understanding of the reform even when they put great effort forth to make sense of it (Cohen & Hill, 2000; Firestone, Fitz, & Broadfoot, 1999; Fullan, 2007; Gross, Giacquinta, & Bernstein, 1971; Hall & Hord, 2006). Additionally, the interpretation of the CCSSM may be more difficult for elementary generalist mathematics teachers since they may neither have the time nor sufficient background in mathematics that is needed to understand what the CCSSM is asking them to do.

Most elementary teachers are generalists (as opposed to single subject specialists found in late elementary, middle, junior high, and high schools) who teach all core academic subjects with a special emphasis on reading and English language arts (Association of Mathematics Teacher Educators, 2010; Fennell, 2006). Therefore, they may not have the deep and broad pedagogical content knowledge to interpret a complex mathematics instructional reform message such as the CCSSM (Fennell, 2006; Shulman, 1986, 1987; Wu, 2009). Furthermore, as generalists many of the State’s teachers have been dealing with “initiative fatigue” as they have been trying to learn about the Common Core State Standards for English Language Arts (CCSSELA) (CCSSI, 2012a) and the State’s new regulations for the evaluation of educators for as long as they have been attempting to interpret the CCSSM.

Educators around America seem to be misunderstanding this complicated curriculum framework that asks teachers to change what and how they teach mathematics. National surveys of K-12 teachers have found that a majority of teachers do not have a sufficient understanding of the instructional shifts required by the CCSSM (ASCD, 2012; EPERC, 2013; Hart Associates, 2013).
Significance of the Problem

The investigation of the problem of a lack of understanding of the CCSSM by teachers is important at local, state, and national levels. The CCSSM is a national curriculum framework with standards that teachers must interpret in order to transform them into teaching activities that will prepare students with the mathematical proficiency needed for college and career (Ben-Peretz, 1990; CCSSI, 2010, 2012e; NCSM, 2013). The CCSSM do not: prescribe instruction, identify a sequence of instruction, indicate how instruction should be differentiated, or show how topics will be connected (Russell, 2012). The CCSSM simply identify what (content – skills and knowledge that students must acquire) needs to be taught and not how the content should be taught.

When students achieve the goals of the CCSSM they leave school mathematically proficient which can allow them and the communities they live in to compete in a global economy (Schmidt & Burroughs, 2013b). During the 2013-2014 school year the content and process standards of the CCSSM formed the basis of mathematics curriculum, instruction, and assessment within schools in 45 states and the District of Columbia, U. S. Virgin Islands, American Samoa Islands, and Guam (CCSSI, 2012c). Thus, the CCSSM is implemented in 87% of American schools (Dingman, Teuscher, Newton, & Kasmer, 2013 p. 561). Moreover, the CCSSM will assess student achievement of the CCSSM with high-stakes tests in 2014-2015 (EPERC, 2013). This may provide more incentive for teachers to make sense of this mathematics reform message.

Teachers across America need to understand what students need to learn from the CCSSM as well as its overall vision (McTighe & Wiggins, 2012). A teacher’s interpretation of curricular materials (i.e., content standards) plays a large role in determining the classroom
learning environment, the learning experiences that will be offered to students, and what students learn (Ben-Peretz, 1990). Further, the interpretations of the CCSSM at the primary elementary grade levels (K-2) are especially important since the skills, understanding, and dispositions that elementary learners gain creates the foundation upon which they will build learning in subsequent grade levels (Bransford et al., 2000; Griffin, 2005; Kilpatrick & Swafford, 2002; Wu, 2009).

If mathematics teachers do not understand what and how students need to learn they can transform the planned curriculum into an enacted curriculum that is not in harmony with the reform (NCSM, 2013). Insufficient understanding of student learning targets (content standards) will result in instruction that provides low level learning experiences and student misconceptions (Carlson, 1990; Hashweh, 1987). Teachers who are not prepared to provide instruction aligned with the planned curriculum will promote a negative effect on student achievement (Darling-Hammond, 2000; Goldhaber & Brewer, 2000; Rivkin, Hanushek, & Kain, 2005).

Teachers cannot properly implement a curriculum reform that they do not fully understand (NCSM, 2013). Given the likelihood that educators may misunderstand aspects of a curriculum framework that requires changes to what students will learn, how students should learn, and the instructional behavior of mathematics teachers in at least 87% of the schools in the United States (Dingman, Teuscher, Newton, & Kasmer, 2013, p. 561) it is important for policymakers, professional development providers, and school leaders to gain insight into the ideas that teachers are constructing about the reform ideas within the CCSSM (Achieve & U. S. Education Delivery Institute, 2012). Little is known about how teachers are engaging in sense-making of the CCSSM and what interpretations they have constructed from the CCSSM.
Therefore, the purpose of this study was to explore how elementary generalists are engaging in making sense of the CCSSM and the ideas they are constructing relative to the CCSSM. An understanding of teachers’ ideas of this reform message can contribute to planning instruction and teacher learning experiences (i.e., professional development) that advance teacher understanding of the CCSSM. When teachers understand the CCSSM they will be in position to create and implement curriculum, instruction, and assessment that achieves the central goal of the CCSSM – to prepare students for college and career so that they can compete in a global economy (Kendall, 2011; Zepeda, 2012).

**Justification of the Research Problem**

Evidence for the problem of teachers’ lack of understanding of mathematics reform ideas can be found in the literature base of education reform implementation and the scholarship on mathematics teacher beliefs.

The educational reform implementation literature goes back to the research on the implementation of the Elementary and Secondary Education Act of 1965 (Honig, 2006). The scholarship on mathematics education reform implementation began in earnest after the release of *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM, 1989). Within this research base, educators’ (teachers and instructional leaders) interpretation of mathematics standards-based reform has been investigated by Spillane (2000), Spillane and Thompson (1997), and Hill (2001).

Spillane (2000) used a cognitive framework to explore district responses to mathematics reforms and found that district leaders misunderstood the intent behind the reform and constructed diverse ideas about the reform. Spillane and Thompson (1997) also highlighted the importance of instructional leaders understanding curriculum reform in their study of local
capacity for ambitious instructional reforms at the district level. They noted that for successful implementation to take place instructional leaders must understand reform so that they can help teachers understand reform. Finally, Hill (2001) examined how teachers interpreted state mathematics standards and found that policymakers used words (e.g., construct conceptual understanding) in content standards to imply teaching methods. However, educators interpreted them differently. As a result of misinterpretations of the policy writers’ intent the standards lost some of their potential to help students achieve at high levels.

Teacher understanding of instructional reform has also been explored within the subject areas of reading (Spillane, 1998a, 1998b; Coburn, 2001) and science (Spillane & Callahan, 2000). Spillane (1998a) found diverse interpretations of reading reform policy to be a result of beliefs about how to teach reading, the context in which teachers interpret the reform, and the sources the reform ideas came from. Spillane (1998b) discovered that district staff understood reading reform in terms of their unique beliefs and experiences. Coburn (2001) used sense-making theory to examine how teachers: collaboratively built understanding of reading policy messages, determined which messages to pursue, and dealt with implementation. Spillane and Callahan (2000) sought to determine the ideas that educators constructed from state standards. They wanted to find out if educators missed or misinterpreted the intent of the reform. They found that a lack of success implementing state and national science standards in ways that were aligned with their instructional intent were in part a result of a lack of understanding by district administrators.

Majone and Wildavsky (1978) stated that what is in reform policy depends upon what is inside those who will be implementing it – mathematics teachers’ beliefs, attitudes, and understanding of the innovation (Handal, 2003; Phillip, 2007). Moreover, teachers (and all
people) enter learning experiences with a diverse range of prior knowledge, abilities, attitudes, conceptions, and beliefs that influence what they see and how they organize and make sense of experiences (Bransford, Brown, & Cocking, 2000; Pajares, 1992; Shulman, 1986). These existing cognitive structures form the basis upon which learners construct understanding (Bransford et al., 2000). For example, Remillard and Bryans (2004) found that the way teachers read, interpret, and use a curriculum are influenced by their understanding and beliefs about mathematics, views on external pressures, ideas about the purpose of education and how people learn, as well as school norms. They also noted that minimal teacher learning occurs when teachers simply read the curriculum.

**Deficiencies in the Evidence**

Despite the large volume of research within the scholarship on education reform implementation (McLaughlin, 2006) and mathematics education teacher beliefs (Phillip, 2007) there has been little research on the ideas that elementary generalists have constructed from reform mathematics education policy. Sense-making of curriculum reform initiatives has also been an important and rarely explored aspect of the curriculum implementation process (Marz & Kelchtermans, 2013; Remillard, 2005; Schmidt & Datnow, 2005; Spillane, Reiser, & Reimer, 2002). Further, case study research is needed to gain insight into how teachers build curriculum ideas collaboratively within their setting (Remillard, 2005). Finally, this researcher is not aware of any published research on how elementary generalists are learning about the CCSSM and the ideas they are constructing from it. Such research is important for policymakers, professional development providers, and school leaders across America to know if teacher understanding of the CCSSM is in harmony with CCSSM content and process standards. This evidence can also promote mathematics professional development and reform policy writing.
Related Audiences

The audiences that have the most to gain from this research will be federal and state policymakers, professional development providers, as well as school leaders and teachers.

Policymakers may gain knowledge of what degree teachers or “street level bureaucrats” (Weatherly & Lipsky, 1977, p. 171), who are the key implementation agents of federal and state policy, understand their reform messages. Policymakers need to understand how their reform messages are being received by educators so that they can represent their reform ideas within coherent policy which can be comprehended by teachers with varied beliefs, understanding of reform mathematics, and dispositions.

Professional development providers whose task is to promote understanding of the CCSSM among teachers need to know which aspects of the reform are understood and misunderstood so they can provide appropriate learning experiences to teachers that close the gap between the teacher’s current level of understanding and a level that is congruent with the CCSSM.

Finally, school (instructional) leaders need to know what teachers understand and misunderstand so that they can foster the transformation of teachers’ ideas into teaching and learning activities that help students achieve the goals of the CCSSM.

This research could put the author in a position of change agent at the research site. The results of the study could identify to the educators what individual and collective (shared) ideas they have about the CCSSM and how much more they need to learn in order to create instruction that promotes student achievement of the CCSSM.
Positionality Statement

I believed that I was in a position of great potential to execute and deliver high quality and trustworthy research on the ideas educators have constructed about the CCSSM. I came to this research on mathematics education with an open mind due to my status as an independent and isolated professional educator.

As a physical education teacher I am an unknown native within the school I teach at. Each day in the Leibniz School (pseudonym) gymnasium I teach seven 45 minute classes, take a 30 minute lunch, and have a 45 minute planning period. This keeps me in the gymnasium for 93% (seven hours and five minutes) of each school day. I spend the final 7% (30 minutes) outside supervising the boarding of students on buses. Therefore, I do not experience mathematics education and have had virtually no interaction with teachers and administrators other than casual greetings with teachers and the instructional aides who drop off their students in my classroom. Additionally, during weekly Tuesday professional development sessions (almost exclusively dedicated to the high stakes tested subject areas: English/language arts and mathematics) I am required to, as a special subject teacher (music, visual art, information technology, and physical education), attend only as an observer. Such experiences have developed my status as an outlier within the school.

I have had no experience with mathematics education as a physical educator. I have spent my entire teaching career of 22 years at the Leibniz School implementing essentially the same daily schedule described above. This has separated me from mathematics education as well as the instructional culture of the rest of the school. During my time as a physical educator I have engaged exclusively and deeply within my subject area. I have written extensively about physical education teaching and learning (Baumgarten & Langton, 2006; Langton, 2004, 2007,
2014); given presentations on instructional methods in physical education at local, state, and national conventions; and contributed to California’s physical education curriculum framework (California Department of Education, 2009, pp. 284-285). However, about five years ago I became interested in how the rest of the school operates.

In 2008, I began preparing myself to make the transition from physical educator to instructional leader. In service of this goal I obtained a Master’s degree in teaching and learning, a Certificate of Advanced Graduate Study (CAGS) in school management and educational leadership, and a license as a P-6 assistant principal/principal. Additionally, in 2010 I was invited (unexpectedly) to serve as a teacher advisor on K-12 education policy to my state’s governor. These experiences have promoted my interest in learning as much as possible about the content and instructional methods of mathematics education as well as those of all other school subjects in order that I can be the best teacher leader that I can be.

Prior to this research project I had virtually no understanding of the content, instructional practices, and principles of reform mathematics (the type of mathematics education recommended by the CCSSM). I had not taken a mathematics course or thought deeply about mathematics education since I was a high school mathematics student over 30 years ago. My experience with the CCSSM as a teacher has taken place during my required observations of professional development at the Leibniz School over the past two school years. At these sessions I observed teachers discuss and try to understand the CCSSM. I also became engaged in the mathematics community at national and state levels.

In the spring of 2013, I became a member of the National Council of Teachers of Mathematics (NCTM, 2013) in order to learn about the current trends and practices in K-12 mathematics education. Through discussions with members of these organizations I learned
much about the CCSSM along with the past and present status of mathematics education in the state and throughout the country.

As a physical education teacher/researcher within my building I had unique access and time to conduct a case study. I was well situated to collect the six potential sources of case study data: documents, archival records, interviews, direct observations, participant observations, and physical artifacts (Yin, 2009). Further, my unconnected position within the school allowed me to use time before school, during school (75 minutes of daily planning and lunch time), and after school to collect data.

In summary, as a result of my unique status as a physical educator and student of instructional leadership I was equipped to execute quality research. I do not believe I have any significant biases relative to mathematics education, how teachers should or should not teach mathematics, nor to what elementary teachers might understand or misunderstand about a reform mathematics curriculum framework such as the CCSSM. Last, qualitative case study requires committing large amounts of time within a setting observing activities and interactions, reflecting, and editing meanings of what is going on with the phenomenon (Stake, 2000). I was in a position with unique opportunity to spend much time examining teachers learning about this important education reform.

**Research Questions**

Gaining insight into how teachers are learning about the CCSSM and the ideas they have constructed from these experiences can assist those who are trying to understand and implement the CCSSM. Therefore, the overarching aim of this case study research is to explore the process of teacher sense-making of the CCSSM and how the CCSSM means to three elementary mathematics generalists (P-4 teachers) at the Leibniz School in the Euler School District.
Yanow (1996) used the question, “How does a policy mean (p. ix)?” to ask how (the adverb how modifies the verb mean) policy can provide many, diverse meanings to its readers. In other words, this research explored how teachers learn from and about the CCSSM and their perceptions of what the CCSSM is asking them to do. This research included four sub-questions. The answers to the sub-questions provided insight into how the CCSSM means to elementary generalists at the Leibniz Elementary School. Sub-questions for this research include:

1. What were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM?
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?
3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?
4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

In addition to informing professional development, reform implementation, and policymaking the results of the study will build on the following sense-making theoretical framework.

**Theoretical Framework**

In order to gain an understanding of how teachers construct ideas from the CCSSM the sense-making theoretical framework of Spillane et al. (2002) will be employed (Anfara & Mertz, 2006). Sense-making is the active effort of drawing on one’s framework of experiences, attitudes, beliefs, and knowledge (cognitive structures) to construct meaning from stimuli. The main idea of this cognitive theoretical framework is that sense-making requires accessing one’s cognitive structures within a social context and applying it to facilitate the ability to notice, frame, and interpret reform messages (Spillane et al., 2002). Thus, what educators comprehend
from a reform message depends upon the interaction of three variables: the educator’s cognitive structures, the social context, and how the reform message has been represented (i.e., the policy’s signals) (Spillane et al., 2002; Yanow, 1996). These three variables will be addressed in turn.

**Cognitive Structures**

Cognitive structures include attitudes, beliefs, and knowledge developed from one’s experiences (Spillane et al., 2006). When people process information and try to make sense of reform messages, such as those in the CCSSM, they build understanding on these three cognitive structures.

Attitudes refer to feelings, emotions, dispositions and opinions that can change quickly (Phillip, 2007). An attitude related to mathematics could be math anxiety. Beliefs can come from school norms. Beliefs are things that are thought to be true. Beliefs can include what and how students learn mathematics as a result of one’s experience as a student and teacher of mathematics (Lortie, 1975; Richardson, 2003). Teacher beliefs are dynamic, mental structures held with varying levels of intensity that change according to experience (Thompson, 1992). School level beliefs and norms affect individual teacher and group beliefs which can create norms of performance (Sampson, Morenoff, & Earls, 1999). Teachers often recognize learning experiences that are aligned with their beliefs (Opfer & Pedder, 2011).

Knowledge refers to beliefs that are held with a great degree of certitude (Phillip, 2007). Knowledge related to mathematics could include understanding of content (content knowledge) and how to teach mathematics (pedagogical content knowledge).

Implementing agents use their unique cognitive structures such as beliefs about what students should learn from mathematics education and how they should learn it as a lens that influences what reform elements are recognized as well as how the recognized information is
processed, encoded, connected, and interpreted (Firestone, 1989; Spillane, Reiser, & Gomez, 2006). New information is constructed on top of or as a supplement to existing knowledge frameworks (Spillane et al., 2002). This cognitive process can result in teachers failing to see unfamiliar aspects of reform, understanding the familiar or superficial portions, and demonstrating wide-ranging understandings of reform messages.

**Educators miss reform aspects.** Our cognitive structures can cause us to miss and reject reform ideas. During the sense-making process people try to make the unfamiliar familiar and interpret new information in light of prior understanding (Bransford et al., 2000). Thus, policy implementing agents use schemas (connections of beliefs and knowledge) to make sense of what is going on and make predictions. Schemas influence understanding because they are used to fill in what is not understood. As a result of their schemas implementing agents (i.e., teachers) often focus more on familiar information that is aligned with what they know and have experienced and less on more complex, unfamiliar information that challenges or refutes existing schemas. Hence, during the policy sense-making process educators can miss some unfamiliar and complex ideas within the reform and selectively attend to familiar or simple components. Sense-making can also block potential change.

Spillane et al. (2002) stated that our cognitive structures can influence sense-making and maintain traditional ways of thinking about teaching. People build beliefs that are encoded with biases, expectations, and explanations about how we think and learn. We are biased toward interpretations that are aligned with our prior beliefs, experience, and values. Such defensive biases can cause teachers to disregard reform ideas that are incongruent with their beliefs. This is because we want to believe that our beliefs and past behavior were correct and successful in order to protect our self-esteem (Sherman & Cohen, 2002). As a result of this self-affirmation
process a teacher’s experiences and beliefs may be valued more than the ideas that come from policymakers (Sherman & Cohen, 2006).

**Teachers understand superficial reform aspects.** Teachers’ cognitive structures can cause them to interpret curriculum change in a superficial manner. For example, teachers may read a new curriculum framework and believe they are already implementing it. McTighe and Wiggins (2012) noted that these teachers might state that a given reform is the “same old wine in a new bottle” or remark “we already do all of this” (p. 1). However, in reality they may be recognizing and understanding the most concrete and superficial aspects of the reform (e.g., use of manipulatives); yet they may fail to see the deeper, more abstract components that call for fundamental change such as teaching for conceptual understanding and implementing mathematical discourse (Fullan, 2007). Such misunderstanding results from teachers having experience and corresponding knowledge with the superficial aspects of the reform but not the more complex aspects of the required change (Spillane et al., 2002). Fullan (2007) describes this phenomenon of misunderstanding a complete understanding of reform as false clarity.

**Teachers demonstrate diverse interpretations of reform.** Humans enter learning experiences with diverse experiences, attitudes, beliefs, and knowledge that significantly affect what they notice and how they organize and make sense of information (Bransford et al., 2000). This influences their capability to recall, reason, resolve problems and understand (Bransford et al., 2000). Thus, teachers who interpret the same message during identical learning experiences can each construct a different understanding of the reform (Spillane, 1996, 1998a; Hill, 2001). Spillane et al. (2006) stated that some divergence can also be a result of educators having different learning opportunities of varied duration, dissimilar interpretive skills, and diverse levels of willingness to make sense of policy. They also remarked that research shows that
misunderstanding should not be ascribed to teachers’ lack of sense-making or dismissal of the reform (Hill, 2001).

Despite great effort to implement a reform, prior beliefs, knowledge, and practice can interfere with the ability to make sense of a reform in ways that are congruent with the intent of policymakers (Spillane et al., 2002). The more complex the reform the more likely teachers will misunderstand it (Fullan, 2007). Those with strong mathematics content and pedagogical content knowledge and experience teaching reform mathematics are more likely to make sense of reform messages in ways that are aligned with reform ideas than those with less knowledge of reform mathematics education (Hill, Ball, & Schilling, 2008; Spillane et al., 2006).

Many innovations are adopted and implemented by teachers who possess an incomplete understanding of what is being changed (Fullan & Stiegelbauer, 1991; Herriott & Gross, 1979). It may not be clear to some teachers what a reform message is asking them to do differently (Fullan & Stiegelbauer, 1991). As a result of varied sense-making processes people display great diversity in their understanding of reform messages.

**Sense-making Occurs in Social Contexts**

Teacher sense-making does not exist only within the individual. Sense-making is distributed among individuals, groups, and the setting or situated within a context (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). The social groups that teachers belong to influence their sense-making through a process of social sense-making (Spillane et al., 2002). The teacher’s social context can affect what gets noticed and how they make sense of it. Teachers develop unique experiences, expectations, and assumptions on reform messages largely as a result of being members of many diverse social groups at national, state, and local levels.
**Varied opportunities.** As a result of their membership in a variety of social groups, teachers gain opportunities to learn about reform policy (Spillane et al., 2002). For instance, teachers belong to national, state, and local professional organizations, graduate school programs, school districts, school district subject area groups, schools, grade level teams, lesson study and action research groups, and so forth. Some teachers may belong to many groups resulting in exposure to many different ideas of a reform while others may belong to few groups and receive limited ideas. Thus, teachers gain varied opportunities to make sense of the reform. Each one of these social contexts may have different norms for sense-making.

**Diverse social sense-making processes.** Different social groups have varied approaches to sense-making (Spillane et al., 2006). When groups of teachers interact, engage in discussion and debate, collaborate on projects, and make their varied beliefs visible they learn from one another. Additionally, groups may be more or less active in their varied forms of sense-making efforts. First grade teachers, for instance, could be divided into rookie and veteran groups. Their diverse knowledge, experience, and beliefs enable them to see, interpret, and understand different aspects of the reform message. Teachers who are in social groups with teachers who possess deep and broad knowledge for mathematical teaching (Hill & Ball, 2009) might gain a deeper understanding of the reform than others who have a surface level understanding of mathematics education. There are also affective and historical aspects to social sense-making.

**Emotions and values influence social sense-making.** Spillane et al. (2002) noted that group emotions and values affect social sense-making. For instance, elementary teachers may place a large value on feelings of group cohesion and harmony. Thus, they may not challenge a peer’s belief, suggest a divergent interpretation of reform, or disturb the status quo in order to avoid disagreement during group discussions of reform ideas. Additionally, some teachers
whose strongest instructional beliefs are in English language arts (ELA) may not feel a high level of comfort and confidence engaging deeply in mathematical reform ideas with others (Frykholm, 2004). Moreover, such teachers may have anxieties related to mathematics (Beilock, Gunderson, Ramirez, & Levine, 2010; Burns, 1998).

**Organizational history influences sense-making.** Spillane et al. (2002) stated that a group’s organization or history can affect sense-making. For example, a group of teachers that has demonstrated a long history of traditional instruction, strict adherence to a textbook, behaviorist views toward mathematics education, or a lack of instructional experimentation may be less likely to attend to and try to make sense of the constructivist and progressive ideas in the CCSSM.

Teachers with unique cognitive structures engage in many social settings that employ different sense-making processes (Spillane et al., 2006). As a result teachers who participate in the same professional development build diverse understanding of reform (Cohen & Barnes, 1993; Spillane, 1996, 1998a).

**Representation of Reform Policy**

A variety of groups provide different representations of policymakers’ reform messages (Spillane et al., 2002). Thus, educational organizations such as members of state departments of education, professional organizations, school administrators, and textbook publishers make sense of policymakers’ reform ideas and re-create or re-represent the reform in diverse ways to teachers. Hence, the way a policy message is represented can support or constrain sense-making.

The reform message can be represented through pictures, tables and figures, printed words, and language during professional development. These representations can be delivered to teachers through state department of education professional development and web pages, state
standards documents, professional association documents, workshop presentations, student assessments, video vignettes, and so on. These representations may each supply different interpretations of the reform with varied words, graphics, and language.

**Use of language in representing reform.** State standards documents often contain a collection of short statements of student learning goals or outcomes of teaching and student learning (Spillane et al., 2002). Other documents may include a balance of abstract and concrete language that may be easier to understand. For example, if the reform ideas are represented too abstractly or concretely the change can be misunderstood or implemented in a superficial manner (Spillane et al., 2002). For instance, words and language from the CCSSM such as problem solving, understand, repeated reasoning, and mathematically proficient students that come from within the policymakers’ community can have different meanings within a teacher’s community (Hill, 2001; Spillane et al., 2006).

**Implementing agents transmit diverse reform messages.** Spillane et al. (2002) noted that, like the game of telephone, groups within the reform implementation network interpret the reform message and communicate diverse re-representations. For example, a professional organization such as the NCTM could draw on its cognitive structures and make an interpretation of the CCSSM which could be picked up, made sense of, and re-represented by an assistant superintendent to a principal who would re-create the assistant superintendent’s ideas to a group of teachers. Administrators in different subunits (district and school levels) depending on their background (e.g., psychometrician, mathematics specialist, principal, headmaster) and position in the system (e.g., vertical or horizontal responsibility) have diverse lenses to interpret reform. These school leaders with varied beliefs, experience, and understanding of the reform send teachers different and sometimes conflicting messages.
Simultaneously, other groups such as professional development providers, state education department officials, textbook publishers, and private consultants, who build their own unique understandings of a reform, transfer their reform ideas to individual teachers and groups of teachers through documents (e.g., textbooks, websites), videos, and discourse during workshops, professional development sessions, and staff meetings.

**Contribution of the sense-making framework**

A theoretical framework explains what is going on with the issues, contexts, people, and their relationships with what is to be studied (Maxwell, 2009). The framework should also serve as the structure of a research project that connects all of the parts of the design (Merriam, 2009; Ravitch & Riggan, 2012). The sense-making framework (Figure 1) shows how a reform message moves from policymakers to teacher who must interpret a variety of re-representations of the reform. The teacher engages in sense-making to construct ideas directly from and about (gaining reform re-representations from others) reform (Jennings, 1996; McLaughlin, 1987).

The sense-making framework provided insight into the research problem, structured the research questions, methodology, and data analysis. The framework also provided insight into the research problem of how educators misunderstand the CCSSM – as a result of integrating their cognitive structures with the ideas within the CCSSM. This sense-making theory suggested that teachers construct understanding based upon their existing cognitive structures (attitudes, beliefs, and knowledge). Hence, the research question asks about the process of sense-making and the ideas that have been constructed by teachers.

The methodology is affected by the sense-making framework as a result of the frameworks emphasis on how teachers learn and understand which suggests a qualitative research approach. In order to understand a concept one must be able to construct meaning from
National and state policymakers represent reform ideas in the Common Core State Standards for mathematics through text (CCSSI, 2010)

- Standards for Mathematical Content
- Standards for Mathematical Practices
- Guiding principles of coherency, focus and rigor

Prescribes the understanding and skills students must acquire
Implies how content should be taught

The groups below make sense of and Re-represent the CCSSM to teachers based upon their respective cognitive structures and social contexts

|--------------------------------------------------------|--------------------------------|--------------------------------|---------------------------------|-----------------------------------|

Sense-making within different social contexts
Individual teachers within grade level, school, district, professional groups draw on cognitive structures to make sense of many diverse representations of the CCSSM within varied settings

The sense-making process results in the construction of some level of teacher understanding of the CCSSM

Superficial ——— Deep

what is being learned (Mayer, 2002). Teachers understand when they construct connections between what they are learning and their prior knowledge. One who understands can explain, interpret, give examples, make comparisons, categorize, summarize, and make inferences (Mayer, 2002). In other words, tapping into understanding requires the researcher to ask questions (i.e., interviewing participants) and use words; these are the hallmarks of qualitative research (Creswell, 2012). Further, in order to learn about how all the parts of the sense-making process relate to another to enable teacher understanding it will be helpful to examine them deeply within their social context which will require a qualitative case study (Merriam, 1998). The many elements of the sense-making framework can help determine how data analysis will be conducted since a theoretical framework contains what Miles and Huberman (1994, p. 18) describe as “bins” that can be used to sort the diverse ideas (data) that teachers have constructed relative to the CCSSM and the ways they constructed those ideas (Miles & Huberman, 1994).

**Summary of Research Design**

The researcher used qualitative research with an instrumental case study method to study the central phenomena of teacher sense-making of a mathematics curriculum reform by elementary generalist teachers. Data collection included semi-structured interviews, observation of their professional development, and collection of documents. Data analysis of these sources resulted in minor themes for each sub-question which were consolidated into major themes to answer the central question. Limitations for this research included the researchers lack of experience conducting a large scale study, the researcher’s presence in professional development sessions which may influence participant behavior, and the use of just three participants. Chapter three explains each aspect of the research design.
Chapter II: Literature Review

This literature review includes a synthesis and critique of the issues and research related to how elementary generalists teachers have constructed understanding from mathematics education curriculum reforms (i.e., local, state, and federal curriculum reform policies) that have called for changes in what content (e.g., knowledge and skills) is taught and how that content is taught.

The review is divided into four sections. The first part contains background information on the CCSSM and its state context. The second section describes the research on professional development in teacher learning about curriculum reform. The third piece contains the scholarship on individual and collaborative teacher sense-making of curriculum reform. The final portion contains an explanation of what the research suggests to be the outcomes of teacher sense-making of curriculum reform mandates. Figure 2 provides an overview of these components and their relationship to each other.

The Common Core State Standards for Mathematics and Its Expectations

This first component of the literature review provides an overview of the CCSSM and its instructional demands. This introduction includes a discussion of the development of the CCSSM and its expectations for the State’s teachers, the relationship of the CCSSM to reform mathematics and its expected instructional shifts, the language used to communicate the change, and clarification of the content and process standards and guiding principles. The CCSSM is a national curriculum framework that was developed to raise the quality of K-12 mathematics education (CCSSI, 2012a). They require elementary generalists to become aware of standards, gain an understanding of them, and transform their ideas into instruction that helps students achieve its grade level goals (Cohen & Barnes, 1993).
1. Common Core State Standards for Mathematics
   Aligned to high-stakes tests
   Recommends reform mathematics instruction and student problem-solving
   Press for Instructional Changes: Rigorous, coherent, and focused
   Uses language that is difficult to understand
   Components that need to be understood include: Standards for Mathematical Content (content standards), Standards for Mathematical Practice, (process standards), and the relationship of content to process standards

2. District/School-based & Individual Professional Development (PD)
   Transmission style PD delivered by school administrators who may misunderstand the reform
   Teachers draw on their cognitive structures to construct reform ideas within groups
   Teachers need to reflect upon and challenge incongruent beliefs collaboratively
   CCSSELA, teacher evaluation, and other initiatives competing for PD time

3. Elementary Generalist Mathematics Teacher Sense-making
   Cognitive Structures Include:
   Beliefs: Based upon experience as mathematics students and teachers, school norms
   Attitudes: Mathematics anxiety
   Knowledge: Content and Pedagogical Content Knowledge
   Experience: Traditional mathematics instruction, primary focus on ELA instruction

3. Teachers engage in sense-making

4. Teacher fails to see unfamiliar aspects of CCSSM
4. Teacher understands only superficial aspects of CCSSM
4. Teachers demonstrate a wide range of understanding of CCSSM

Figure 2: Conceptual overview of sense-making aspects in literature review

Development of the Common Core for Mathematics

The development of the CCSSM began in 1996, at the National Education Summit, where a bipartisan collection of governors, chief state school officers, and corporation heads created an organization whose goal was to support standards-based education reform (Rust,
2012). Their effort produced the CCSSM - a set of K-12 content and process standards. They identify what students are to learn and imply how teachers should provide instruction to meet these student learning targets. This curriculum framework was developed in collaboration with teachers, school administrators and content experts (ASCD, 2012). The CCSSM were not field tested in classrooms prior to their release (Ravitch, 2012, 2013).

The final standards were released to the public on June 2, 2010 (ASCD, 2012; Wu, 2011). In order to foster the adoption of the CCSS for ELA and math the U. S. Department of education enticed states through the Race to the Top financial grant competition (Gewertz, 2012c; U. S. Department of Education, 2013). The scoring system of this competition awarded bonus points to the states that promised to adopt the CCSS (ASCD, 2012). As of 2013, 45 states and 87% of U. S. public schools have adopted the CCSSM (Achieve, College Summit, National Association of Secondary School Principals, National Association of Elementary School Principals, 2013; Dingman et al., 2013, p. 561). Minnesota, Texas, Virginia, Alaska, and Nebraska have not adopted the CCSSM (EPERC, 2013). Thus, districts in 45 states must align their curriculum, instruction, assessment, and professional development with the content and process standards and guiding principles of the CCSSM (EPERC, 2013).

**Implementation of Common Core Mathematics in the State**

Since 1996, the State has implemented standards-based (reform) mathematics based upon the content standards put forth by the NCTM (1989, 2000). The first reform mathematics curriculum framework issued in 1996 emphasized the process standards of problem-solving, communication, reasoning, and connections. The 2000 revision and its 2004 addition stressed problem-solving, communicating by talking and writing about mathematical ideas, reasoning and
proof, making connections between and within mathematics content, and representing mathematical actions and objects in different ways.

In 2008, the State assembled a group of educators to revise the 2000/2004 curriculum framework. The next year the Council of Chief School Officers (CCSSO) and the National Governors Association’s Center for Best Practice (NGA) initiated a multi-state standards development project. The State consolidated their efforts with the CCSSO and NGA. This effort resulted in the CCSSM being adopted by the State’s Board of Education in July, 2010. The State took advantage of the option provided by the U. S. Department of Education to add 15% more content standards to the CCSSM (Kober & Rentner, 2011, p. 4). Thus, the State’s 2011 reform mathematics curriculum framework combines the CCSSM with unique State mathematics standards. The State’s framework also contains content standards for pre-kindergarten students (the CCSSM does not). The State adopted this combined curriculum framework in December, 2010. In 2011-2012 the State’s school districts began implementing their new mathematics framework; full implementation took place in 2012-2013 and continued through 2013-2014.

The implementation of this framework will ensure that all students are college and career ready (CCSSI, 2012a). The standards are a call to improve mathematics instruction through the transformation of the CCSSM into learning experiences for students. During 2014-2015 student achievement of the CCSSM in the State and other states will be measured and evaluated with a new assessment system (EPERC, 2013).

Educator accountability and the Common Core

Student achievement relative to the CCSSM will be assessed with two new high-stakes summative assessment systems that will replace existing state tests for the 45 states that have
adopted the CCSSM in 2014-2015 (CCSSI, 2012b, Dessoff, 2012). These tests have been developed by the Smarter Balanced Assessment Consortium (SBAC, 2012) and the Partnership for the Assessment of College and Careers (PARCC, 2012). The tests will have consequences for teachers since student test scores will be factored into their annual evaluations (ASCD, 2013; McNeil & Gewertz, 2013).

Rewards for high levels of student achievement and sanctions for low levels of student achievement will be connected to test scores. PARCC and SBAC will measure student progress and attainment of the full range of content standards within the CCSSM (Dessoff, 2012). PARCC will implement a series of tests throughout the school year (Achieve Inc., 2013). The SBAC will adjust the level of subsequent items and tasks based on previous student responses (adaptive testing) and use interim testing with an end of school year test (SBAC, 2012). Model content frameworks from PARCC (2012) and content specifications from SBAC (SBAC Staff, 2012) provide information on how students will be assessed (Ainsworth & Anderson, 2013).

Eventually the summative assessments from SBAC and PARCC will form the tested curriculum and as such educators will align the school curriculum and corresponding instruction to the standards that are tested (Herman & Linn, 2013). This accountability aspect may extrinsically motivate many teachers to gain a strong understanding of the CCSSM. A study of educators in four states found that their greatest concern relative to the CCSS was high-stakes testing (ASCD, 2012). However, some states do not feel they are ready for the accountability pressures since many teachers have not had enough time to learn the CCSSM (McNeil, 2013).

The U. S. Department of Education has issued waivers to many states on the test-based accountability requirements from the No Child Left Behind Act (McNeil, 2013). However, the waivers require states to use student growth on CCSSM aligned tests from SBAC and PARCC as
a significant factor in teacher ratings and are used to inform personnel decisions. Hence, the portion of student growth within the teacher evaluation process will range from 20 to 50% (McNeil, 2013).

Each state has developed its own educator evaluation system (Klein, 2013). States will use student achievement results as a component of their teacher evaluation systems to determine promotion, bonus pay, professional assistance, and dismissal. Schools will also be labeled from low to high performing based on how their students score on SBAC and PARCC assessments (McNeil & Gewertz, 2013). Some states identify consequences for low levels of student growth; other states leave the decision to school districts.

In 2013-2014 the State will begin using evidence of student growth on its high-stakes standardized test, which assesses student achievement of the CCSSM, as a factor in teacher evaluation (USDOE, 2013). The tests will measure extended problem solving where students must reveal their reasoning and conceptual thinking. Most of the teacher evaluation tied to personnel decisions across America will begin during the 2015-2016 school year (McNeil & Gewertz, 2013).

**Relationship of Common Core Mathematics to Reform Mathematics**

The CCSSM is based on the principles of reform mathematics. Reform mathematics education emphasizes understanding students as mathematical learners, conceptual understanding, constructivist learning principles, communication, active learning where students apply skills and understanding to solve real world problems, collaborative problem-solving and sharing of knowledge, reasoning, and student developed algorithms (Chappell, Berry, & Hickman, 2009; Hill, Ball, & Schilling, 2008; Hudson, Miller & Butler, 2006; Kanold, Briars, & Fennell, 2012; Price & Ball, 1997; Sayeski & Paulsen, 2010; van de Walle, 2006).
Reform mathematics learners socially construct understanding, use discourse to identify solution pathways and critique others’ problem solving, engage in active learning, engage with meaningful and challenging problems, and receive timely, explicit feedback from the teacher and others (Bransford et al., 2000; NCTM, 1989, 2000; Piaget & Inhelder, 1969/2000; Vygotsky, 1978). Reform mathematics is cumulative; later, deeper learning is dependent upon earlier learning (NCTM, 2006a).

The CCSSM is built upon all these ideas of reform mathematics (Kanold et al., 2012; Larson, 2011). For example, the CCSSM advocates that students learn collaboratively through ongoing communication and conceptual understanding (Larson, 2011). The move toward reform mathematics is a large instructional change for many elementary generalists.

Reform mathematics began with the “new math.” Schoenfeld (2004) stated that the new math was a response to the 1957 launch of the satellite Sputnik by the Union of Soviet Socialist Republics and a way to promote K-12 mathematics and science education. The new math emphasized discovery, teaching for understanding, and student-centered learning (Walmsley, 2003). The new mathematics movement lasted until the early 1970’s when it was countered by those who supported more emphasis on teaching mathematics as a set of computational procedures (i.e., a back to basics campaign) (Schoenfeld, 2004). In 1989, the NCTM (1989) released Curriculum and Evaluation Standards for School Mathematics. This release began the reform mathematics era that continues today with the CCSSM.

**Common Core Demands Instructional Changes**

The CCSSM are a large shift from previous state standards that will require many elementary generalists to add new content to their curricula and make a uniform interpretation of the standards (Gewertz, 2012a). Content standard shifts will require teachers to become aware of
the new standards and understand what they are asking them to do (Cohen & Barnes, 1993). Robelen (2012) noted that the change to the CCSSM has resulted in content being introduced in different grade levels. It will also require students to acquire more robust understanding of mathematics since the CCSSM calls for deeper more focused student learning (a less is more response to the mile wide and inch deep curriculum coverage of the past). Teachers will need to dissect standards in order to understand pre-requisite skills and understanding learners must gain (in previous grade levels) in order to meet these new learning targets. Gewertz (2012a) stated that teachers also need to understand the pathways from beginner to mathematical expert relative to CCSSM topics (part of pedagogical content knowledge). However, research has shown that teachers will interpret the standards in diverse ways.

Rothman (2013) noted that educators will interpret the CCSSM standards in widely different ways. For instance, some may see the CCSSM as requiring significant change while others will view minor adjustments to instruction. For example, Schmidt and Burroughs (2013b, p. 8) stated that a survey of 700 mathematics curriculum coordinators in 41 states found that 77% of them believed the CCSSM were essentially the same as their old standards. However, a comparison of previous state standards with the CCSSM by Porter et al. (2011) found that the CCSSM represent a considerable change from states’ previous standards; the CCSSM are more focused and cognitively demanding. The CCSSM use abstract and complex language that may be hard for elementary teachers to interpret (Wiggins, 2011).

**Representation of the Reform Message**

Spillane (2004) described the communication of curriculum standards from standards writers at the beginning of the policy transmittal chain to teachers at the end as like the game of telephone. The CCSSM were developed by a national committee of mathematics scholars who
had little experience writing standards (Wurman & Wilson, 2012). The standards were adopted by state departments of education who used them to create curriculum framework documents. These curriculum framework documents were delivered to school district leaders who interpreted them and communicated their interpretations to teachers during professional development. Thus, the key variable in this reform message transmission is the language used in the CCSSM.

The most common representation of the CCSSM that educators are using to learn about the CCSSM is a State department issued publication such as the State’s mathematics curriculum framework (EPERC, 2013). The exact language (except for the states that added 15% of their own standards) used by the states in these curriculum framework documents comes from the original CCSSM created by the National Governors Association Center for Best Practices and Council of Chief State School Officers (2010). Experts in curriculum development have described the language used throughout the CCSSM as abstract and hard for teachers to understand (Carmichael et al., 2013; Wiggins, 2011).

The implementation research conducted by Hill (2001) has suggested that how a curriculum reform policy message or desired instructional change is communicated can affect teacher sense-making. This research suggests that the language policymakers use to show teachers the instructional changes they desire exists at too high a level for some teachers such as elementary generalists, who may not have been prepared with deep, specialized knowledge, to understand this reform language (Ma, 1999, Wu, 2009).

Hill (2001) used a case study method with observation of teachers’ professional development sessions and interviews with teachers, administrators and policymakers to examine how teachers interpret State mathematics standards. Hill found that policymakers used abstract words in content standards such as construct, understand, and concept to imply teaching
methods. However, educators interpreted them differently and in ways not intended by policymakers. Hill stated that as a result of teachers’ misinterpretations of the policy writers’ intent the standards lost some of their power to show teachers what and how to teach and in turn help students achieve at high levels. Further, Hope (2002) stated that teachers will not put effort into implementing an innovation when they do not understand its purpose, content, or how to implement it. Hill’s research suggests the importance of studying elementary generalists’ interpretations of the abstract language used throughout the framework (e.g., understanding).

**Understanding the Common Core Mathematics Standards**

The bridge between standards (reform ideas) and potentially powerful effects on student learning hinges upon local understanding and then implementation (Berman & McLaughlin, 1976). The CCSSM will not implement themselves (CCSSI, 2012d). Teachers must understand the CCSSM in order to transform the standards into teaching and learning activities that promote the achievement of standards (Hope, 2002). The aspects of the CCSSM that teachers must understand include its content standards, process standards, and guiding principles.

**Content Standards.** A content standard is a statement that describes what students must learn or the skills, attitudes, and understanding they must gain (Weiss et al., 2001). When policymakers set high level (i.e., rigorous) content standards it can improve and equalize the quality of instruction which in turn can advance student learning (Sandholtz, Ogawa, & Scribner, 2004). Standards also imply a tool for holding schools accountable for student learning (Weiss et al., 2001). Yet, standards are difficult to understand and implement (Marzano, 2006). It can take school districts five to 10 or more years to fully implement content standards (Collins, 1997; Fullan & Stiegelbauer, 1991. Many curriculum reforms are never fully implemented because teachers do not fully grasp the intended change suggested by standards (Herriot & Gross, 1979).
Content standards (standards that describe what students should learn at each grade level) such as the standards for mathematical content (SMC) in the CCSSM leave the decisions on how to implement instruction up to schools (Ogawa, Sandholtz, Martinez-Flores, & Scribner, 2003; Weiss et al., 2001). Therefore, educators must understand what the standards are asking teachers to teach and students to learn and do.

The SMC identify what mathematics learners should understand and be able to do (Burns, 2013). They are organized into domains that include groupings of related standards in order to present mathematics as a set of connected ideas.

The SMC of the CCSSM are potential sources of misunderstanding by teachers. Curriculum scholars have stated that these content standards are lengthy, verbose, lack specificity and clarity, and use language that might not be understood by many teachers and administrators (Carmichael et al., 2013; Stotsky & Wurman, 2010; Thomas B. Fordham Institute, 2011; Truth in American Education, 2013; Wurman & Wilson, 2012). For example, Wurman and Wilson (2012, p. 46) identified a fourth grade standard that was shared by California’s previous mathematics curriculum framework and the CCSSM. The California content standard consisted of 12 words; while the CCSSM communicated the same student learning goal in 44 words. Another source of misunderstanding is the student behavior - to understand.

**Understanding understanding.** The CCSSM uses the learning outcome: students will demonstrate understanding more than previous state standards did (Porter et al., 2011). The U. S. Coalition for World Class Math (2010) stated that the student goal of understanding, used throughout the content standards, can be interpreted in many different ways. For example, Wiggins and McTighe (2005) have described student understanding and teaching for understanding as “ambiguous and slippery terms (p. 35).” They also discussed how scholars of
teaching and learning such as John Dewey (1933), Benjamin Bloom (Bloom, Hastings, & Madaus, 1971), Jerome Bruner (1973), and Howard Gardner (1991) have provided diverse definitions of what it means to understand.

Krathwohl (2002) and Mayer (2002) defined understanding as the ability to construct meaning from instructional messages (oral, written, and graphic representations). This cognitive procedure requires the learner to build connections from existing knowledge to the knowledge that is to be acquired. Thus, new knowledge is integrated with existing knowledge. These authors identified the following cognitive processes to represent understanding: explaining, inferring, exemplifying, clarifying, comparing, summarizing, and interpreting.

The CCSSM require students to demonstrate understanding more than the State’s previous standards did (Porter, McFadden, Hwang, & Yang, 2011). In mathematics, understanding refers to the comprehension of concepts, operations, and relationships (Kilpatrick, Swafford, & Findell, 2001). A student with mathematical understanding has a foundation for remembering or building knowledge and procedures, solving novel problems, and creating knowledge (Kilpatrick & Swafford, 2002). The CCSSI (2012d) stated that the term understanding used in the SMC represents learning with conceptual understanding. The definition of the word curriculum is also a source of potential misunderstanding.

**Diverse understanding of curriculum.** Some elementary generalists may see the set of content standards as the curriculum (Oliva, 2005). Schools will respond to the content of the CCSSM in diverse ways since there is no agreed upon definition of curriculum (Glatthorn, Boschee, & Whitehead, 2006; Wiles, 2009). For example, McTighe and Wiggins (2012, p. 3) uncovered 83 definitions of curriculum in the curriculum scholarship while researching their book *Understanding by Design* (Wiggins and McTighe, 1998). Oliva (2005) stated that the term
curriculum could mean anything from a listing of courses taught in a school to all the learning experiences planned by the school. A synthesis of the curriculum and mathematics curriculum literature produced the following elements of a curriculum: a guiding philosophy; the identification of what students are to learn and be able to do (content); a statement of when content is taught and how content is to be taught; a description of the type of learning environment required; a listing of instructional resources; and an explanation of assessment methods (Glatthorn et al., 2006; NCTM, 1989; Oliva, 2005; Ornstein & Hunkins, 2004). Thus, teachers must understand these aspects of the CCSSM in order to translate it into teaching and learning activities. The first step toward understanding what the content standards require students to learn necessitates that educators examine them.

Unwrapping content standards. Content standards need to be broken down so that teachers can determine the understanding, knowledge, and skills that students must gain in order for them to achieve the content standard (Ainsworth, 2003; Barlow & Harmon, 2012; Larson, 2011; Marzano & Haystead, 2008; Wiggins & McTighe, 2005). This breaking down process allows teachers to identify the prerequisite knowledge, understanding, and skill that students must gain from previous grade level standards in order to achieve a content standard in a subsequent grade (Larson, 2011; Wiggins & McTighe, 2005). McTighe and Wiggins (2012) stated that the process of breaking down and interpreting standards is a vital part of understanding each standard and how the standards connect to form a coherent whole. Another difficult to understand part of the CCSSM is its process standards.

Standards for Mathematical Practice

The standards for mathematical practice (SMP) are similar to process standards (or habits of mind). Process standards are student behaviors (e.g., dispositions, understanding, ways of
thinking, and skills) that enable and support their learning of content standards (Cuoco, Goldenberg, & Mark, 1996; Marzano, 2006; Parker & Novak, 2012). Teachers need to provide learning experiences that can develop the competencies identified in the SMP (Reys, 2013). The SMP represent the ways students should engage with mathematics content (Burns, 2013). Each SMP may not be evident in all learning experiences. The process standards do not exist independently; they live together with the SMC in real classrooms during teaching and learning activities (William McCallum, personal communication, July 23, 2013).

Curriculum scholars have stated that the SMP are nebulous, highly abstract, and difficult to comprehend (Hull, Miles, & Balka, 2012; McCallum, 2013; Wiggins, 2011). The SMP are meant to permeate the schools’ mathematics curriculum (Reys, 2013). However, since they are not unified with grade level content standards educators may not recognize their significance. Yet, it is essential for educators to understand them since students must use the SMP to learn with understanding (Parker & Novak, 2012). The SMP are both a set of desired student actions (i.e., goals) and a means for achieving the content standards (Larson, 2011). Curriculum scholars, including the lead author of the CCSSM - William McCallum (2013), have described the SMP as abstruse since they are difficult to read, hard to understand, and do not provide sufficient guidance on how students are supposed to do mathematics (Hull, Miles, & Balka, 2012; Wiggins, 2011). Hull et al. (2012) stated that the key question for teachers to understand is: how do we translate each SMP into teaching and learning actions?

Many of the terms in the SMP might seem unfamiliar and new to teachers (Reys, 2013). However the key ideas within the SMP have existed for many years. In order for teachers to understand the SMP they need appropriate background knowledge that comes from having an understanding of the reform mathematics advocated by the NCTM (NCTM, 2010). Larson
(2011) noted that the emphasis on process (e.g., how students should learn mathematics) found in the SMP began with the problem solving process (e.g., formulating questions, defining the problem, identifying patterns, drawing on background knowledge, and applying understanding to new problems) set forth in NCTM’s (1980) *An Agenda for Action* and was developed further with the process standards in *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). *Curriculum and Evaluation Standards* emphasized students using manipulative materials, cooperative learning, discourse, justification, writing about mathematics, and problem solving. The NCTM (2006a) further clarified the process of learning mathematics with *Curriculum Focal Points for Prekindergarten through grade 8* and *Focus in High School Mathematics* (NCTM, 2009, 2010). Two other more significant documents formed the foundation of the SMP.

The CCSSM states that the SMP were built upon two influential mathematics documents: *Principles and Standards for School Mathematics* (NCTM, 2000) and the National Research Council publication *Adding it Up* (Kilpatrick et al., 2001). In order to fully understand the terms used in the SPM one must understand these texts.

**Background to the standards of mathematical practice.** *Principles and Standards* identified five process standards that compromise student mathematical proficiency (NCTM, 2000). These process standards include: problem solving, reasoning and proof, communication, connections, and representations.

The NCTM (2000) described problem solving as the ability to engage in a task for which the manner of solution is not known prior to beginning the task. Problem solving is both a means and an end for mathematical learning. Solving problems in a variety of ways can help learners develop an understanding of concepts and connections between mathematical concepts
(Lambdin, 2003; Leikin & Levav-Wayneberg, 2007). The problem solving process was first emphasized by the NCTM in 1980 (Krulik & Reys, 1980). They stated that student problem solving should be the central aspect of mathematics education. The NCTM’s view of problem solving drew heavily upon Stanford University mathematics professor George Polya’s (1945/1990) basic four-step problem solving method. Polya’s four steps included understanding a problem, creating a plan to solve the problem, implementing the plan, and reviewing the solution process and result of that process.

Reasoning and proof are methods of creating and expressing ideas as well as important mathematical habits of mind. Reasoning refers to the use of logic to explain and justify solutions, extend from what is known to what is not known, and the ability to relate concepts to situations (Kilpatrick & Swafford, 2002). Mathematical proof is a method of conveying specific types of reasoning and justification (NCTM, 2000).

Communication is the way a learner shares mathematical ideas logically, explicitly, and clarifies understanding to peers, educators, and others (NCTM, 2000). It permits students to: reflect upon, refine, discuss, and revise mathematical thinking, ideas, and conclusions; and examine the thinking and methods of others.

When learners connect mathematical ideas in settings external to the classroom their understanding of the cumulative and coherent nature of mathematics becomes more robust and enduring. Mathematics is not a set of unique strands or standards. It is an integrated whole that students can understand by recognizing connections within and outside of the discipline.

Mathematics requires using diverse types of representations for objects and actions, including numbers, shapes, operations, relationships, diagrams, graphics, algebraic expressions, graphs, and matrices that can show a method for solving equations. Students must learn to use a
tool kit of mathematical representations. These tools can enlarge students’ ability to think mathematically.

*Adding it Up* (Kilpatrick et al, 2001) provided five interdependent strands of mathematical proficiency that support and enable learning for P-8 students. These include conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Conceptual understanding refers to one’s grasp of mathematical concepts, operations, and relationships. A concept is a class, category, or group of ideas and information (Miller & Hudson, 2007). Students who possess conceptual understanding have organized what they know into a coherent whole. Such understanding allows them to gain new understanding by consolidating new information into what they already know and use what they know to solve unfamiliar and non-routine problems. When understanding is connected it is easier to use and remember (Kilpatrick et al., 2001).

Procedural fluency includes the skill of executing procedures (i.e., computation) flexibly, accurately, efficiently, and appropriately. Procedural fluency includes using mental strategies, algorithms as general procedures (to solve classes of problems), and paper and pencil to find sums, differences, products, and quotients as well as to estimate the results of computations. Procedural fluency should be gained along with conceptual understanding (Kilpatrick et al., 2001).

Strategic competence corresponds to planning a solution pathway and using various strategies to solve non-routine mathematical problems. This requires the ability to identify what the problem is, represent it, and identify a solution. This problem solver is able to represent problems numerically, symbolically, verbally, and through graphics. The process begins when the student creates a mental image of the problem’s major components (Kilpatrick et al., 2001).
Adaptive reasoning relates to the capacity of a student to think logically about the relationships between concepts and problem situations. Such a student reasons by carefully considering alternative potential solutions and justifying conclusions (Kilpatrick et al., 2001). Finally, the student with a productive disposition has a positive attitude toward math, sees mathematics as valuable and having great utility, believes that putting effort into mathematics will pay off, and views oneself as an effective mathematician. It is essential for students to partner with strong mathematics teachers during the elementary years so that learners can build skill with understanding and see themselves as capable learners of mathematics (Kilpatrick et al., 2001).

**Interpretations of the standards for mathematical practice.** The explanations of the SMP below show the actions that students and teachers might take during lessons. The descriptions are a synthesis of mathematics teacher educators and mathematics scholars’ explanations of the SMP (Fennell, 2012; Hull, Balka, & Miles, 2011a, 2011b, 2012; Kanold, Briars, & Fennell, 2012; Larson, 2011; Koestler, Felton, Bieda, & Otten, 2013; White & Dauksas, 2012).

The first SMP states that students should make sense of problems and persist in finding solutions for them. Problem solving is a central part of all content areas. Teachers should provide time and guide students in developing their ability to create a plan for solving non-routine mathematical problems. Such problems allow for multiple points of entry and solution pathways. Students should persevere in trying to understand, find an entry point into, and solve problems through the application and adoption of diverse and appropriate strategies. They should also make and investigate conjectures. Students can make sense of problems by discussing, explaining, and demonstrating problem solving and using representations to organize,
record, and communicate mathematical ideas (NCTM, 1989). Finally, learners should monitor and reflect upon their problem solving strategies.

Process standard two holds that students should reason abstractly and quantitatively. This means teachers can offer a range of representations of mathematical ideas and situations, promote diverse solution strategies, and allow learners to make sense of quantities and relationships in problems. Students should relate representations and procedures to each other, use different representations (e.g., use pictures and words to describe numbers as well as use manipulatives, graphs, graphics, words, tables, and figures) and methods when solving problems. Students should also contextualize and decontextualize (moving back and forth from the problem and its mathematical representation). This standard has a strong connection to number and operations as well as algebra.

Students constructing viable arguments and critiquing (i.e., evaluate) the reasoning of other students is the focus of SMP three. In order to promote this standard, teachers should offer opportunities for learners to make conjectures, organize, explain, and justify their thinking (e.g., present and defend their solution pathways to a peer) orally and in writing to partners and groups, compare problem solving strategies, refute others’ claims, and interpret and evaluate the conclusions and arguments of peers. This process requires logical and valid thinking in order to determine whether a mathematical idea is true or false.

Students working with SMP three should be able to make a plan to solve a problem and explain the plan (with words, objects, pictures) as well as listen to, ask questions, and critique others’ reasoning by comparing and contrasting diverse solution strategies. Students can also learn to distinguish logic from fallacy by building plausible arguments based on established results by justifying and explaining with precise language and vocabulary why their response is
correct. Teachers should provide ample opportunities for students for such work with non-routine problems.

Modeling with mathematics to analyze mathematical relationships is the fourth SMP. It focuses on the relationship between mathematics and real world problems. During instruction teachers may create diverse settings for students to apply their understanding of mathematics and allow students to hear, discuss, and examine others’ solutions to challenging, real world and non-routine mathematical problems. Students should apply their understanding of mathematics to solve these problems and evaluate the results. Students should use pictures, symbols, objects, words, and technology tools to show solutions to problems. Last, learners should monitor and reflect upon the quality of their solution strategies.

The fifth SMP holds that students should use proper tools in a strategic manner in order to explore and deepen their understanding of concepts. Teachers can develop this practice by allowing students to use a variety of mathematical tools (e.g., ruler, calculator, software, number line, an array, blocks, computer) to solve diverse problems. Students should strategically use proper math tools, pictures, drawings, models, and other problem solving aids efficiently. Learners should also know when to use each tool, how to use it, identify its strengths and limitations, be able to justify their tool selection, and evaluate the correctness of their problem solution.

Students’ striving for precise communication is the focus of SMP six. Teachers should foster this skill by stressing the importance of precise mathematical vocabulary (i.e., language) when presenting, defending, and critiquing ideas and solution strategies. Precise communication is enabled by using accurate labels, measurements, symbols, strategies, units, calculations, mathematical thinking and representations (e.g., showing work, making and refining conjectures,
asking questions, critiquing others, and explaining thinking). Precision should include checking to see if a problem solving plan is efficient and accurate. Last, students should reflect on their solutions for accuracy and revise their arguments to ensure effective communication.

The ability to shift perspectives to discern patterns or mathematical structure is the focus of SMP seven. Teachers can help students look for and make use of structure by providing time for learners to apply and talk about mathematical properties. Students should monitor, develop, and generalize what they have learned about mathematics to solve problems and gain understanding by looking for patterns and structure within problems and recognizing connections among mathematical ideas. This process allows students to see the big mathematical ideas (e.g., commutative, associative, and distributive properties for arithmetic) within a problem (and in time gain conceptual understanding) and consolidate those ideas into a smaller related set of ideas. This understanding can in turn be applied to solve more complex problems.

The eighth SMP relates to maintaining oversight of the overall process of problem solving while attending to details. Teachers should develop students’ ability to look for and express regularity in repeated reasoning by encouraging learners to look for and talk about using a plan to solve problems that they have used before (i.e., look for short cuts), recognize repeating patterns, see generalities and limitations, and make connections from past to present episodes of problem solving. This SMP shows how procedural fluency and conceptual understanding are mutually supportive. As students engage in procedural tasks they can begin to see aspects of larger mathematical ideas and the connections between those ideas.

**Relationship of Content Standards to Process Standards**

The SMP relate to the SMC during instruction. Students learn the SMP when they are engaged in the mathematical tasks required by each student learning goal (SMC) (Parker &
Novak, 2012). Students need to learn how and when to use each SMP for each SMC. The meaning of each SMP, the interrelated nature of the SMP, and how they relate to the SMC can be difficult for teachers to understand (Hull et al., 2012). McTighe and Wiggins (2012) stated that successful implementation of the CCSSM will require understanding of the entire document and, especially, how the SMP and content standards work together. The CCSSM suggests that teachers connect the SMC and SMP by looking for content standards that begin with the word understand.

**Guiding principles of focus, coherence, and rigor.** There are three important principles that reinforce the entire CCSSM. When implemented properly the CCSSM should emphasize the principles of focus, coherence, and rigor (Ainsworth, 2013; CCSSI, 2012d). Focus requires that teachers provide students with a narrow scope of content so that learners can engage in deeper learning experiences in order to gain a sophisticated understanding of concepts and begin to understand their relationship to each other. Such understanding forms a foundation for more complex learning in subsequent years (Michigan State University, 2009). During the K-5 years students should engage in arithmetic and the concepts that form its foundation, the application of arithmetic (i.e., computation) to solve problems.

Coherence refers to the cumulative progression of mathematics learning and the connectedness (within and between grade levels) of mathematical topics, concepts and skills (Daro, McCallum, & Zimba, 2012). In other words, each standard builds on a previous standard. As primary learners gain skills and understanding it forms a foundation that enables and supports later, deeper and more complex learning. Simple concepts are introduced to beginners within simple topics. As learners gain competence topics are developed by moving to more complex topics (Michigan State University, 2009).
The final guiding principle of the CCSSM rigor relates to teaching for conceptual understanding, procedural (computational) fluency, and the application of skills and understanding to real world problems.

**Common Core Mathematics Conclusion**

The CCSSM are only a few years old and little is known about what and how elementary generalist mathematics teachers (or any teachers) understand about them. This researcher is not aware of any published research on teacher understanding of the CCSSM. In order for teachers to implement a curriculum reform they must achieve clarity (i.e., understanding) on the demands of the reform. These demands include what will be taught and learned, how it will be taught and learned, and the guiding principles that underpin the curriculum innovation (Fullan & Stiegelbauer, 1991; Fullan, 2007). Teachers can learn about these demands through professional development.

**The Role of Professional Development in Learning about Reform**

This second portion of the literature review covers how professional development relates to teacher learning about curricular reform. It includes a discussion of the research on the role that professional development has played in transmitting information about the CCSSM, the issues with traditional professional development and learning about reform mathematics, and the importance of school leader participation in professional development.

Learning even the most straightforward and basic reform ideas can be challenging. Cohen and Barnes (1993) used the simple reform example of states lowering the speed limit to 55 miles per hour as a challenging and demanding learning experience for motorists. They noted that drivers accustomed to traveling at much faster speeds had to learn to continually monitor their speed and start trips sooner. Many did not learn this seemingly undemanding reform and
received speeding tickets. Some states had to implement driver re-education programs to foster the necessary learning.

Similarly, elementary teachers in states that had clear and rigorous mathematics standards (such as those used in the state where this research occurred) need to become aware of the new ideas in the CCSSM and acquire new ways of thinking about instruction (Carmichael et al., 2010). This learning usually occurs through professional development.

Elementary generalists need sustained professional development to understand the CCSSM (Robelen, 2012). Yet, many mathematics curriculum reforms come with insufficient professional development (Stephen & Varble, 1994). Successful implementation of curricular reform should be a process of clarification or learning about the change (Fullan, 2007). The misunderstanding of curricular reform can result from a poorly communicated innovation, nebulous curriculum standards, the complexity of the reform language, insufficient professional development, and/or a lack of time (Fullan, 2007; Fullan & Stiegelbauer, 1991; U. S. Coalition for World Class Math, 2010). Time for teacher learning, high quality professional development, and support are always in short supply (Fullan, 2007; Hall & Hord, 2006).

In addition to school delivered professional development teachers learn about curricular reforms from a variety of sources (Coburn, 2001). These include getting information from the State curriculum framework itself, other teachers, professional organizations, web sites, curriculum materials (e.g., textbook), a district curriculum guide or webpage, and school administrators (EPERC, 2013). However, school professional development is usually the main setting for teacher learning about curriculum reform (Spillane, 2002).
Professional Development for the Common Core Standards

Policymakers create reforms to change what (content) is taught and how it is taught in order to promote student learning. Teachers must learn about the reform in order to provide instruction that helps pupils achieve the learning goals that policymakers identify. Professional development has the potential to help teachers understand these reform initiatives (Borko, 2004; Cuban, 1993). Professional development can consist of a wide range of teacher learning experiences such as formal seminars, independent study, study groups, lesson study, action research, informal teacher discussions, mentoring, peer coaching, reflecting on one’s instructional practices, workshops, coursework at a university, and professional association conferences (Borko, 2004; Desimone, 2011; Lewis & Hurd, 2011).

Features of quality professional development. The characteristics of effective professional development include: a focus on content and how students learn that content; active teacher learning where educators acquire new knowledge, practice new methods of instruction, give, receive feedback, reflect on their teaching, examine student work, and confront beliefs and attitudes; congruency with school and district goals, other professional development, curriculum, assessment, and standards; at least 20 hours of teacher participation time through half of a school year; and interactive participation by groups such as grade level, schools, subject area departments focused on problem solving (Darling-Hammond & Richardson, 2009; Desimone, 2011). Additionally, high quality professional development should be ongoing and permeate each teaching day (Desimone, 2011).

Professional development should also build teacher commitment toward improving curriculum and instruction (Hochberg & Desimone, 2010). Such professional development relies heavily on teachers building understanding through social networks or teacher learning
communities (Dufour & Eaker, 1998; McLaughlin & Talbert, 2006). Effective teams of teacher learners should: collaborate regularly with high levels of trust on solving teaching and learning problems and achieving common goals, share leadership, demonstrate a willingness to confront others’ beliefs and assumptions and their own within open and respectful discourse, engage in ongoing dialogue to examine their instruction and student learning in order to identify instructional interventions, exhibit self and group accountability, access many diverse learning resources, and maintain a central focus on promoting student learning (Darling-Hammond, 2010; Dufour & Eaker, 1998; Lencioni, 2002; Talbert, 2010). Collaborative professional development allows teachers to understand curricular reforms, improve knowledge and skill, change instructional practices and beliefs, and promote student learning (Desimone, 2011; Desimone, Smith, & Ueno, 2006; Fullan & Stiegelbauer, 1991). Finally, professional development related to curricular reform should develop teachers’ ability to translate the new curriculum into instructional plans (Fullan, 2007).

Those responsible for instructional change in schools should create professional development experiences for teachers that allow them to reflect on, discuss, and challenge their beliefs and how these beliefs are congruent with the CCSSM (Lambert, 2002). Moreover, Jennings (1996) stated that teachers need to perceive dissonance between their current instructional practices and the policy’s ideas. Next, teachers can begin to learn new ideas and act to reduce the dissonance. This could happen in non-traditional professional development.

**Reform mathematics professional development.** Reform professional development occurs when learners engage in active and collaborative experiences in order to promote reform-based mathematics education (Parise & Spillane, 2010). Experts in teacher learning have stated that professional development must focus on teachers’ prior knowledge, experience, and beliefs
on how students should learn mathematics (Battista, 1994; Spillane et al., 2006). Teachers’ initial understanding and preconceptions must be engaged because misconceptions can constrain understanding of new information (Bransford et al., 2000). Professional development also needs to provide teachers with learning experiences that are similar to the type of learning experiences their students are expected to participate in (Guskey, 2000).

**National mathematics professional development.** The professional development that has been offered to promote understanding of the CCSSM has not helped to create sufficient teacher understanding. About three quarters of mathematics teachers have stated that their district has not provided enough professional development time for them to gain a sufficient understanding of the CCSSM (Hart Research Associates, 2013). A study of 599 educators found that most teachers have spent three days or less in professional development for the CCSS (ELA and mathematics); close to one third of teachers had not received any professional development on the CCSSM; less than 20% stated they were very familiar with the CCSSM; more than two-thirds said they were not well enough prepared to teach the standards to ELL’s or students with disabilities; professional development content has emphasized ELA over mathematics; and most professional development consisted of workshops for large groups of teachers conducted by administrators (EPERC, 2013). However, the administrators in elementary schools have three major initiatives competing for professional development time.

**Initiative overload.** The State’s Secretary of Education, described keeping up with education reform initiatives as “like trying to drink water from a fire hose.” In addition to the enactment of the CCSSM and CCSSELA many states are implementing educator effectiveness regulations that connect a significant portion of the teacher’s annual evaluation to student test scores on state tests that are (or will be) aligned to state standards (ASCD, 2012). Districts are
developing educator evaluation plans while helping teachers learn these guidelines in addition to trying to gain an understanding of the CCSSM and CCSSELA (ASCD, 2012). Thus, administrators are uncertain what to emphasize in professional development with three major reforms underway. Moreover, the demand for teacher professional development has surpassed the ability of many states and districts to implement it (ASCD, 2012).

**Learning Reform Math from Traditional Professional Development**

The research on professional development relative to curriculum development implies that elementary generalists may not be able to gain a strong understanding of the CCSSM from traditional professional development. Traditional professional development can be an obstacle for elementary generalists to learn about the instructional requirements of the CCSSM (Loveless, 2013). Traditional professional development (is similar to traditional mathematics instruction) is where learners sit and receive facts, procedures, and information with little or no follow up and support to help them understand and implement what they have learned (Garet, Porter, Desimone, Birman, & Yoon, 2001; Little, 1993). Such professional development is also focused on a hodgepodge of topics of insufficient duration to allow sufficient teacher learning (Miller, Lord, & Dorney, 1994). This professional development is unlikely to lead to understanding and instructional change (Hawley & Valli, 1999). Wilson (2009) stated that most teachers are unlikely to participate in high quality professional development related to their grade level, subject area(s), and students within their school.

Schools are the major providers of teacher professional development (Miller et al., 1994; Spillane, 2002). Yet, schools have little capacity to implement high quality professional development (Jennings, 1996). Additionally, teachers with strong content knowledge in mathematics are more likely to participate in sustained and focused professional development
than teachers with weak content knowledge in mathematics (Desimone et al., 2006). Thus, it will be difficult for such professional development to promote understanding of reform mathematics among elementary generalists. Teachers with lower levels of content knowledge who need to learn the most about the CCSSM may not be getting it.

Learning about the CCSSM by elementary generalists from traditional professional development will be challenging. First, the content (what students will learn) of reform mathematics is easier for teachers to learn than learning how to teach reform mathematics (Firestone, Mayrowetz, & Fairman, 1998). Second, changes to traditional instruction require unlearning of behaviors, beliefs, and attitudes and learning about the reform (Mousley, 1990). Third, traditional mathematics (teaching mathematics as a set of procedures) is easier and more comfortable to implement than reform mathematics (Frykholm, 2004; Skemp, 1978). Last, the learning environments in many schools are not in harmony with the professional environment needed for learning to understand reform mathematics instruction. Many schools offer short time periods for teacher learning, little instructional collaboration, rigid school policies, and do not have the resources to offer large amounts of support and potent curriculum materials (e.g., textbooks, mathematics instructional materials) (Handal & Herrington, 2003).

**School Leaders’ Role in Implementation of Reform Policy**

Principals and administrators are the key school personnel for facilitating teacher understanding of the CCSSM through professional development and instructional leadership (ASCD, 2012). Most teachers are learning about the CCSSM from their school’s administrators (EPERC, 2013). Moreover, the ASCD (2012) stated that many principals do not have a strong understanding of the instructional demands of the CCSSM. The curriculum implementation research conducted by Spillane and colleagues (all in Michigan school districts) and others
suggests that it is important to consider the role of school instructional leaders when studying teacher sense-making.

Spillane and colleagues’ research supports the ideas that administrators need to possess a robust understanding of reform since they are responsible for helping teachers learn about the reform. Spillane and Thompson (1997) studied the local capacity for ambitious instructional mathematics and science reforms in nine school districts through case study methods and noted that instructional leaders must understand reform so that they can help teachers understand reform. They found that implementation depends upon the ability of the school’s instructional leaders to interpret reform accurately and teach the reform to teachers. Spillane and Zeuli (1999) also suggested that the success of a reform message depends largely upon school leaders understanding it since they often educate the school’s teachers about the reform.

The following research by Spillane and Callahan implies that administrator understanding may not always be congruent with reform messages. Spillane (1996) conducted a case study of two school districts’ responses to reading curriculum reform. He found that the ideas the district administrators constructed about reading reform diverged from that of state policymakers. Spillane and Callahan (2000) conducted a multi-site case study using only interviews with teachers, instructional leaders, and administrators in nine school districts to explore district level ideas that were constructed from state science standards. They found that the lack of success implementing standards, in ways that were aligned with their instructional intent, were in part a result of a lack of understanding of the reform by district administrators. Spillane (2000) used a cognitive framework and case study methods to explore district responses to mathematics reforms. The researcher found that district leaders misunderstood the intent behind the reform and constructed diverse ideas about the reform. Spillane (1998a) conducted a case study with a
cognitive conceptual framework of two school districts response in order to determine how school districts responded to reading instructional reform policy. These district policymakers had varied understandings of the reform that influenced staff development, curriculum frameworks, and curriculum materials. Other research hints at administrators’ beliefs as an obstacle toward teacher understanding of reform messages.

Spillane and Coburn’s research suggests that administrators may hold behaviorist beliefs about how students should learn. However, the CCSSM is based on socio-constructivist principles (NCTM, 1989, 2000). Spillane (2002) examined educators’ behaviorist, situated, and cognitive views in nine Michigan school districts. He collected data from state level policymakers and school district administrators and found most educators held behaviorist beliefs. Spillane suggested that those school leaders who hold behaviorist orientations to instruction may not have been as effective in teacher education of the reform. Relatedly, Coburn (2005) conducted a case study of how two California elementary school principals influenced teacher learning through their interpretations of reading policy. One principal drew upon her behaviorist beliefs on reading instruction while the other used socio-constructivist beliefs to make sense of reform. They passed on their interpretations of the reforms to teachers. The author found that principals’ understanding of policy shaped teacher access to reform ideas and teacher learning relative to reading reform policy and in turn the enactment of the policy.

Mathematics Professional Development Conclusion

School level professional development led by district administrators is the main source of learning for the CCSSM. However, school level professional development has traditionally relied on a teaching as telling style of professional development by administrators who may have an insufficient understanding of or a divergent orientation to reform ideas. Professional
development that will enable and support elementary generalists learning of the CCSSM will require teachers to construct ideas that are congruent with the reform ideas in the CCSSM in collaborative groups. High quality professional development should also consider how teachers’ experience, beliefs, attitudes, and knowledge contribute to the sense-making of reform ideas.

Teacher Sense-making of Curriculum Reform

This portion of the literature review includes the scholarship related to elementary generalists’ sense-making of curriculum reforms. This section begins with a discussion of how teacher attitudes, experience, knowledge, and beliefs influence sense-making. It is followed by a brief explanation of how teachers bypass sense-making by adopting curriculum materials. This section concludes with empirical research on individual and collective sense-making of curriculum reform.

Since 1985 when California introduced reform mathematics policy, researchers have studied how teachers, administrators, and schools have responded to mathematics curriculum policy across America and internationally (Cohen, 1990; Honig, 2006). However, there has not been a research emphasis on the ideas that elementary generalists construct from curricular reform. Elementary generalists face many obstacles toward understanding and implementing the CCSSM as a result of their beliefs, experience, knowledge, and attitudes relative to mathematics education (Ma, 1999; Stigler & Hiebert, 1999; Wu, 2009). The understanding of the CCSSM is especially important for them since elementary mathematics is the foundation upon which all students build their mathematical knowledge, skills, beliefs and attitudes that they will draw upon during future learning. In other words, their existing cognitive structures will influence what and how they learn (Bransford et al., 2000). Like their students, elementary generalists
gain understanding of reform demands through a process of constructing ideas on top of their existing cognitive structures (Spillane et al., 2002).

**Role of Cognitive Structures in Interpreting Standards**

Teachers’ experience, attitudes, beliefs, and knowledge (i.e., cognitive structures) can enable or constrain their learning of the CCSSM (Bransford et al., 2000; 1992; Shulman, 1986). Humans enter learning experiences with a diverse range of prior knowledge, abilities, conceptions, and beliefs that influence what they see and how they organize and make sense of experiences (Bransford, et al., 2000). This affects their ability to gain new knowledge. In other words, what is in reform policy depends upon what is inside those who will be implementing it – teachers’ beliefs and understanding relative to the innovation (i.e., the reform) (Majone & Wildavsky, 1978).

Teachers, like their students, may begin learning with false beliefs, partial understandings, and crude versions of concepts. If these pre-existing cognitive structures are not dealt with, the knowledge they construct from their attempts to make sense of reform may diverge from what is desired by policymakers. In addition to sense-making a lack of resources, support, and time can limit the potential of the sense-making process (Berman & McLaughlin, 1978; Borko, Roberts, & Shavelson, 2008; Cohen & Ball, 1990a; Elmore & McLaughlin, 1983; McLaughlin, 1987, 1990; Oleson & Hora, 2012).

Teacher beliefs are dynamic, mental structures that change according to experience (Thompson, 1992). The sense-making process is also influenced by the social, physical, and cultural context of the sense maker (Resnick, 1991). Changes to teachers’ knowledge structures form the foundation of enduring curricular reform (Fullan, 2007).
The term beliefs can generally refer to many different cognitive structures. Phillip (2007) reviewed the literature on mathematics teacher beliefs and put forth the following definitions. He explained beliefs as understandings, premises, or propositions that are thought to be true. Beliefs can be held with varied levels of intensity. He described knowledge as beliefs that are held with a high level of certainty. Knowledge for one might represent a belief for another. An attitude was identified as a way of acting, feeling, or thinking that represent a disposition or opinion. Attitudes are likely to change more quickly than a belief.

Mathematics Teachers’ Attitudes

The mathematics scholarship shows some of the major beliefs and attitudes of elementary teachers may keep teachers form deeply engaging with the reform ideas within the CCSSM. The beliefs that teachers bring to their jobs are, to a large degree, shaped by the kind of instruction they experienced as K-12 students (Lortie, 1975; Richardson, 2003). School level beliefs and norms affect individual teacher and group beliefs which can create norms of performance (Sampson, Morenoff, & Earls, 1999). Teachers often recognize learning experiences that are aligned with their beliefs (Opfer & Pedder, 2011).

Beilock et al. (2010) identified an attitude common to many elementary generalists – mathematics anxiety. Mathematics anxiety is a state of mind characterized by unpleasant emotional responses to mathematics and a feeling of mental disorganization that happens when one is required to perform mathematically (Swarz, Daane, & Giesen, 2006). Those with high levels of mathematics anxiety try to avoid mathematics related situations. Another attitude was discussed by Frykholm (2004). He found that the type of teaching required by reform mathematics such as problem-solving, critical thinking, and discourse is challenging and uncomfortable for many teachers. This might make them less likely to deeply engage in learning
the CCSSM. Finally, Battista (1994) noted that many mathematics teachers’ beliefs are not compatible with reform mathematics as a result of their experiences with traditional mathematics.

**Teachers’ Experience with Mathematics Education**

Elementary generalists usually teach all core subjects (English language arts, social studies, science, mathematics and sometimes physical education, art, and music) with a strong emphasis on reading and language arts (Fennell, 2006; Wu, 2009), a subject area that gets more emphasis from administrators than mathematics (Ball & Cohen, 1996). Hence, it is unusual for an elementary generalist to possess deep and broad understanding of mathematics (or any single subject) curriculum, content, and pedagogical content knowledge (AMTE, 2010; Ball, 1990; Liljedahl, 2009; Ma, 1999; NCSM, n.d.; NCTF, 1996; NCTM, 2000; National Mathematics Advisory Panel, 2008; NRC, 1989; Rech, Hartzell, & Stephens, 1993; Tirosh & Graeber, 1989; Wu, 2009). This is neither a statement of blame nor the fault of elementary teachers (AMTE, 2010). Research suggests that teachers’ experience with mathematics education may not have prepared them to understand the CCSSM.

*Traditional mathematics dominates.* The scholarship on mathematics teacher beliefs shows that their beliefs and experiences as students and teachers are aligned with traditional mathematics instruction. After more than 20 years of reform mathematics there has been little change to traditional mathematics instruction (NCSM, 2013). Traditional teacher-dominated mathematics education has been the major form of instruction in K-12 education for the past 100 years (Alberti, 2013; Blanton & Kaput, 2005; Cooney, 2009; Jacobs et al., 2006; Nisbert & Warren, 2000; Romberg, 1983; Stigler & Hiebert, 1997,1999; Truxaw & DeFranco, 2008). Traditional mathematics instruction involves teacher directed instruction with whole class
lecture, checking homework, telling and demonstrating a single procedure (algorithmically-based instruction), individual seatwork, rote learning, following and memorizing recommended steps to getting the correct answer to a problem, an emphasis on coverage over conceptual understanding, and allowing students to ask questions about tasks (Cohen & Ball, 1996; Cuban, 1993; Civil, 1990; Foss & Kleinsasser, 1996; Goodlad, 1984; Gregg, 1995; NCSM, 2013; Stigler & Hiebert, 1999; Stodolsky, 1988). Recent research shows that teachers’ experiences and preparation may not have prepared them for the more complex aspects of reform mathematics.

**Insufficient teacher preparation.** A study by Michigan State University (2006) found that most elementary teachers did not feel well prepared to teach algebra topics (operations and algebraic thinking is a major component [domain] of the K-5 content standards of the CCSSM). A national survey of teachers found that a majority believed they were unprepared to teach to all of the topics in the CCSSM (EPERC, 2013; Gewertz, 2012b). The reason that generalist feel underprepared is because they typically take only two or three mathematics courses as part of their teacher preparation program (Fennell, 2006; Greenberg & Walsh, 2008). Further, only about 1% of mathematics teachers in grades one through six had an undergraduate major in mathematics (Michigan State University, 2006, p. 13). Nevertheless, most mathematics teachers stated that they liked the CCSSM and would teach to them (Gewertz, 2012b; Hart Research Associates, 2013). The following studies suggest that mathematics teachers’ beliefs about instruction are in harmony with traditional mathematics.

**Teacher beliefs aligned with traditional mathematics.** Raymond (1993) conducted qualitative research to examine the factors that influence the beliefs and practices of six elementary mathematics teachers. Raymond found that mathematics beliefs were influenced by K-12 experiences as a students and teacher education. Raymond (1997) also conducted a study
on the relationships between the beliefs and instructional practices of a beginning elementary mathematics teacher and found that instruction was more congruent with beliefs that came from experience as a mathematics student than professional beliefs about instruction.

Ross, McDougall, and Hogaboam-Gray’s (2002) review of the literature on mathematics education found that the main obstacle toward implementation of reform mathematics were teacher beliefs about mathematics instruction. They stated that teachers’ beliefs are generally aligned with traditional instruction (mathematics as learning computational procedures) rather than reform mathematics principles (e.g., teaching mathematics for conceptual understanding). Thus, many elementary generalists have much experience and associated beliefs in traditional mathematics from their experiences as students, as pre-service educators, and teachers. This may not be true for teachers in the State where this research project will take place.

**The state’s reform mathematics history.** The State’s teachers are in their 19th year using reform mathematics curricula. The State modeled its content and process standard for its first reform mathematics curriculum after the NCTM’s (1989) *Curriculum and Evaluation Standards for School Mathematics*. This State framework offered 36 (total) content standards for grades K-5 and five process standards.

The content standards were organized into four domains: number sense; patterns, relationships, and functions; geometry and measurement; and statistics and probability. The content standards were written in broad terms. The process standards described in more specific terms the habits of mind that students should employ while engaging with the content standards. Many of the recommendations in the process standards within the CCSSM can found in this document.
The first process standard noted the importance of students trying to go beyond their area of competence when learning mathematics. The second standard asked students to deepen their mathematics understanding by communicating and justifying their solutions (comparable to SMP 3). The third standard required mathematics learners to gain an attitude of persistence (similar to SMP 1) and have confidence in their abilities. The fourth standard stated that students should integrate mathematical ideas and understanding into a network of ideas. The final standard held that pupils should value all areas of mathematics.

The State’s framework for mathematics also stressed problem solving (problems that allow for many strategies and have many solutions), communication (discussing solution strategies with peers), reasoning and proof (making conjectures and justifying solutions), as well as connections (linking procedural and conceptual knowledge). The State’s 2000/2004 mathematics framework was also built upon the ideas put forth by the NCTM.

The 2000/2004 State framework organized mathematics content into five domains: number sense and operations; patterns, relationships, and algebra; measurement; and data analysis, statistics and probability. The content standards were written for grade level bands: PK-K, 1-2, 3-4, 5-6, 7-8, 9-10, and 11-12. The 2004 revision added content standards for grades three, five, and seven. Finally, the framework included the five process standards from *Principles and Standards for School Mathematics* (NCTM, 2000): problem solving, communication, reasoning and proof, making connections, and using representations. This framework strengthened the State’s commitment to learning mathematics through problem solving where students simultaneously gain procedural fluency and conceptual understanding.

The State has achieved mixed results from its long term commitment to reform mathematics (i.e., standards-based instruction). Its 2000/2004 curriculum framework that the
CCSSM replaced had standards that were judged to be just as rigorous as those of the CCSSM (Carmichael et al., 2010). Additionally, the mathematics performance of the State’s eighth grade students has been among the highest five achieving countries on international tests. However, the State has experienced high remediation rates for pupils entering postsecondary institutions (Hyslop & Tucker, 2012). This suggests that elementary generalists’ instruction may be closer to reform mathematics than traditional mathematics. However, the CCSSM is still a change that will require teachers to make sense of.

**Teacher Content and Pedagogical Content Knowledge**

There is strong agreement that mathematics teachers need strong content knowledge as well as knowledge of teaching, pupils as learners, and assessment in order to implement high-quality standards-based teaching (Michigan State University, 2006). Lee Shulman (1986) stated that Aristotle said, “Those who can, do. Those who understand, teach” (p. 14). This statement shows the importance of deep teacher knowledge as a requirement for understanding how to teach. In order to understand standards and their demands teachers must have sufficient content and pedagogical content knowledge (Ball, Hill, & Bass, 2005). Shulman identified several bases of knowledge that successful teachers should possess under the umbrella of pedagogical content knowledge (PCK).

Shulman (1986, 1987) stated that content knowledge is the volume and organization of what is to be taught within a subject area within the mind of an educator. Such knowledge includes facts, concepts, and how knowledge is built and organized within the subject area. Curricular knowledge involves understanding how subject area topics are arranged within and between grade levels (important for understanding the coherency and focus of the CCSSM) as well as understanding curriculum resources such as textbooks and tests. General pedagogical
knowledge includes understanding of classroom management techniques, students and their learning styles, readiness for learning, and interests; the classroom and school context; and overall school goals, beliefs and values.

Teachers need PCK in order to understand instructional approaches that fit content and how to organize the content (Ball, Hill, Bass, 2005). A teacher with PCK knows the typical stages of learning that a student will pass through on their way to proficiency of a topic, anticipates what students will typically understand and misunderstand; predicts the conceptions and misconceptions that pupils bring with them to learning; knows what students will use for problem solving strategies; understands why a learning experience will be simple for some and complex for others; provides demonstrations and explanations that promote understanding; and predicts the difficulties each student will have with each topic (Griffin, 2005; NCSM, 2013). Teachers need shifts in beliefs, mathematical content knowledge, general pedagogical knowledge, PCK, and mathematical curriculum knowledge in order to understand the CCSSM (NCSM, 2013). Empirical research supports the notion that knowledge about teaching is gained from experience and necessary for understanding curriculum materials (Ball et al., 2005).

Weiss, Knapp, Hollweg, and Burrill (2001) stated that teacher content and PCK is affected by their experiences with mathematics’ content and how it has been taught to them as students as well as how taught as pre-service and in-service teachers. Remillard (2005) discussed how teachers use their beliefs about instruction to make sense of curriculum reforms. These cognitive structures include knowledge of mathematics, mathematical content knowledge and pedagogical content knowledge, general beliefs about mathematics, instructional goals, instructional experience, pedagogical design capacity, perceptions of the curriculum, perceptions of students, an identity, and tolerance for discomfort.
Remillard (2005) also noted that beliefs represent assumptions about curriculum, approaches to education, how students should learn, and what and how teachers should teach. Such beliefs serve as filters through which new information and experience are interpreted (and implemented). However, teachers often bypass the work of trying to understand the instructional intents of standards documents by simply adopting a mathematics textbook or curriculum materials.

**Curriculum Materials Adoption**

Schools have traditionally responded to new content standards by simply adopting a textbook or a mathematics program which serves as the de facto curriculum for teachers (Gross, et al., 1971; Remillard, 2005). Sosniak and Stodolsky (2000) found that elementary teachers explicitly follow their mathematics textbooks. The textbook is the major instructional resource for instruction (Lloyd, 2002). It provides a list of content to be covered, assignments to be done, and whole class activities to implement (Remillard, 2005). Some of the elementary curriculum materials aligned with the CCSSM that teachers may be relying on include *EnVisionMATH* (Pearson Education, 2012), *Everyday Math* (University of Chicago, 2012), *Math Trailblazers* (Kendall Hunt Publishing Company, n.d.), *Investigations in Number, Data, and Space* (TERC, 2012), *Think Math!* (Education Development Center (2013), *Saxon Math* (Houghton, Mifflin, & Harcourt, 2013), and *Math in Focus: Singapore Math* (Cavendish, 2012).

A textbook or mathematics program adoption with no teacher learning of the reform messages within the CCSSM blocks the understanding of the necessary instructional changes required by the CCSSM and as a result reduces the potential of the CCSSM to prepare students for college and career (NCSM, 2013; Wu, 2011). Experts in reform mathematics education stated that teachers must take the time to understand the CCSSM rather than simply follow a
textbook in a linear fashion (Barlow & Harmon, 2012; Dacey & Polly, 2012; Schmidt & Burroughs, 2013b). The NCSM (2013) and Wu (2011) have stated that textbooks are not of sufficient quality nor fully aligned to the CCSSM and thus, should not serve as a proxy for the CCSSM. Finally, Elmore and McLaughlin (1988) stated that in order to execute curricular reform teachers must gain a conceptual understanding of the reform through sustained learning.

**Research on the Teacher Sense-making Process**

The curriculum-reform-as-interpreted branch of the education policy implementation literature implies that teachers draw on their diverse beliefs and experiences to their processes of sense-making of reform policy. What they come to understand relative to a reform’s demands depends upon the implementing agents’ existing cognitive structures (Jennings, 1992; Remillard, 2005; Spillane & Callahan, 2000). This branch of the scholarship includes teacher interpretation of policy, and sense-making within a community of educators.

**Teacher Cognitive Structures and Understanding of Curricular Reform**

The research on implementation of reform curriculum frameworks suggests that teacher beliefs, prior knowledge, and experience (cognitive structures) play an influential role in how teachers make sense of reform demands (Remillard, 1992; Spillane et al., 2006).

Cohen and Ball (1990a) conducted a case study of five California elementary teachers’ responses to reform mathematics reform. Their research suggested that teachers assimilate new practices through their more deeply held beliefs in traditional instruction (Cohen & Ball, 1990b). They stated that reform mathematics is the new wine in a traditional instruction bottle. Similarly, Mayrowetz’s (2009) case study compared instructional practice with mathematics reform curriculum with 12 fourth grade teachers from inclusive classrooms in New Jersey. He found
that teachers reframe policy in terms they know, believe, and did within their classroom instructional practice.

Lloyd (1999) used a case study method to study two high school teachers’ conceptions of the cooperation and exploration aspects of a reform mathematics curriculum. Lloyd found that the teachers’ conceptions of these themes differed based upon their experience teaching traditional mathematics. Firestone et al. (1999) used a case study to examine the implementation of mathematics assessment policy in the United States and the United Kingdom. The reform was intended to challenge ideas about mathematics content knowledge and pedagogy. Instead, teachers understood the intent of the reform in ways consistent with their beliefs and past practice rather than rethinking their beliefs and practice in order to promote reform mathematics.

**Collaborative Sense-making**

In addition to making sense of reform policy individually educators makes sense of policy in formal and informal groups. The “policy-as-perceived literature” (Jennings, 1996, p. 15) proposes that educators’ diverse cognitive structures affects their collective sense-making of the reform.

Coburn (2001) used a case study with sense-making theory in an urban California elementary school to explore how teachers co-construct an understanding of multiple policy messages on reading policy in the context of a professional community. The author found that teacher interaction and discourse influenced the process by which teachers adopted, adapted and ignored information about instruction mediating the way information shaped instruction. The social process of reconstructing a policy message allowed some messages to be accepted by grade level groups of teachers while others were rejected. Messages were kept out because the majority of the group felt the reform idea did not apply to their grade level, the practice was
perceived as too difficult for students, the ideas were too far from current practice, the practice would not be manageable for teachers, ideas were too complex to understand, or teachers were philosophically opposed to the reform idea.

Marz and Kelchtermans (2013) explored individual and collective sense-making of a new mathematics (statistics) curriculum through a multiple case study using interviews with 20 secondary teachers from nine schools in Belgium. The researchers focused on how individuals and group processes of sense-making and school structures influenced implementation. They found that teachers responded in varied ways to reform. The researchers stated that individual and social sense-making depends upon teachers’ beliefs, content knowledge, and pedagogical content knowledge.

Spillane’s (1998b) case study of two Michigan school districts responses to reading reform policy noted that the sense-making is situated within the school context. He noted that there are administrators from low to high levels within the administrative hierarchy, who had varying perspectives of the reform, participating with teachers in sense-making efforts. Moreover, he described the reform message as complex and not well articulated. This resulted in diverse understandings of the message as a result of a wide variety of existing cognitive structures among groups of implementing agents in different levels of the district. The cumulative result was a heterogeneous instructional response to the reading reform.

**Teacher Sense-making Conclusion**

Teachers draw on their beliefs, knowledge, experience, and attitudes to make sense of a reform curriculum framework individually and in groups. If these cognitive structures are not aligned with reform ideas this incompatibility could block implementation. Gaining a sufficient understanding of the instructional demands of the CCSSM will be an enormous task for
elementary generalists (Gewertz, 2012a, 2012b; Robelen, 2012). Some educators may sidestep the heavy lifting by simply adopting curriculum materials.

In order to implement the CCSSM as it was intended generalist mathematics teachers must individually and collectively confront misaligned attitudes, unlearn traditional mathematics practices by examining and challenging incongruent beliefs and gain a robust grasp of the instructional demands of the CCSSM (Larson, 2011; Schmidt, 2012b; White & Dauksas, 2012). Interpretation of the CCSSM requires strong PCK (Shulman, 1986, 1987) such as comprehending how to: build learning upon what students know, how to deal with student misconceptions, how to present ideas, and how to assess student learning, and how students learn mathematics (Confrey & Krupa, 2010; Hill, Ball, & Schilling, 2008; Larson, 2011; Leikin & Levav-Wayneberg, 2007; Price & Ball, 1997). The results of teacher interpretations of curricular reform messages can result in teachers misunderstanding the reform.

Results of Teacher Sense-making of Curriculum Reform

This final part of the literature review shows what the curriculum reform-as-perceived scholarship within the reform implementation research has shown to be the three major results of individual and collaborative teacher sense-making: teachers do not recognize unfamiliar ideas within reform ideas, teachers achieve superficial understanding of the reform, and teachers gain a wide range of understanding of the reform (Spillane et al., 2006).

Educators Missed Unfamiliar Aspects of Reform Policy

The following implementation research shows that because of a lack of teacher knowledge and experience with reform ideas educators missed or did not recognize unfamiliar and complex recommended approaches to instruction.
Cohen (1990) conducted a case study on one elementary teacher in rural California in order to understand the processes used by teachers to build understanding of reading reform policy. The researcher found that teachers missed new and unfamiliar aspects of reform and instead focused on familiar components.

The following three studies showed how teachers missed key reform ideas within science education. Beck, Czerniak, and Lumpe (2000) identified factors that influenced K-12 science teachers’ implementation of constructivist instruction with a survey of 203 Ohio teachers. They found that teachers missed new and unfamiliar aspects of reform. Czerniak and Lumpe (1996) also explored the beliefs of science teachers and found (through surveys of K-12 teachers in Ohio) that they did not recognize unfamiliar aspects of reform. Vesilind and Jones (1998) conducted a case study of two teachers’ attempts to implement constructivist science teaching at the elementary level and the influence of school culture on the change. They found that teachers see new policies relative to current traditional understanding of instruction. The teachers missed the deeper ideas of constructivism and inquiry-based, student-centered learning and viewed the change simply as the use of more textbooks and hands-on activity.

In his book *Standards Deviation* Spillane (2004) explained his four-year case study on the implementation of mathematics and science standards in school districts in Michigan. His research with observations, surveys, and interviews found that educators failed to see important aspects of the reform. For example, educators saw the reform mathematics idea of problem solving as more traditional computation rather than as engaging in a task of which the solution procedure is not routine in order to gain conceptual understanding (Latterell & Copes, 2003).
Teachers Gain a Superficial Understanding of Reforms

Related to missing or not perceiving complex and unfamiliar reform ideas, the following implementation scholarship shows that teachers make shallow connections from reform policy to their instructional experiences, knowledge, and beliefs. This results in the implementation of the superficial aspects of the reform.

Gross et al. (1971) used case study method to explore how 11 teachers at an elementary school executed planned whole school change and found that a majority of teachers could not identify the major features of an innovation. However, they believed they were meeting the policymakers’ intentions. The most superficial aspects of the curriculum were understood and implemented while more complex ideas were implemented incompletely or left out. Moreover, they found that teacher understanding declined with the complexity of the innovation. They also noted that a textbook may be adopted in place of learning about the ideas and instructional practices of a curriculum reform.

Obara and Sloan (2009) conducted a case study with three sixth-grade teachers in Georgia and their mathematics coach on their implementation of a mandated reform mathematics curriculum. The researchers found that changes to instruction were minimal and superficial despite teacher beliefs that they had made larger instructional changes.

Spillane and Zeuli (1999) investigated patterns of instructional practice among 25 third and fourth and seventh and eighth grade teachers in nine Michigan districts. They found that mathematics teachers interpreted the reforms through diverse lenses as a result of divergent beliefs on content, instruction, and how students should learn. They stated that many teachers see standards-based reform as requiring trivial changes in instruction and how students learn rather than as a complex change that requires substantial teacher learning. Further, those that do
see the required major changes to what is taught and how it is taught may not have the understanding and pedagogical skill to put these requirements into practice.

Studies by Marsh and Odden (1991) and Guthrie (1990) examined the stories of California teachers responding to mathematics reform. The authors found that the teachers understood and put the more superficial and easily interpreted aspects of the reform into practice. The other aspects were not understood nor implemented since teacher beliefs and knowledge were not in harmony with the reform. Furthermore, the teachers were not able to translate the standards into learning experiences. This research did not show, specifically, what aspects of the reform were not understood.

In summary, teachers often see ideas as more familiar than they are. This is a result of teacher expectations that come from existing experience and knowledge that focus interpretation away from and reject information that is not aligned with their expectations (Spillane et al., 2006). In order to understand unfamiliar and complex reform teachers must reorganize what they know through sustained engagement (Spillane et al., 2006).

**Teachers Demonstrate a Range of Understanding of Reform Ideas**

A third consequence of teacher misunderstanding of reform policy is that teachers construct a wide range of ideas from curriculum reform messages based on their diverse experiences teaching and learning mathematics.

Haug (1999) conducted a multiple case study with four Colorado school districts that were leaders in standards-based reform implementation. The researcher found a large divergence in teachers’ understanding of the reform mathematics main ideas. The ideas educators constructed from the reform ranged from seeing the curriculum as a checklist to believing the curriculum demanded fundamental instructional change. Similarly, Collopy (2003)
used a case study method with interviews and observations of two upper elementary teachers. The author found that the teachers read, interpreted, and used curriculum guides in varied ways based upon their diverse beliefs.

Ben-Peretz (1990) stated that teachers read curriculum materials to learn what is in it and interpreted to evaluate based upon their experience as educators, knowledge of the subject area and its learners, and instructional beliefs. Teachers revise, adapt, or reconstruct curriculum materials in different ways in order to make them appropriate for their students and context. What teachers interpret depends upon content knowledge, teaching experiences, their classroom reality, pedagogical content knowledge, willingness to accept new ideas, and interpretive skill. Relatedly, Remillard (2000) executed a case study on two fourth grade teachers to determine if reform mathematics curriculum materials supported teacher learning and found that teachers read the curriculum materials while drawing on their beliefs, knowledge of mathematics teaching, and students to understand curriculum. Hence, teachers interpreted the curriculum in different ways.

Remillard and Bryans (2004) sought to comprehend the role that (commercially developed) reform mathematics curricula play in helping teacher learning. Their study of eight teachers at an ethnically and racially diverse public elementary school found that the way teachers read, interpret, and use curriculum are influenced by their understanding and beliefs about mathematics, views on external pressures, ideas about the purpose of education and how people learn, as well as school norms. They found that minimal teacher learning occurs when teachers simply read the curriculum and teachers responded to the reform in different ways. The authors recommended that teachers should receive support with the unfamiliar portions of the curriculum.
Jennings (1996) examined the impact of reading reforms on three elementary teachers in Michigan. She looked at policy implementation through a teaching and learning framework. Jennings found that the teachers each had a unique understanding of the reform and what teachers learned depended upon their prior knowledge, experience, and dispositions. The author noted that prior knowledge includes who teachers are as learners and what they believe about content and instruction. Additionally, the teachers created additional time for learning about the reform. Jennings suggested that policymakers, as teachers of their reform ideas, need to know the ideas that teachers have constructed from reform policy.

**Teacher Understanding of Reform Conclusion**

Since what teachers come to understand depends, to a large degree, upon their cognitive structures some may misunderstand reform messages. Heinlein (1973/1987) summed up this phenomenon by stating, “Belief gets in the way of learning (p. 20).” The case study research on teacher sense-making of curricular reform demands showed that PCK, beliefs in how students should learn, and experiences weighed heavily in teacher sense-making. Teachers’ cognitive structures caused them to miss unfamiliar reform ideas, recognize the most superficial ideas, and construct many different ideas on the reform that diverged from those of policymakers.

**Literature Review Conclusion**

This literature review has shown what is known about what and how elementary generalists understand the demands of reform mathematic curricula. This scholarship contained four elements: an explanation of what the components of the CCSSM and reform mathematics are asking teachers to do, the role of professional development provided by the school and teacher collaboration in learning about curriculum reform, teachers’ cognitive structures and the sense-making process, and research on what teachers come to understand from reform policy.
Background on Common Core Mathematics

Part one revealed that the language used in the SMC and SMP has been difficult for teachers to understand. Further, it has been challenging for teachers to comprehend how the SMC and SMP relate to each other.

Mathematics Professional Development

Part two showed that elementary schools and teachers cannot focus exclusively on learning what the CCSSM is asking them to do since they are dealing with two other major changes (CCSSELA and a new educator evaluation system), administrators can misunderstand reform and transmit that misunderstanding to teachers, school delivered professional development has been of insufficient duration and quality, and teachers need to construct meaning of the CCSSM collaboratively. This research does not acknowledge that teachers may be receiving and interpreting diverse ideas about the CCSSM from other sources such as local curriculum frameworks, mathematics curriculum materials, and professional association conferences.

Mathematics Teacher Sense-making

The third component of the literature review revealed that teachers erect an understanding of what the reform is asking them to do based upon their cognitive structures. They do so independently and as a process of collective sense-making within a social context. It also showed that elementary generalists, who are often expected to focus on literacy more than mathematics, have a long history providing traditional mathematics. A dominant emphasis on traditional mathematics instruction does not seem to be taking place in the State as they have been using reform mathematics standards since 1996. Therefore, this research should focus on
teachers’ awareness of the aspects of the CCSSM that are new and their understanding of what those standards are asking teachers do rather than their understanding of reform mathematics.

Outcomes of Sense-making

The final part of the review demonstrates that when teachers’ attitudes, experience, believes, and knowledge deviate from the reform’s intents misunderstanding of the reform message can occur. Thus, teachers need to reflect upon and question their divergent beliefs and instructional practices cooperatively. Further, interpretation requires that teachers understand how students should learn reform mathematics. Thus, the sum of this corpus of data suggests that many elementary generalists situated in social contexts are constructing divergent ideas from instructional reform messages from this ambiguous curriculum framework “on top of” their existing individual cognitive structures largely during school delivered professional development.

Gaps in the Literature

These findings from the largely case study scholarship do not show the orientation or position of individual and groups of teachers’ cognitive structures to the ideas put forth in the CCSSM, how elementary generalists are engaging in learning about the CCSSM during school provided professional development and elsewhere (e.g., textbook publishers, professional associations, state department of education, and university courses), and perhaps most importantly, the specific ideas elementary generalists have constructed about the CCSSM. Hence, this missing data will comprise the research questions for a case study. A case study within an elementary school that has been deeply engaged in learning about the CCSSM would be useful for exploring these questions.
A qualitative case study in one school would have great utility for deep research on teacher sense-making processes and the ideas they have constructed through ongoing social interaction. Ultimately, it is teachers who must understand and implement what the CCSSM is asking them to do since their understanding at the end of the policy transmission line determines what and how standards will be delivered to students (McLaughlin, 1987). Therefore, the understanding of the CCSSM by individual elementary generalist mathematics teachers will be the unit of analysis. A second unit of analysis could be the shared understanding of a group of elementary generalists.

The CCSSM are only a few years old and little is known about what and how elementary generalist mathematics (or any) teachers understand them. This researcher is not aware of any published research on teacher understanding of the CCSSM.
Chapter III: Research Design

Methodology

The research problem for this study is that teachers who are expected to implement reform policy, such as the CCSSM, frequently misunderstand or do not gain a sufficient understanding of the reform even when they put great effort forth to make sense of it (Cohen & Hill, 2000; Firestone et al., 1999; Fullan, 2007; Gross et al., 1971; Hall & Hord, 2006). Moreover, the CCSSM press for large instructional shifts that require deeper and more focused mathematics education. Since elementary generalists teach all subjects they may not be prepared or have the time to understand such a large change. In order to implement reform teachers must first make sense of what it is asking them to do. Little is known about how and what elementary generalists have learned from and about the CCSSM. An understanding of sense-making processes and the ideas teachers construct (understanding and misunderstanding) can help policymakers create reforms that are more easily understood and local districts implement this reform that calls for significant changes to teaching and learning in order to prepare students for college and careers.

Research Question Development

In order to address the research problem the researcher identified the central research question: how do teachers learn from and about the CCSSM and what are their perceptions of what the CCSSM is asking them to do? This central research question includes four sub-questions. Stake (1995) stated that sub-questions to the central research question deal with the major concerns that need to be resolved. These queries are sub-topics to the central question that require study (Creswell, 2007). Sub-questions for this research included:

1. What were teachers’ major beliefs, experiences, and overall orientation to mathematics and mathematics education prior to the CCSSM?
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?

3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?

4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

These sub-questions were developed from the sense-making theoretical framework (Spillane et al., 2002). The first sub-question resulted from the first aspect of the theoretical framework. This states that teachers build their understanding of reform policy on their experiences, attitudes, beliefs, and knowledge (cognitive structures).

The second sub-question was designed to tap into the third aspect of the framework – how a reform message has been represented. A reform message can be represented through language, words, text, and pictures. A message can also be represented in different ways when it is transferred through a chain of school employees (e.g., superintendent, to assistant superintendent, to principal, to assistant principal, to lead teachers, to teachers).

The third research question was built to gain insight into the social networks of teachers or the second aspect of the framework. The second portion of the theoretical framework states that teachers belong to a variety of social contexts or networks. Each group may influence what aspects of a reform policy they notice and understand.

The final research question relates to the interaction of the three elements of the theoretical framework. A teacher’s cognitive framework, social contexts, and the messages from and about the reform messages influence what they notice and understand relative to the reform
message. The findings of these four sub-questions provided understanding on how teachers learn from and about the CCSSM and their perceptions of what the CCSSM is asking them to do.

The most appropriate methodology for this research was instrumental case study extended through multiple cases or collective case study (Stake, 1995, 2000). Collective case study allowed the researcher to investigate teacher understanding of reform policy by exploring three cases (Stake, 2000). Each case was selected because the researcher believed each would represent the issue in a different way. During a collective case study each case is examined in depth, the contexts studied fastidiously, and the activities described in rich detail so that the researcher can learn about the overarching interest (Stake, 2000).

Examining and describing how each third grade teacher and their instructional leaders interacted within their social context during professional development activities related to the CCSSM provided an understanding of how different teachers come to understand what this reform policy is asking each of them to do. This permitted understanding of the issue relative to a larger group of cases. This method represents the stories of three unique teachers’ sense-making and the ideas they each constructed relative to the CCSSM. The researcher believed that this representation would have appeal to teachers and school leaders in 45 states since they must also come to understand the CCSSM.

This case study method is in harmony with this research due to the importance of the context in how teachers make sense of reform. Teacher sense-making is situated within a social context (Spillane et al., 2002). Teachers largely make sense of reform together by making their reform ideas visible to their colleagues and building on others’ thinking. This theory supports the need for studying a sense-making group of grade level teachers situated within their context. Thus, exploring this case will enable understanding of how and what teachers learn from policy.
Qualitative Research

The research questions and this research were best approached through a qualitative case study. The research questions for this study required investigating how a group of teachers within an elementary school interpreted a reform policy message and the ideas they constructed. How humans make sense, misunderstand, and come to understand is a sophisticated process (Bransford et al., 2000). Qualitative research is conducted when such deep understanding of a participant’s construction of reality is needed (Creswell, 2007; Merriam, 1998, 2002).

Merriam (2002) stated that qualitative researchers are concerned with how the social elements of a context influence how people construct reality. The varied meanings that elementary generalists erected relative to the CCSSM were influenced by each teacher’s social context. Qualitative researchers assume that people construct many diverse interpretations or reality that change over a given period of time. Correspondingly, qualitative researchers attempt to determine how participants make interpretations at a given time within a social setting (Merriam, 2002). Qualitative research can also show how the parts of a social phenomenon such as building ideas within varied social contexts of reform policy connect to their overall understanding of a phenomenon (Merriam, 1998).

Finding out about the ideas teachers construct within professional development in a school requires interviewing, observation, and examining activities (Merriam, 1998). These are the methods of data collection common to qualitative research. The data analysis requires sorting through enormous amounts of data to create large patterns within the data called themes that could be used to show how elementary generalists understand and misunderstand aspects of the CCSSM (Creswell, 2007). Qualitative research requires elaborate description through words and pictures to portray the context, participants, and activities such as those of elementary generalists.
(Merriam, 2002). Descriptions are made through the participant’s viewpoint. A write up of a qualitative study should include participant voices and a sophisticated description and statement of the meaning of the problem. The participants’ words should be highlighted to support the study’s findings (Merriam, 1998).

**Research Paradigm**

The research paradigm for this research is constructivism. The foundation of the approach to qualitative research is known as the paradigm (Merriam, 2009). The paradigm or worldview (Creswell, 2007) that relates to these research questions is social constructivism. Maxwell (2009) described a paradigm as the assumptions about how things work and can be understood. Such research that is oriented toward social constructivism recognizes that participants will construct many, diverse meanings of their experiences such as elementary generalists varied ideas on how mathematics should be taught and learned (Merriam, 1998). Thus, the qualitative researcher sought the participant’s ideas that they constructed.

Social constructionism holds that ideas or meanings are usually built collaboratively within communities of practice through discourse, negotiation, and sharing experiences (Lave & Wenger, 1991; Palinscar, 1998; Vygotsky, 1978). A constructivist paradigm requires that research questions be open ended and general (Merriam, 2002). Such questions allow the participant to construct a response that considers their social context without being led toward an answer (Creswell, 2007; Merriam, 2002).

**Responsibilities of the Researcher**

The role of this researcher in this qualitative study with a constructivist paradigm was to allow the participant’s diverse ideas on what the CCSSM means to them to come forward. This required an emphasis on getting data on how participants interacted with one another to gain an
understanding of cultural norms. The qualitative researcher has many other responsibilities during data collection and data analysis.

This investigator recognized that he is the main instrument for collecting and analyzing data (Merriam, 2002). This means the data goes through the researcher rather than through a survey, questionnaire, or a software program. The examiner was placed in the world of the participants in order to understand their context in which a problem exists (Bogdan & Biklen, 1998; Creswell, 2007; Merriam, 2009).

The responsibilities of this researcher within the participants’ setting included gaining permission from the school superintendent to conduct the study within the Euler Schools, making contact with each of the seven participants to request their participation, spending many hours in the field conducting interviews with the participants and observing their professional development, and collecting documents (Creswell, 2007). While in the field the researcher was sensitive to the participant’s time, respected the research site and the participant’s right to anonymity, behaved ethically, established rapport, asked high quality questions and probed deeply, listened attentively, recognized body language, recorded notes about how they went about collecting and analyzing data, and recognized when enough had been observed or discussed (Creswell, 2012; Merriam, 2009; Seidman, 2006).

The researcher responded to cues in the context and shifted between methods of data collection (i.e., interviewing, observing professional development, and collecting documents). The researcher tried to be flexible and adjusted data collection and analysis to changing research conditions (Creswell, 2007). In other words, he was able to withstand the nebulous nature of all phases of qualitative research such as designing the research process, creating research questions, identifying a sample, data collection, and deciding whom to observe (Merriam, 2009).
After data was collected Creswell (2007) stated that qualitative researchers must be prepared to analyze enormous amounts of data collected from interviews, observations and documents. The researcher followed this by: consolidating data into codes, minor themes, major themes; communicating findings with long elaborate descriptions of the meaning participants constructed; and including direct quotes from participants.

Finally, qualitative researchers must be aware of how their own experiences and beliefs can shape interpretation of data. Therefore, the researchers’ positionality and biases and their potential influences on the research were made explicit. This qualitative researcher sought to find out how teachers perceived the CCSSM from their unique perspective (Merriam, 2002).

**Research Tradition**

Instrumental case study extended through multiple cases (i.e., collective case study) is the research tradition for this study because of its ability to investigate the issue of teacher sense-making of a reform policy through multiple, divergent teachers (i.e., cases) (Stake, 2000). Creswell (2007) stated that in a single instrumental case study the researcher focuses on a single issue or concern and identifies a case to portray this issue. Collective case study allowed this researcher to investigate the central issue - how teachers engage in sense-making of the CCSSM and the ideas they construct through multiple cases (third grade teachers) in order to gain a deep understanding of how teachers construct ideas of the reform (Stake, 2000). Each case or teacher was selected because they could each represent the issue in a unique way. The collective case study showed diversity in sense-making since teachers have unique experiences and beliefs relative to mathematics, participate in a variety of social contexts during professional development, and are more or less active in their sense-making. When these three teachers engaged in sense-making together the collective case study approach focused on each teacher’s
level of engagement and discourse style (Spillane et al., 2002). Such a case study required that each case be examined deeply, the contexts studied comprehensively, and the activities described in robust detail so that the reader can learn about the overarching interest (Stake, 2000). The collective case study included the following research steps: creating research questions, data collection and analysis, and interpretation (Stake, 1995),

Case study is appropriate for in depth examination of complex issues such as how and what teachers learn (Stake, 1995). Stake suggested purposive sampling and cautioned case study researchers to lean toward selecting the case that the reader can learn the most from; this is the participant that the researcher can spend the most time with. Opportunity to learn should be a determining factor in sample selection. Hence, the researcher chose three teachers in the same grade level since they often met together during professional development.

Case study data collection included observation of professional development, interviews, document collection, and noting details about context (Stake, 1995). In order to explore the issue of sense-making of the CCSSM the researcher obtained data related to teacher background, professional development, and the history and culture of the school relative to mathematics. Stake (1995) proposed four methods of data analysis: categorical aggregation (development of minor themes), direct interpretation, establishing patterns, and the development of naturalistic generalizations. The researcher, to varying degrees, employed each of these methods during data analysis. Stake also suggested that researchers focus on thick descriptions on what was going on with each case rather than trying to waste precious time and effort making comparisons between cases. The researcher employed robust descriptions of the reality of each case since they are more trustworthy than the researcher’s ideas on how the cases compare (Stake, 2000). This
allows the reader to learn from the case vicariously by reading the rich description of the case (Stake, 2000).

**Case study approaches.** Creswell (2007) identified two different approaches to case study. Stake’s (1995) approach is that case study is not a methodology but a selection of what will be researched within a system. Stake (2005) noted that the case is the defining element for case study research. This case should have explicit boundaries and be a specific, complex functioning entity such as a person or a program (Stake, 2000).

Others such as Yin (2009, 2013) and Merriam (1998, 2009) suggested that case study is a specific research strategy. Yin (2009) explained that researchers should use this method when their research questions ask how or why a social phenomenon works. Case study method is also a good fit for questions that seek deep descriptions of a current social phenomenon in a real world setting where the researcher has little control over behavioral events (Yin, 2013). Yin (2013) noted that the boundary between the issue being studied and the context is not explicit. Finally, Yin (2009) stated that data collection in a case study can include quantitative data, qualitative data, or both. This study included quantitative data on the type and amount of district provided professional development provided to teachers.

Stake’s (1995) instrumental collective case study was chosen over other methods because the central issue of teacher sense-making of reform message needed to be the unit of analysis rather than the case (i.e., the teacher) itself. A collective case study approach allows teacher sense-making of reform and the ideas they construct from it to be explored through different teachers (cases) within varied social contexts (e.g., grade level meetings, whole school professional development, study groups).
Maximum variation sampling. Maximum variation sampling was selected in order to choose a small but highly diverse sample of three elementary generalists. This maximum variation sample demonstrated a wide variety of experiences, beliefs, and perspectives of an issue (Creswell, 2007). Another major factor in the selection of the participants for this study was opportunity to learn. The researcher had access to the participants each day and during weekly professional development sessions. Stake (2000) suggested that a reader can learn more from a typical participant who has been studied deeply than a seemingly more interesting participant that the researcher was only able to gain a small amount of data from. The primary criterion in the sampling process requires asking from whom we can learn the most from (Merriam, 1998). There were also secondary reasons for selecting the sample.

Participants. Qualitative research usually relies on a purposeful sample of participants (Creswell, 2007). Maxwell (2009) noted that the sampling process requires that researchers select the unit of analysis or the sample, the setting for the research, other people to be studied, time frame for the research, and events to be examined. Purposeful sampling is when the researcher identifies the people, settings, and events in order to gain vital information that they can provide that other sources may not be able to (Maxwell, 2009). This study included seven participants (see Table 1).

The researcher identified three potential teacher participants who represented a range of backgrounds, teaching styles, exposure to the policy, and dimensions commonly recognized as important such as years of experience, teacher preparation, age, gender, and racial and ethnic background (Merriam, 1998). Such diversity among participants allowed their three stories to resonate with readers who may be policymakers, school leaders, and teachers of varied backgrounds.
Table 1

Participant Demographics

<table>
<thead>
<tr>
<th>Name (pseudonym)</th>
<th>Gender</th>
<th>Race/Ethnicity</th>
<th>Role</th>
<th>Instructional setting</th>
<th>Professional Experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carl</td>
<td>Male</td>
<td>White</td>
<td>Grade 3 generalist</td>
<td>Inclusion with pull-out services</td>
<td>3 years as a math tutor, in 17th year as an elementary generalist (grades 3 and 4); entire career at Leibniz</td>
</tr>
<tr>
<td>Emmy</td>
<td>Female</td>
<td>White</td>
<td>Grade 3 generalist</td>
<td>Inclusion with pull-out services</td>
<td>6 years as a classroom aide, Leibniz grade 3 generalist for 9 years; Grade 4 generalist in another district for 2 years; in 12th year as an elementary generalist (grades 3 and 4)</td>
</tr>
<tr>
<td>Charlotte</td>
<td>Female</td>
<td>White</td>
<td>Grade 3 generalist</td>
<td>Inclusion with pull-out services</td>
<td>2 years as a P/K/1 teacher, 1 year as Preschool inclusion teacher, 2 years as a reading teacher, 1 year as a special education tutor, 7 years as a special educator, in 12th year as an elementary generalist (grades 3 and 4); 19th year at Leibniz</td>
</tr>
<tr>
<td>Maria</td>
<td>Female</td>
<td>White</td>
<td>K-4 Mathematics coach</td>
<td>Not applicable</td>
<td>13 years teaching 5th and 6th grade mathematics; 2nd year as math coach; 1st year at Leibniz</td>
</tr>
<tr>
<td>Elena</td>
<td>Female</td>
<td>White</td>
<td>Leibniz School Principal</td>
<td>Not applicable</td>
<td>11 years teaching in grades K-6; 8 years as elementary assistant principal, 12th year as an elementary principal; 5th year at Leibniz</td>
</tr>
<tr>
<td>Sophia</td>
<td>Female</td>
<td>White</td>
<td>K-8 Director of teaching and learning</td>
<td>Not applicable</td>
<td>12 years as an elementary generalist (Grades 2, 3, &amp; 4); 2 years as elementary assistant principal; 7 years as an elementary principal; 1st year as a district administrator; 1st year at Euler</td>
</tr>
<tr>
<td>Grace</td>
<td>Female</td>
<td>White</td>
<td>Former grade 3 classroom generalist</td>
<td>Not applicable</td>
<td>35 years as an elementary generalist at Leibniz, member NCTM, reform mathematics professional development provider</td>
</tr>
</tbody>
</table>
The population for this study included the three third grade elementary generalist mathematics teachers at the Leibniz School (pseudonym) in the State (pseudonym). The teachers were identified based on a purposeful, maximal variation sampling (Patton, 2004). A small sample of three teachers in the same grade level was identified rather than choosing teachers from different grade levels since teachers attend district and school professional development in grade level teams.

Each Tuesday teachers were provided with district or school level professional development from 1:45 p.m. to 3:50 p.m. The professional development usually occurred with the faculty together in the school’s media center. This meeting was regularly followed by additional professional development for grade level teams. Studying one grade level meant that the researcher was able to observe all of their professional development participation for the duration of the data collection period (November 7, 2013 through February, 2014). This allowed the greatest opportunity to learn about their sense-making processes, hear how they construct ideas, and experience their context. The three third grade generalists were identified because of their diversity of experience with mathematics education.

Emmy (pseudonym) is a white, female in her 11th year as an elementary generalist. She is a member of the NCTM who has been deeply engaged in learning about the CCSSM through coursework, reading, and school provided professional development. She is recognized by her peers as having strong mathematical pedagogical content knowledge (Shulman, 1986, 1987). Emmy was responsible for convincing the administration to hire a mathematics coach for the school district.

Carl (pseudonym) is a white, male who is in his first year as a third grade teacher. He is in his 17th year as an elementary generalist. Charlotte (pseudonym) is a white, female in her 12th
year as an elementary generalist who is recognized within the Leibniz Elementary School as an exemplary ELA teacher. The Leibniz School had other potential participants.

The Leibniz School has pre-kindergarten through grade four teachers. All of these teachers are generalists except those in grade four. The five fourth grade teachers all teach their students ELA and historically have their students switch classrooms during mathematics, science, and social studies. The P-2 grade levels are true generalists who are all female. Emmy is the most salient potential participant as a result of her deep engagement in mathematics education. Carl is the only male generalist in the school. Charlotte is similar to many of the other generalists in the school in that she is primarily focused on ELA instruction. Thus, Emmy’s mathematics experiences, Carl’s gender, and the desire to maximize observation time with one grade level resulted in the selection of these three third grade teachers.

**Limitations of the sample.** Qualitative investigators often research one setting with a small number of participants with a purposeful sampling method. Hence, they do not usually make claims about generalizing their findings beyond the setting researched (Maxwell, 2009). Generalization of findings relates to external validity. External validity is related to the degree to which the findings of research can be transferred to other situations (Merriam, 2009). Maxwell (2009) suggested that case study findings can transfer to other settings if the phenomenon being studied is universal and it corroborates with other research. Yet, qualitative research such as this study does not allow the type of generalization to populations that probability sampling does.

In this case it is hoped that the findings of this study will transfer to the reader. This researcher attempted to understand in depth how each of the three teachers made sense of a reform message and the ideas they constructed from that sense making process. This sample size of three teachers is too small to generalize to the almost 90% of teachers who are charged with
implementing the CCSSM (Dingman et al., 2013). However, Stake (1978, 1995) noted that readers of research draw upon their experience and knowledge to seek patterns that explain what is going on in their world. When they read the comprehensive and robust descriptions in each of these three cases they may see similarities to their world and use them to understand what has happened or will happen in their world. Stake (2000) described such reading as vicarious learning from the case (naturalistic generalization). The researchers’ account of the phenomenon within the case transfers to the reader and helps the reader construct understanding of the phenomenon (Stake, 2000). Therefore when teachers, administrators, and policymakers read the specific, rich descriptions of teacher sense-making within their social contexts the readers may draw on their experiences with the CCSSM in order to gain a better grasp on how to approach learning about the CCSSM. In order for this research to be meaningful to the reader the researcher did three things.

First, the researcher offered a sufficient account or a robust description of the phenomenon (in Chapter four) so that readers may determine the degree of alignment to their situation. Second, the researcher’s account of each case explained how representative each was relative to the others in order that the reader can relate the findings to their situation. Last, the researcher employed three cases of maximum diversity relative to the issue of interest. Such diversity (through purposeful sampling) among cases permits the findings of the study to be used by readers in diverse contexts (Merriam, 1998).

**The setting.** At the beginning of the planning for this study the researcher considered conducting studies in three other districts that have made significant efforts to help teachers understand the CCSSM. However, the researcher realized that his 4:00 school day finish, long drives from potential sites, and allowance of five professional day absences would not be
sufficient to conduct a high quality case study. Research was not considered in Euler until the spring of 2013 when the district made dramatic personnel changes to improve instruction.

Since the start of 2013, the Euler Public Schools replaced every district level administrator (superintendent, assistant superintendent, business manager, K-8 director of teaching and learning, and director of technology), two of the five school committee members, and the leadership team at its middle school. The district made many of these moves to improve instructional leadership relative to mathematics and ELA. The K-8 director of teaching and learning has a 20 year record of mathematics instructional leadership as an elementary teacher and principal. Finally, the district, for the first time in its history, hired a mathematics coach to assist with the implementation of mathematics professional development. The leadership changes and the addition of the mathematics coach have set the stage for potential teacher learning of the CCSSM.

**Other participants.** Most teachers are learning about the CCSSM from their school’s administrators (EPERC, 2013). These school leaders make sense of the CCSSM and provide their interpretation or a re-representation of the reform to elementary generalists (Spillane et al., 2002). Therefore, it is important to collect data from them to find out their mathematics background and beliefs, gain insight into their process of learning about the CCSSM, and understand the ideas they have constructed relative to the CCSSM. The administrators who provided their ideas on the CCSSM and influenced teacher sense-making included Elena (pseudonym) the Leibniz School principal, Sophia (pseudonym) the K-8 director of teaching and learning, and Maria (pseudonym) the math coach. The researcher added a fourth person through a snowball sampling method (Patton, 2004).
The three generalist participants each stated that their mathematics instruction was profoundly influenced by professional development provided by Grace (pseudonym). Grace is a former NCTM member, Leibniz third grade generalist, and professional development provider of reform mathematics education to elementary teachers across the country.

**Time frame and events.** The Leibniz School third grade generalists were scheduled to participate in 24 professional development sessions from September, 2013 through February, 2014 (see Appendix A) or 44 hours of district provided professional development. The researcher was able to attend all of these sessions allowing him to have full time access to the participants and gain quality data. In between these professional development sessions the researcher conducted interviews and collected documents from the participants.

**Recruitment and Access**

**Institutional Review Board Approval**

Prior to the recruitment and access stage of research the researcher gained approval to conduct this research project from Northeastern University’s Institutional Review Board (IRB) and the Office of Human Subjects’ Research Protection (OHSRP) at Northeastern University. The OHSRP (2010) stated that the researcher’s main responsibility in human participant research is to maintain the rights and well-being of the subjects involved. This requires protecting them from unnecessary risks. Federal statutes require a review of the procedures a potential researcher will employ with human subjects before any research can start. The institutional review board (IRB) at Northeastern University performs these reviews. Therefore, the researcher completed an application for approval for use of human participants in research. Additionally, the researcher submitted a signed assurance from the principal investigator (Northeastern University faculty advisor). The appendix contains recruitment letters (Appendix B), informed consent forms (Appendix C), interview questions (Appendix D), professional development observation forms
(Appendix E), and document analysis forms (Appendix F) that were approved by the IRB and used in this study.

**Access and Recruitment of Leibniz Educators**

A researcher hoping to study teachers and administrators at a school must attain access through the person who has responsibility for the management of the site (Seidman, 2006). This person is the superintendent of the Euler Public Schools, Mr. Isaac (pseudonym). The researcher contacted Mr. Isaac with a recruitment letter (see Appendix B, Figure B.1) as an attachment to an e-mail. Next the researcher met with the superintendent and received his consent to proceed with the research. Mr. Isaac recommended contacting Sophia (the K-8 director of teaching and learning), Elena (the Leibniz School principal), and Maria (the math coach) to gain their permission.

The researcher sent e-mail recruitment messages with the recruitment letter (see Appendix C) as a PDF attachment to Sophia, Elena, and Maria. The researcher made initial visits to each of these people and received their consent to participate in the research. The researcher spoke to Elena about the potential inclusion of the third grade elementary generalists in the research. The principal agreed to their participation. The researcher then sent e-mail recruitment messages with the recruitment letter attached as a PDF to the three generalists who agreed to participate. Later, the researcher tried to recruit Ada (a professional development provider) through e-mail.

The researcher followed Seidman’s (2006) recommendations for these initial contact visits. The initial visit helped establish a foundation for a quality relationship for the interviews that followed (Seidman, 2006). This personal visit showed the participants that he was taking them seriously by taking an extra trip to explain the research project. During the initial visit the
researcher explained the research in a concise, purposeful, respectful, friendly, and professional manner (Seidman, 2006, p. 47). The contact visit at the school also allowed the researcher to gain an initial understanding of the participant’s work environment, evaluate the participant as a potential candidate, and begin the process of explaining the study (the start of informed consent). During the initial contact the researcher explained that the teacher participants would take part in two one-hour interviews, be observed during professional development in school, and have curriculum materials collected. Sophia, Elena, Maria, and Grace were told that they would participate in one one-hour interview, be observed participating in professional development only when they were scheduled to participate with the three teacher participants, and contribute CCSSM related documents.

During the initial contact visits the researcher developed a list of potential participants that included contact information and optimal dates, times, and locations to conduct interviews. Prior to the start of the first interview with each participant the researcher gave a verbal explanation of the study from the content of the informed consent form.

**Informed Consent**

Prior to the beginning of each initial interview with each participant the participants signed the informed consent form (see Appendix D). The participant’s signature on the informed consent form indicated an agreement to participate in the study, have their quotes published in the final report, and have their rights protected. Informed consent was an ongoing process that required ensuring that each participant had a full understanding of the research and their role within it prior to an agreement to participate (Kvale & Brinkmann, 2009; OHSRP, 2010).
During the informed consent process participants learned about the purpose of the research, the potential risks and benefits, as well as the main parts of its design in order to determine if they wanted to engage in the study (Kvale & Brinkmann, 2009; Seidman, 2006).

The consent form included Seidman (2006) and Kvale and Brinkmann’s (2009) recommended elements of an informed consent form: a request for participation, the purpose of the research, how long participation will last, the process of participation, the risks of participation, a request for permission to use the interviewee’s statements, the rights of participants, the benefits of participation, the steps that will be taken to ensure anonymity and confidentiality of the participant’s identity, the researcher’s right to publish the whole interview or portions of it, how results will be reported, and the contact information for the IRB and researcher in the event the participant has a question. The consent form was checked to make sure it was written at an eighth grade reading level (OHSRP, 2010).

During the last portion of the informed consent process the researcher alerted each participant to the fact that research and the process of gaining informed consent can be subject to (unannounced) audits from a variety of organizations (e.g., National Institutes of Health, Office for Human Research Protections) in order to ensure that the researcher is following agreed upon human protection protocols (OHSRP, 2010).

After the signings the researcher provided the participants with the study’s interview protocols (without the probes listed) so they could be better prepared to provide quality data during interviews. During the interview phase of data collection the researcher contacted the IRB in order to ask permission to add another participant (Grace) during the data collection phase of the research. The researcher also discussed confidentiality with the participants.
Confidentiality. In order to maintain confidentiality the researcher employed the least identification possible during transcription and the write up of findings. Additionally, the investigator let the participants know that he would do all of the interviewing and subsequent transcription. The researcher told the participants that the principal investigator (Northeastern University faculty advisor) would also know their identities. They were also informed that their identities would be represented during data collection, analysis, and in the final report with a pseudonym. Last, the researcher informed each participant that their words (connected to a pseudonym) would be published in the published report of the research. The researcher and the participants also discussed incentives.

Incentives. The participants were not offered compensation in exchange for their participation. The investigator made every effort to minimize the use of their time. The written report of this research was provided to the superintendent and executive summaries were provided to the seven participants. It is the researcher’s hope that the findings can offer insight into how educators in the Euler School District shaped policy through a process of social sense-making within their professional communities. The study may also inform educators on how to improve professional development related to teacher understanding of curricula.

Ethics. Throughout this project the researcher attempted to achieve and maintain the protection of human subjects. This effort required attention to ethical issues, IRB approval and informed consent, as well as confidentiality. Kvale and Brinkmann (2009) stated that ethical issues in interview research come up as a result of researching private lives and reporting them publicly. They noted that researchers should demonstrate awareness of issues that could keep them from protecting human subjects. Throughout data collection the researcher recognized that he was a guest in the private spaces of the study’s participants. The researcher demonstrated
good manners, respect, ethical behavior, and appreciation for the participants’ time and space (Stake, 2000).

**Data Collection**

The overarching actions of the researcher relative to data collection were “enquiring” (asking educators about their experiences and ideas), “experiencing” (observing educators engaging in sense-making), and “examining” (documents) in order to gain a holistic understanding of sense-making and the ideas each teacher has constructed (Wolcott, 1992, p. 19). Data collection relied on all three sources because no single source could provide all the data needed to understand the research questions. Additionally, data collection was interactive and inseparable from data analysis (Merriam, 2009). For example, the investigator often saw something he did not understand during a professional development session and asked about it during interviews with the elementary generalists. The researcher also found evidence of teacher understanding of the CCSSM within a document (lesson plan) that was corroborated during an interview. Thus, the researcher went back and forth between collection and data analysis while enquiring, experiencing, and examining (Wolcott, 1992).

The data for this collective case study was collected through semi-structured interviews, observations, and documents. The data collection took place from November 7, 2013 through March 14, 2014. The data collection activities included semi-structured interviews, professional development observation, document collection, and audio-visual materials (see Table 2).

**Interviews**

The purpose of collecting data through interviewing participants was to acquire data that helped the researcher understand the research questions (Merriam, 2009). Interviewing can be used as a data collection when phenomena cannot be observed (Merriam, 1998).
Table 2

Overview of Data Collected

<table>
<thead>
<tr>
<th>Source</th>
<th>Interviews</th>
<th>Observation of participation in Leibniz Professional Development sessions</th>
<th>Documents</th>
<th>Audio-visual materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carl: Third Grade Generalist</td>
<td>Two (two hours total)</td>
<td>Yes (Table B.1)</td>
<td>Yes (Table H.5)</td>
<td>No</td>
</tr>
<tr>
<td>Emmy: Third Grade Generalist</td>
<td>Two (two hours total)</td>
<td>Yes (Table B.1)</td>
<td>Yes (Table H.6)</td>
<td>No</td>
</tr>
<tr>
<td>Charlotte: Third Grade Generalist</td>
<td>Two (two hours total)</td>
<td>Yes (Table B.1)</td>
<td>Yes (Table H.7)</td>
<td>No</td>
</tr>
<tr>
<td>Elena: Leibniz Principal</td>
<td>One (one hour)</td>
<td>Yes (Table B.1)</td>
<td>Yes (Table S.1)</td>
<td>No</td>
</tr>
<tr>
<td>Sophia: K-8 Director of Teaching and Learning</td>
<td>One (one hour)</td>
<td>Yes (Table B.1)</td>
<td>Yes (Table R.1)</td>
<td>No</td>
</tr>
<tr>
<td>Maria: Math Coach</td>
<td>One (one hour)</td>
<td>Yes (Table B.1)</td>
<td>Yes (Table Q.1)</td>
<td>Yes (Table P.1)</td>
</tr>
<tr>
<td>Grace: Former Leibniz Third Grade Generalist</td>
<td>One (twenty minutes)</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Leibniz Elementary School</td>
<td>No</td>
<td>Yes (Table B.1)</td>
<td>Yes (Tables H.3, M.1, O.1, T.1)</td>
<td>No</td>
</tr>
<tr>
<td>Euler School District</td>
<td>Yes (see above)</td>
<td>Yes (Table H.2)</td>
<td>Yes (Table H.3)</td>
<td>No</td>
</tr>
<tr>
<td>State Department of Education (Website)</td>
<td>No</td>
<td>No</td>
<td>Yes (Tables, H.1, K.1, L.1, N.1, N.2)</td>
<td>No</td>
</tr>
<tr>
<td>Ada: Mathematics consultant</td>
<td>No</td>
<td>No</td>
<td>Yes (Table H.8)</td>
<td>Yes (Table H.8)</td>
</tr>
</tbody>
</table>

Note. All of the Tables referred to on this Table can be found in the Appendices.

The interview protocol. The researcher followed Creswell’s (2007) recommendations for interview protocol development (See Appendix E for teacher and administrator interview protocols). He suggested that the interview protocol form should have about five open ended queries and space to record interviewee responses. The questions should be created from the central research question and sub-questions of the study. He also suggested that researchers
begin with a question that gets the interviewee to provide a comprehensive response and end by asking whom to go to for more information or thank the interviewee.

These same set of questions were asked to each teacher. Such uniformity helped ensure standardization and may allow the reader to compare the findings from each case. The first teacher interview related to research sub-question one. It asked teachers about their experiences with mathematics and gathered demographic information. The second interview protocol dealt with sub-questions two through four. The second interview began with general questions (in bold) on how and what they are learning in professional development to more specific questions about the CCSSM. The second portion asked them to explain the specific content of grade three, what it means for a student to understand, each of the SMP, and the overall intent of the CCSSM. Since time would not permit explanations of each of the 26 content standards (and 12 subordinate content standards) the researcher sampled their understanding of the SMC by asking the generalists to interpret 3.NF.A.1. The responses allowed the researcher to determine how well each teacher understands what the CCSSM is asking them what to do.

The interviews with Sophia, Elena, Maria, and Grace (the professional development providers) garnered demographic information, their beliefs and experience with mathematics, the ideas they constructed from and about the CCSSM, and the messages they sent to teachers.

The interview protocol or schedule served as a guide for the researcher (Yin, 2011). There were many times when the interviewee unknowingly provided information to a question that had not been asked. This required the researcher to stray from the order of questions. The interviews took place in locations that were quiet and convenient to each participant. All interviews with teachers occurred in their classrooms. The interviews with the Leibniz principal and math coach took place in their offices. The closed door interview with the K-8 Director of
Teaching and Learning happened in the private reading room of the Leibniz School. The last interview with retired teacher Grace was done over the telephone as a result of her 60 mile distance from the Leibniz School.

**Recording of interviews.** The interviews were recorded with an Olympus WS-801 portable voice recorder with an Olympus ME-15 external microphone. This produced an MP3 file of the interview. The researcher also used the sound recorder on his personal computer as a back-up recording device.

**Starting the interview.** Prior to asking the main questions the researcher made statements about the purpose of the study, the recording process of the interview, the use of pseudonyms to maintain privacy and identity as confidential, the transcription of the recording by the interviewer, and the length of interview (Seidman, 2006). The researcher made collegial pleasantries (i.e., small talk) to establish rapport (King & Horrocks, 2010; Seidman, 2006) during the guided conversation (Rubin & Rubin, 2012). He demonstrated interest in what the participants said along with well-mannered behavior throughout the interview (Seidman, 2006). The interviewer memorized all questions, probes, and prompts prior to each interview in order to promote a conversational flow. Last, the researcher tried to foster high quality participant responses by listening and talking as little as possible after asking questions and demonstrating neutral body language (Seidman, 2006).

**Asking questions.** The questioning during each interview began with a “grand tour” query (Spradley, 1979, p. 50). This question was designed to be broad in nature in order to collect much data with one question; sometimes probes did not need to be used to prompt the participant to discuss desired information.
**Using probes.** The purpose of the probes was to keep easy conversation going and to gain the desired information (Yin, 2011). The researcher added some prompts such as why, tell me more, how did you do that and so forth. There were some slight adaptations to the interview protocol based on data collected from previous questions and interviews, observation, and document collection (Merriam, 2009). The researcher closed each interview by asking the participant to provide any experiences or related meanings or provide relevant information not brought up by the interview schedule.

**Observations**

Observation of professional development provided the researcher with opportunities to see how educators engaged in social sense-making of the CCSSM. Observation of sense-making of the CCSSM during professional development also offered access to the ideas that educators constructed. Teachers made sense of the CCSSM in many social contexts during school delivered professional development (the most prominent context), grade level teams, and informal groups (pairs of teachers from adjoining classrooms). The researcher’s membership as a “native outsider” in the school offered a high level of access to sense-making activities.

**Researcher role.** An investigator in qualitative research can assume many roles during observation of participants (Gold, 1958). The researcher is a member of the school community as a physical education teacher. However, the physical education teacher is not a usual participant in the professional development experiences of elementary generalists. This allowed the researcher to assume the role of a complete observer during professional development. This role was known only to the participants. The researcher was able to attend all professional development sessions and grade level meetings as a complete observer. However, the participants could control their behavior during these activities (Merriam, 2009).
The researcher conducted observations of teachers engaging in 14 professional development sessions on Tuesday afternoons and third grade teacher meetings. He was also able to obtain agendas, minutes, and documents related to the 10 previous professional development sessions that were conducted prior to the beginning of the study on November 7, 2013.

**Field notes.** The researcher took field notes during professional development and grade level meetings. Figure F.1 (Appendix F) shows the field notes form that were used to record notes during professional development observations. The researcher focused his observations on how the teachers and administrators engaged in sense-making of the CCSSM. While observing the researcher was prepared to look for information related to multiple research sub-questions (Creswell, 2007).

He noted the types of messages administrators sent to the teachers on the CCSSM, the method of delivery of the message (e.g., transmission, guided discovery), how teachers engaged in sense-making (e.g., discourse, de-construction of content standards), the depth of engagement in sense-making, the attitudes toward mathematics that were exhibited, how educators interacted, and the ideas they constructed. The researcher also noted his behavior in order to consider how it influenced the behavior of the participants.

The observation required shifting attention back and forth between teachers and administrators. The research focused some attention on how the administrators and professional development providers delivered messages to the teachers and the content of those messages. Simultaneously, observation emphasis was given to the process and product of teacher sense-making of mathematical ideas. This observer looked for reform mathematics language such as
procedural fluency, conceptual understanding, and mathematical discourse. The observation of professional development provided many opportunities to collect documents.

**Document Collection**

Documents provided another source of data for the researcher to discover meaning and gain a deeper understanding of the research problem (Merriam, 2009). As a member of the Leibniz School the researcher had direct access to documents developed during professional development sessions (e.g., PowerPoint presentations, ideas represented on chart paper, graphics) as well as other documents such as figures, pictures, videos, memos, and web pages (See Figure G1 in Appendix G for document analysis form).

The documents collected for this research included artifacts created by the State, the Euler School District, the Leibniz School, administrators, the math coach, professional development providers, and the three generalists (see Appendix H). Most of the documents were based on their membership within three groups: documents with ideas that re-represented the CCSSM and were sent to teachers by professional development providers (e.g., figures, handouts), primary sources of the CCSSM (documents produced by the authors of the CCSSM), and documents that contain ideas that teachers have constructed from these first two sources.

**Data Storage**

The data storage plan helped the researcher assemble, store, monitor, retrieve, and use all of the files associated with this project (Miles & Huberman, 1994). These files included audio recordings of interviews, transcripts, noted and coded transcripts, contact information, signed consent forms, field notes, and documents. A system of managing files is important since it can foster retrieval of documents, safe keeping, and study replication (Miles & Huberman, 1994). Table I.1 (Appendix I) provides an index of all the files associated with this project as well as
storage locations, and the relationship of files to each other. The files were digital and paper-based.

**Storage of Digital Data**

All digital data were stored on the researcher’s password protected personal laptop in electronic folders within a superordinate folder titled NURES. All digital files were created with Microsoft Word and replicated with PDF copies. The researcher created backups (printed copies of files) of all master data sources and files in case of loss, damage, accidental erasure, or theft (Corti, 2008; Richards, 2009). A backup copy of each digital file was stored on a flash drive kept in a locked, steel file cabinet within the researcher’s locked, brick and steel constructed school office at the Leibniz School.

**Storage of Physical Data**

Corti (2008) stated that storage decisions related to paper-based files should recognize: lighting, temperature and humidity control; risks of flood, fire, pollutants, and theft; using a structurally sound building; and who could gain access to files. A copy of each digital file was printed and stored within a three ring binder in the researcher’s locked file cabinet of his locked school office.

**Data Storage and Confidentiality**

The investigator promoted confidentiality with careful storage of files containing participants’ identities. All files refer to the participants, town, school district, and school with pseudonyms. The only documents that contained the participants’ identities were the signed consent forms which remain in the researcher’s locked file cabinet.
Data Destruction

The audio recordings of interviews and all files containing information related to identities were deleted and or destroyed after completion of data analysis (except for the signed consent forms). The signed consent forms will be kept for three years in the researcher’s file cabinet within his locked office.

Data Analysis

The researcher analyzed the interview transcripts, field notes, audio-visual materials, and documents to answer the central research question - How teachers learn from and about the CCSSM and their perceptions of what the CCSSM is asking them to do? and the four sub-questions listed below.

1. What were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM?
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?
3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?
4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

In order to respond to these questions the researcher engaged in a process of thematic development (Creswell, 2012) described below. These themes formed the basis for the final report of the three cases.

In qualitative data analysis the researcher tries to understand the data (Stake, 1995, 2000). Such a process requires merging, reducing, and a decoding of data (Merriam, 1998). During data
The researcher used the constant comparative method to conduct data analysis (Glaser & Strauss, 1967/1973). The data from interviews, field notes, and documents were compared within and between interview transcripts, field notes, and documents. The researcher also looked to the literature review and the theoretical framework to make sense of data and the relationships between them. These comparisons resulted in minor themes for each research question (Creswell, 2012). These minor themes were compared to each other repeatedly until major themes emerged to answer the overarching research question.

Data Analysis and Case Study

Stake (1995) remarked that data analysis is about a search for meaning by looking for patterns, consistency within settings, and correspondence. The researcher found meaning in a single word or sentence and in several pieces of data scattered through interview transcripts, field notes, and documents. However, meaning was usually discovered from seeing something repeatedly in the data. Stake (1995) suggested four types of data analysis that the researcher employed. These methods included categorical aggregation, direct interpretation, establishing patterns, and developing naturalistic generalizations.

Categorical aggregation (developing minor themes) relates to looking for instances of a phenomena repeating in the data (Creswell, 2012; Stake, 1995). When repeated instances were found the researcher identified them. Direct interpretation recognizes that sometimes important things might only occur through single instances within the data. In order to do this the research
made sense of remote instances through prolonged engagement and study of the data. The researcher sometimes did this by taking datum apart and putting it back together. Stake noted that investigators can rely on both of these methods. The investigator also developed patterns by looking for correspondence between minor themes. Last, the researcher attempted to use naturalistic generalizations. These may result from readers feeling as if they are experiencing a given phenomenon as a result of the researcher’s robust reporting of findings. When data analysis and the corresponding final report are done well readers may be able to establish a relationship with the text that makes them feel close to it which in turn creates a learning experience for readers (Stake, 1995).

Creating a vicarious experience that allows the reader to understand how teachers are learning about the CCSSM and what they have learned should arise from data analysis (Stake, 1995). The central goal of data analysis in this case study was to understand the central phenomenon (how and what a given elementary generalist understands relative to the CCSSM) within each case (Stake, 1995). The researcher tried to understand the behavior, issues, and settings that surrounded each case. This data analysis process began when data collection started. The data collection process began with interviews.

**Transcription**

The transcription of the interview by the researcher was the first step in data analysis; this process helped the researcher gain an initial understanding of the data (King & Horrocks, 2010; Kvale & Brinkmann, 2009). The researcher created interview transcript templates that followed Merriam (2009) and Rubin and Rubin’s (2012) formatting guidelines (Figure J.1 Appendix J). All interviews were transcribed by the researcher and given to each interviewee for review and feedback on the day following the interview (Kvale & Brinkmann, 2009).
The researcher conducted word-for-word transcriptions while noting voice tone, intonations, false starts, pauses, laughter, and significant body language (Kvale & Brinkmann, 2009; Rubin & Rubin, 2012). The researcher and participants reviewed the text for errors and made corrections when necessary. The researcher also examined the document for words that could identify the participants in order to maintain confidentiality. The next step in the data analysis of the interviews was coding.

**Coding Data**

The researcher began the process of interpreting the data to discover meaning through a process of coding. All interview, field notes, and documents were subjected to coding. Coding was done by highlighting and labeling of segments of data with a word or brief phrase to create descriptions of data (Creswell, 2012). The coding of all data was an emergent, bottom up, and inductive process (Creswell, 2007, 2012; Thomas, 2006). The researcher looked manually to the data to discover codes.

This process was initiated by a deep reading of the transcripts that allowed the researcher to become immersed in their content (Creswell, 2012). Throughout the coding the researcher asked the data questions such as: What does this text segment mean? And how does this segment contribute or not contribute to understanding the major beliefs and experiences of teachers relative to mathematics, the content of the CCSSM messages presented to teachers, how and with whom teachers have engaged in making sense of the CCSSM, the ideas teachers constructed relative to the CCSSM and what ideas that were hard to comprehend? In other words, the researcher asked of the data: what do you have to tell me that answers my research questions (Creswell, 2012).
Each line of field note data, documents, and interviewee’s responses on transcripts were examined and noteworthy elements were assigned a word or brief phrase that summarized the meaning of that portion of data (Boeije, 2002; Saldaña, 2009; Suter, 2012). During the process of initial coding the investigator evaluated the corpus of data for bits of data that showed similarity, difference, frequency, relationships, and causation (Saldaña, 2009, p. 6).

**Memos.** Throughout coding the researcher wrote memos. Memo writing is a data analysis strategy where a researcher documents personal thoughts related to the assignment of meaning to segments of text, and the development of minor and major themes and their relationships (Creswell, 2012; Grbich, 2007). Memos with the date they were written were used to record hunches and thoughts on what is going on with the data relative to the research questions, and the relationships between bits of data, and minor and major themes (Creswell, 2012; Merriam, 1998).

**In vivo codes.** During the entire data analysis process the researcher tried to look for quotes or in vivo codes (Saldaña, 2009) that represented major ideas from the data corpus (Kvale & Brinkmann, 2009). Quotes were used in the write up of the report to represent and support minor and major themes within findings (Creswell, 2012; Thomas, 2006). The codes from interview transcripts, field notes, and documents were merged or consolidated to create minor themes to answer the research sub-questions (Creswell, 2012).

**Minor Theme Development**

The researcher developed minor themes for each research sub-question. While codes are labels that describe portions of data, minor themes are abstractions generated from data (Creswell, 2012; Merriam, 1998). The minor themes for this research were developed according to Merriam’s (2009) recommendations. Merriam (2009) noted that minor themes (categories)
should be responsive, exhaustive, mutually exclusive, sensitive to data, and conceptually congruent. Responsiveness relates to the degree to which the category responds accurately to the research questions. Minor themes that are exhaustive are those where all the related data match to one category or subcategory. A mutually exclusive minor theme includes only relevant data and not those that could belong to another minor theme. Minor theme sensitivity corresponds to the minor theme title being a fine representation of the data that fits within it. Last, conceptually congruent minor theme titles should all represent concepts on the same level of abstraction.

Constant comparison was also used to develop minor themes (Glaser & Strauss, 1967/1973).

Constant comparison is a process of generating minor themes from a continuing review of data that progresses from examining specific pieces of data to developing minor themes that indicate data by comparing codes to codes, minor themes to codes, and minor themes to other minor themes to find recurring and significant ideas (Creswell, 2007, 2012). During constant comparison there will be ongoing checking to see which pieces of the puzzle (e.g., bits of data, ideas, and concepts) overlap and fit within a potential minor theme and which did not fit to form a coherent network among codes, minor themes, and concepts (Creswell, 2012; Miles & Huberman, 1994; Saldaña, 2009). The process of minor theme development continued until no more minor themes could be discovered (i.e., saturation) (Miles & Huberman, 1994).

**Minor Theme Aggregation**

The researcher developed the minor themes into major themes that spanned the entire data set (Creswell, 2012; Merriam, 1998). This entailed a process of integrating and refining minor themes, properties, and memos in order to interpret the meaning of data. Here, the researcher thought more abstractly, took a big picture view, and inferred what the data were saying relative to the central research question (Merriam, 2009).
Major themes (usually five to seven) emerged from deep, comprehensive reflection on the minor themes (Creswell, 2012). These themes summarized, showed meaning, and offered relationships among data (Creswell, 2012; Rubin & Rubin, 2012; Saldaña, 2009). Major themes are superordinate categories connected to subordinate minor themes and are usually written in two to four words (Creswell, 2012; Grbich, 2007). In developing the major themes the researcher constantly moved back and forth among interviewee quotes, codes, memos, the sense-making theoretical framework, the literature base, and minor themes (Creswell, 2012; Glaser & Strauss, 1967/1973). These actions continued until there was a saturation point where all of the minor themes related to a larger major theme.

**Write Up of Data Analysis**

The writing of the final report for this project told three stories on how each teacher made sense of the CCSSM and the ideas they constructed from this reform message. The write up of each case contained minor themes related to each research sub-question and the overarching major themes developed from the minor themes. These superordinate themes answered the central research question

**Trustworthiness**

In order for readers to trust research it must create valid and reliable knowledge for the reader (Merriam, 2009). Qualitative research should make the reader feel assured that proper methodological procedures have been followed. Trustworthy case study research should also provide a rich enough description of events in such detail that the researcher’s conclusions make sense to the reader (Merriam, 1998). Further, this research project followed Merriam’s (1998) recommendations relative to internal validity, external validity, and reliability.
Promotion of Internal Validity

Internal validity is concerned with how the findings of research align with reality and findings and telling the truth about events (Merriam, 1998). The researcher promoted internal validity through member checking, spending a large amount of time in the research setting, clarifying biases, and data triangulation.

Member checking was performed by bringing observations, interview transcripts, findings, conclusions and interpretations of the data to the people that provided the data and inquiring on the veracity of and comments (e.g., is the information offensive, correct, more or less complex) on those findings (Stake, 2010). This was done on an ongoing basis. Upon completion of findings they were brought to each participant for their review, feedback, and guidance.

The researcher was in the field every day for about five months observing and speaking with participants. This prolonged stay within the field promoted a greater match between the reality of each case and the researcher’s interpretations. The researcher’s deep knowledge of the research setting and its inhabitants could be also be considered a validity threat.

While conducting data analysis the researcher collected and analyzed data through a personal lens of views, beliefs, conceptions, and assumptions. As stated earlier, the researcher is a member of the community and as such could have feelings about the participants that could influence interpretations of data. Thus, the researcher promoted the alignment of findings with reality by identifying his assumptions, worldview, and biases in the positionality statement in chapter one.

Last, the researcher promoted internal validity through the use of data triangulation where multiple sources of data where used to support findings (Denzin, 2009). The researcher
validated potential findings by looking within each type of data (i.e., interview transcripts, audiovisual files, documents, and observation notes of professional development) in order to find information that would confirm or disconfirm conclusions. For example, the researcher did not find evidence in any interview transcript, observation notes of professional development, document, or audiovisual file that indicated third grade teachers had received district provided professional development related to the CCSSM prior to the 2013-2014 school year.

**Promotion of External Validity**

External validity relates to the degree to which findings of research can be transferred to other settings. In other words, what the reader understands from one case can be generalized to comparable situations (Merriam, 1998). A central goal of this case study research was to identify cases that allow the reader to gain a deeper grasp of the issue of teacher understanding of the CCSSM and not to survey a population. Such an understanding on behalf of the reader was enhanced as a result of the researcher studying teachers with unique orientations to the CCSSM. The researcher aimed to describe each case in great detail so that the readers may see similarities to their situations. This relates to Stake’s (1978, 1995) notion of naturalistic generalization. Readers draw upon their understanding and experience and recognize similar situations in different settings. Thus, the reader experiences the phenomena being studied due to the detailed and robust descriptions of research settings (Stake, 2000).

**Promotion of Reliability**

Reliability refers to the degree to which findings can be reproduced (Merriam, 1998). Gaining reliability in qualitative research is difficult due to the variability of the interviewee’s memory as well as the multiple realities and interpretations participants assign to common events. Instead of focusing on reliability qualitative investigators should be concerned with
research dependability or whether findings are in harmony with the data collected (Merriam, 1998). In order to promote dependability (i.e., reliability) the researcher explained his beliefs about the study, positions about the teachers being studied, how the participants were identified (and a description of each), and the social setting from which the participants were drawn. In addition to fostering internal validity, triangulation of data sources promoted dependability in the results of the study. Finally, the description of how this research was conducted within this methodology chapter may be used as an audit trail to build the reader’s trust in the research (Merriam, 2009; Richards, 2009).

**Summary of Research Methodology**

This chapter provided details on the methodology (research design) for this instrumental case study. It provided the reader with an explanation of how data was collected, analyzed, and stored. It also included an account of how human subjects were protected as well as the trustworthiness of the research.

**Conclusion**

Teacher learning is of fundamental importance to the success of any reform policy (Jennings, 1996). The CCSSM is perhaps the largest and most important mathematics reform in our nation’s history. However, the CCSSM is ambiguous, abstract and difficult to understand. The interpretive duty of the CCSSM may be the most challenging for elementary generalists who are also trying to understand the CCSSELA and a new teacher evaluation system. Further, elementary generalists often have a limited preparation in mathematics education which can also constrain sense-making. Student learning in mathematics is of major importance at the elementary level since all future learning is built on this foundation. This case study that shows how generalists related to the CCSSM, how they engaged with it, and the ideas they constructed
may inform professional development practice, mathematics education, and policy writing. Little is known about how and what teachers are learning about this reform.

This project will fill a void in the education reform literature. The literature base on teacher interpretation of education reform policy is under researched (Marz & Kelchtermans, 2013; Spillane et al., 2006). There is a dearth of research on how elementary teachers make sense of mathematics reforms. Haug (1999) looked at mathematics reform interpretation from the district viewpoints. Lloyd (1999) and Marz and Kelchtermans (2013) investigated high school teachers’ interpretation of reform mathematics. Finally, Cohen (1990) focused on the implementation of elementary mathematics reform. Remillard and Bryans (2004) explored how a reform curriculum supported elementary teachers’ learning. Finally, all of the research on the issue of teacher sense-making has been case study research.

Understanding of sense-making is a complex process that requires examination from a variety of ways that only a case study can allow. Instrumental case study research was employed to allow readers to understand the issues of: how teachers of varied orientations to the CCSSM learned different aspects about the reform in varied professional development contexts, the messages teachers received from and about the CCSSM, and the ideas they constructed from them. Studying how these issues play out among three teacher cases and writing up the results in a robust and comprehensive description may help readers experience their stories. This experience will permit the transfer of findings to many readers who are teachers, school leaders, and policymakers. Such transfer may inform improved local implementation, professional development, and policymaking.
Chapter IV: Report of the Findings

The researcher explored a central question - how three third grade generalists at the Leibniz School learned from and about the CCSSM and their perceptions of what the CCSSM is asking them to do. This central question included four sub-questions. The answers to the sub-questions informed the central question. Sub-questions for this research included:

1. What were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM?
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?
3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?
4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

This chapter begins with a description of the research context. This description contains an illumination of the State, Euler School District, and Leibniz School contexts and the administrative personnel that made sense of the CCSSM and sent related messages to the three third grade generalists. This is followed by the findings for each research sub-question and the major themes for the central question.

The sense-making theoretical framework suggested that teacher sense-making occurs within the varied social contexts of which teachers are members (Spillane et al., 2002). These contexts or teacher settings influenced what teachers noticed, how they made sense of a policy, and what they came to understand. The three elementary generalists in this study made sense of the CCSSM inside the Leibniz School in the Euler School District within the State. Each of
these contextual spheres of influence offered unique professional development resources, support, time, and representations of the policy. The data that informed the findings for these context descriptions included interviews with all participants; observation of professional development sessions; and documents collected (see Appendix H) from the State, the Town of Euler (website), the Leibniz School, and the participants.

The State Context

The state has implemented reform mathematics curriculum frameworks as the basis for K-12 instruction since 1996. That year the State put forth its first reform mathematics curriculum framework based upon the content standards of the NCTM (1989, 2000). Carl, Emmy, and Charlotte have each planned and taught with these reform mathematics curricula for their entire careers as generalists. The 2000 revision and its 2004 supplement introduced more specific reform mathematics content standards. The State adopted the CCSSM in 2010 and released its version of the CCSSM in March of 2011. The State took advantage of the option provided by the U. S. Department of Education to add 15% more content standards to the CCSSM (Kober & Rentner, 2011, p. 4). Thus, the state’s 2011 reform mathematics curriculum framework combined the CCSSM with unique state mathematics standards. These new content standards (SMC) are similar to the 2000/2004 standards (See Table 3).

Table 3

| Comparison of State’s Third grade Standards to CCSSM Third Grade Standards |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| State grade 3 Standards that match grade 3 CCSSM standards | State grade 3 Standards that match CCSSM standards in higher grade levels | State grade 3 Standards that match CCSSM standards in lower grade levels | State grade 3 standards that do not match any CCSSM standard |
| 25 | 5 | 2 | 1 |

Source: State comparison of 2000/2004 mathematics curriculum framework to the CCSSM from State Department of Education
However, the representation of the third grade SMC and SMP are identical to the CCSSM. The state adopted this combined curriculum framework in December, 2010. Full implementation of the CCSSM in the State began in 2012-2013. In order to promote teacher understanding of the CCSSM the State offered teachers courses and provided documents such as previous curriculum frameworks, comparisons of the CCSSM to these frameworks, unit and lesson plans, student work samples, progressions of content, and external links (see Appendix K).

The Euler School District Context

The Euler School District is in the suburban town of Euler, about 25 miles south of the State’s capital with a population of approximately 14,000. There are about 2,600 students in the Euler Public Schools. The Euler School District student population is about 96% white. Sixteen percent of its students are on individualized education programs, 8% have been identified as low income (receive free or reduced lunch), and 1% are English language learners. About 98% of students in each grade level cohort graduate in four years and 89% of these participate in two or four year postsecondary education (see Appendix L race/ethnicity information on the students of Leibniz, Euler, and the State).

The response of the Euler School District to the CCSSM has done little to support teacher understanding of the CCSSM. The Euler School district became involved with the CCSSM in 2011 when the administration identified the need for a Common Core implementation plan in the spring. However, this plan was never created. Carl, Emmy, and Charlotte did not experience district or school provided professional development related to mathematics during the 2010-2011 and 2011-2012 school years. In November, 2013 the Leibniz principal, Elena, described the professional development offered during this time period as “flavor of the month” teacher
learning related to educational fads. She also noted that the district and the Leibniz School have
done a poor job of providing professional development in mathematics.

Nine months after the State released the CCSSM document to school districts in March,
2011 the Euler School District handed out the State’s adaption of the CCSSM in the form of a
bound paper copy in December, 2011 (known by the Leibniz teachers as the blue book). In
February 2014, Maria the math coach stated that some elementary teachers told her they have
never opened their blue books. Further, the district neither promoted nor used any of the
resources (Appendix K) provided by the State to foster understanding of the CCSSM.

The Euler School District did respond to the accountability pressures of the CCSSM.
During the 2012-2013 school year the State’s high-stakes test began to measure students’ (in
grades three through 10) achievement relative to the CCSSM. Throughout the summer of 2012
Euler elementary teachers created benchmark assessments for students in first through fourth
grade. In grade three these tests are used twice during each of the four academic terms to
measure and evaluate student performance to determine if the test takers are making adequate
progress toward achieving grade level performance standards on the State’s high-stakes test. The
benchmark test items were designed to replicate the State’s high stakes test items. The Leibniz
principal Elena noted that one of her major roles relative to mathematics education was to make
sure that test data is collected and used to drive instruction. The 2012-2013 year also began a
series of changes to Euler’s administration.

The district administration turnover did not support teacher learning and understanding of
the CCSSM. During the school year in the fall of 2012 the instructional leader of the Euler
School District, the Euler superintendent, retired from the district and was replaced by an interim
superintendent for the remainder of the 2012-2013 school year. During this school year Carl,
Emmy, and Charlotte did not experience any district provided professional development related to the CCSSM. In July, 2013 the assistant superintendent resigned and Mr. Isaac (pseudonym) was hired as the new superintendent. He brought in Sophia (pseudonym) later that month as the new K-8 Director of Teaching and Learning (described as an assistant superintendent by Elena, the Leibniz School principal).

**Sophia**

Sophia is in her 10\textsuperscript{th} year as a school administrator and first year as a district administrator in the Euler School District. Sophia’s experience, attitudes, beliefs, and knowledge relative to mathematics are oriented toward the reform mathematics within the CCSSM. Sophia experienced textbook-driven learning from arithmetic to calculus in K-12 mathematics, a traditional teacher preparation focused on ELA, and taught mathematics in grades two to four for 12 years. Sophia taught reform mathematics with *Everyday Math* (Bell & University of Chicago, 1998) by using manipulatives, encouraging students to move from concrete to abstract thinking, having learners draw and illustrate problems, and assigning number sentences. Sophia values working on a team of teachers in a learning community and believes in mathematics education as a place for student exploration, interaction, inquiry, and problem solving.

Sophia’s beliefs and experiences as an administrator represent a commitment to teacher learning of reform mathematics. Sophia was an elementary assistant principal and principal for eight years prior to assuming her district administration position at Euler. She is also a member of NCTM and several networks of school administrators. She believes professional development related to the CCSSM is a high level need for elementary teachers and that teachers should learn within their community of practice.
Sophia described the CCSSM as a curriculum framework that means deeper learning for students. She stated that the SMP are not a new approach to problem solving that Euler teachers are using. She went on to state that they should be applied in many lessons at every grade level. Sophia (along with Elena the Leibniz principal) designated Maria the math coach to provide teachers with instruction on the SMP. Sophia believed the SMP could be displayed in classrooms with bulleted posters.

As a new administrator to Euler Sophia is trying to determine what CCSSM resources teachers are using and how she can support CCSSM implementation. Sophia’s actions relative to mathematics have included creating a district professional development plan for 2014-2015, overseeing instruction, monitoring student achievement, and collaborating on the Vision 2020 initiative.

In the fall of 2013 Euler began the Vision 2020 initiative to determine what resources teachers were using to implement the CCSSM and to identify and adopt an instructional resource (mathematics program or textbook) aligned with the CCSSM at the elementary, middle, and high schools in September, 2015. This initiative began with a survey that found mathematics educators are using many resources to teach to the CCSSM. These include *Math Expressions* (Fuson & CMWRP, 2006a, 2006b, 2011), *On Core Mathematics* (Houghton, Mifflin, & Harcourt, 2012), internet resources, and varied teacher lesson plans. The survey also revealed that 54% (35 of 65) of K-12 mathematics teachers stated that they do not feel they understand and can implement the CCSSM. One survey respondent identified the difficulties associated with the lack of time available for interpreting and implementing the CCSSM by stating, "The process is overwhelming. Math is not the only subject most of the teachers teach and, therefore, our focus cannot be solely devoted to math, yet the expectation is that we
are devoting 100% of our time on this subject. There is not enough time in the day to properly prepare for any planning/lessons as most of our prep time is used for meetings with parents and other various meeting.

Sophia’s role in promoting professional development and the messages she has provided to elementary teachers have included promoting the benchmark assessments and test data collection efforts in the elementary schools, recommending interactive learning experiences led by Euler teachers, and endorsing courses in mathematics content at a local city university.

**The Leibniz School Context**

The Leibniz School culture is not as supportive to mathematics learning as it is to ELA education. This is evidenced by the school’s physical resources and staffing, instructional time, curriculum materials, professional development, and test scores.

In the non-Title I, Leibniz School there are about 400 students and 37 teachers who are highly qualified to teach their respective subject areas. The Leibniz School was described as an ELA focused school by Emmy, Maria, Carl, and Charlotte. The corridors outside the school’s 30 classrooms were devoted to student work samples from ELA (except outside Emmy’s classroom where mathematics student work was found). Further, the physical resources for mathematics are limited. The school has four storage rooms for instructional resources; the largest of which (the reading room behind the teachers’ workroom) contains only ELA resources. The remaining rooms have a total of five four-foot shelves holding mathematics textbooks and manipulatives.

The staffing of the Leibniz School is more supportive of ELA education than of mathematics education. None of the school’s 37 full-time licensed teachers specialize in mathematics. Five staff members are focused only on reading and language. The staff includes 19 generalists, four specialists (e.g., art, music, PE, information technology), seven special
education teachers, two reading teachers, two speech and language therapists, a speech and language focused special educator, an occupational therapist, and a physical therapist. The part-time math coach, Maria, is shared among Euler’s three elementary school buildings. Maria was hired to work three days per week in the Euler Schools to support mathematics education. She is at Leibniz one day per week (usually on Monday). Thus, Maria is only able to assist Leibniz mathematics teachers 34 (of the scheduled Mondays on the Euler school calendar) out of 180 school days or 19% of the school year.

The instructional time allotted is more supportive of ELA than mathematics. Hence, teachers spend more time engaging in learning the CCSSELA, planning lessons for ELA, and providing instruction in ELA than they do for mathematics. Mathematics instructional time at the Leibniz School is scheduled for less than the NCTM (2006b) recommended one hour per day in first and fourth grades (see Appendix M). Third grade teachers are scheduled to provide 45 more minutes of ELA instruction than mathematics instruction. Maria (the math coach) noted that these grade level totals do not reflect the actual amount of mathematics instructional time. She remarked that interruptions and transitions bring the totals down by several minutes at all grade levels.

The mathematics instructional resources are not congruent with the CCSSM. Three years after the release of the CCSSM in the State the Leibniz mathematics curriculum is not aligned to the CCSSM. The Leibniz teachers are in their 8th year using Math Expressions which is not aligned with the CCSSM.

The Leibniz’ teachers are more interested in ELA-related professional development than mathematics professional development. In February, 2014 the district administration surveyed the Leibniz educators on their top three areas of need for 2014-2015 district professional
development through an online survey. The top three needs included: general curriculum, instruction, and assessment topics; improving ELA instruction; and improving the use of instructional technology.

The Leibniz ELA culture may be contributing to less of an emphasis in mathematics education and lower student achievement in mathematics (see Appendix N). Over the last six years the percentage of Leibniz third grade students scoring proficient or advanced on the State’s high-stakes test in reading has averaged 72%; while State peers’ scoring proficient or advanced over the same time frame averaged 59%. However, in mathematics the amount of Leibniz third grade students scoring proficient or advanced over the last six years has averaged 72% while their State peers averaged 63% over the same time period. Further, fourth grade ELA scores averaged 15 percentage points higher than their peers statewide and only nine points higher than their state peers in mathematics. A major influence of the Leibniz’ school teaching and learning culture, the principal Elena, does not have a strong background in reform mathematics.

**Elena.** Elena is in her 20th year as a school administrator and fifth year as principal of the Leibniz School. Her background in mathematics is not aligned with the reform mathematics present in the CCSSM. Elena’s K-16 (kindergarten through undergraduate education) experience as a mathematics student included rote computation, and textbook-driven instruction to Algebra. She went through a traditional (two or three math methods courses) teacher preparation program. As a K-6 teacher for 11 years Elena taught arithmetic as a set of step-by-step procedures. She sees mathematics as one part of a holistic K-12 education and the mathematics in the budgeting process as a necessary part of her job as an educational leader. Learning and doing mathematics has always been difficult for Elena. As an instructional leader she recognizes the need for mathematics.
Elena’s knowledge of mathematics instruction relates to traditional mathematics instruction. She views the teacher’s role as to explain and model problem solving to students. She stated that teachers should demonstrate how to solve problems and assign similar problems for students to replicate the teacher’s problem solving methods.

Elena also believed that a mathematics curriculum should give students in successive grade levels repeated exposure to topics and related learning experiences that increase in complexity (a spiraling curriculum). Further, she said that using a new state mandated curriculum such as the CCSSM means adopting a commercially developed program since the people who develop these programs are the experts in mathematics education.

Elena expected the Euler school district to adopt a mathematics program as a proxy for the CCSSM. Elena feels this program should be implemented with a high level of fidelity. She described the CCSSM as deeper learning for students and stated that the SMP bring some new vocabulary to teachers but are nothing new to mathematics educators. Elena maintained that her major curriculum related role is making sure that teachers get data from benchmark assessments and state high-stakes tests to drive their instruction. This activity made up a portion of Leibniz professional development time.

**Leibniz professional development.** The Leibniz School has offered little professional development time and resources for learning the CCSSM to the Leibniz Schools’ third grade teachers. Each Tuesday during the 2013-2014 school year from 1:45 to 3:50 and on two full days (from 8:00 a.m. to 3:00 p.m.) the Leibniz teachers (for 36 total sessions) participated in school provided professional development known as in-service time (see Appendix B). The content or professional development topics were determined in the spring of 2013 by Elena in
consultation with the interim superintendent and assistant superintendent (these district administrators are no longer working for Euler).

The Euler principals develop professional development topics from the goals in their respective school’s improvement plans and the district’s professional development plan. The 2013-2014 Leibniz’ improvement plan included using student test score data to promote instruction and student achievement, training teachers on the State’s new teacher evaluation system, reinforcing teachers’ technology skills, and creating a safe school. A district professional development plan was not developed for 2013-2014.

The third grade generalist experienced a small amount of professional development relative to the CCSSM. Carl, Emmy, and Charlotte received a hodgepodge of professional development experiences during district and school professional development (Figure 3). Since the Leibniz’ teachers were provided their blue book copy of the CCSSM in December, 2011 there have been many professional development initiatives competing for in-service time (see Appendix O and Figure 3).

The 2012-2013 Leibniz improvement plan identified teacher learning of the CCSSM as a goal and the need of professional development time for teacher learning of the CCSSM. However, the 2012-2013 school year did not offer any CCSSM learning time for grade three teachers. The 2013-2014 Leibniz professional development calendar (see Appendix B) provided the third grade generalists with a modicum amount of learning relative to the CCSSM. This time included 1,545 minutes of reviewing student assessment data (classroom assessments, formative assessment scores, student grading, twice quarterly benchmark assessment scores, and annual state high-stakes test scores), 185 minutes of time for searching the internet for Common Core related instructional resources (e.g., lesson and unit plans, graphic organizers, student learning
experiences), and one 39-minute seminar on the SMP with the math coach during the morning of February 3, 2014 (see Figure 3).

![Time Spent in Professional Development at Leibniz School](image)

**Figure 3.** Percentage of time spent in nine activities during school and district provided professional development by Leibniz School grade three teachers from September 4, 2013 through February 25, 2014.

The potpourri of in-service activities has limited time for teachers to gain an understanding of the CCSSM. The Leibniz School has historically given professional development time for activities that do not involve teacher training such as providing teachers
with time to prepare for open house night, perform student grading and corresponding data entry, and participate in parent conferences. Additionally, a portion of professional development time was devoted to Elena telling teachers general school news (housekeeping issues such as scheduling, safety concerns, and staffing). Thus, these non-training activities and news reports comprised 41% of the professional development time from September, 2013 through February, 2014. Elena stated that she did not believe the administration has done a good job providing teachers with quality professional development experiences and time for teachers to learn about the Common Core.

She noted that there was a commitment to helping teachers learn the CCSSM and CCSSELA among the administration. However, she also noted the previous Euler School District administration’s tendency to continually adopt and reject educational fads and provide teachers with too many professional development initiatives by stating,

And then six other things come down the pike that maybe look better and smell better and oh, let’s try this. So I think we have done a very poor job on professional development for our teachers around the Common Core.

Elena described the multiple topic professional development plan of the Leibniz School as “flavor of the month” professional development.

During her time as principal of the Leibniz School Elena has received little direct professional development in mathematics. Elena’s professional development has included membership in the National Association of Elementary School Principals (NAESP, 2014) and the State’s elementary principal organization. In her role as principal in her previous district she traveled across the country to attend conferences conducted by the ASCD and the International Center for Leadership in Education. These conferences included professional development in
mathematics. However, a lack of funding by the Euler district has prevented her attendance at these conferences and as a result participation in professional development for mathematics.

Elena’s messages to teachers included reminding them to complete and turn in their pre and post benchmark assessments each term, suggesting a family math night in January or February, 2014 (the math night did not take place), and authorizing Maria the math coach to provide mathematics instructional leadership each Monday. Sophia and Elena rely on Maria to support mathematics teachers.

**Maria.** Maria is in her second year as a math coach (first year in the Euler District). Formerly she was a fifth and sixth grade teacher of reform mathematics and science for 13 years in a neighboring small town. As a K-16 student she experienced traditional mathematics learning experiences focused on memorization of algorithms and textbook-driven instruction to calculus and a few methods courses as a graduate student.

Maria’s responsibilities include developing math leadership capacity in mathematics teachers by supporting them in areas of curriculum, instruction, and assessment so they can promote student learning and achievement. Maria’s district job description stated that it is also her responsibility to promote collaboration, reflection and professional growth among elementary (P-4) teachers.

Maria described Leibniz as a place where teachers have not received enough professional development in mathematics. She stated that the Leibniz teachers have repeatedly informed her that they need more professional development in mathematics and time for teaching mathematics. She also observed that the Leibniz School professional development calendar did not allocate any time to her to provide mathematics professional development during in-service time. Her Leibniz professional development efforts have focused on student test score data
analysis, student remediation (through an online program called Symphony Math [Symphony Learning, 2014]), and supporting teacher implementation of the CCSSM when possible.

Maria provided Carl, Emmy, and Charlotte with one SMP seminar. Figure 4 shows how she represented the SMP as the solution process to the third grade generalists during this seminar. Maria explained the SMP (along with a PowerPoint presentation) as habits of mind for students to employ while engaging with the SMC. Maria provided the teachers with a variety of basic representations of the SMP from many sources (see Appendix P). The generalists’ discussed their interpretations of the content of the presentation and the SMP representations. Maria’s messages to teachers (see Appendix Q) included memos on a variety of topics including reminding them to use Symphony Math as a diagnostic evaluation and remediation tool, offering online lesson plan resources, test score information, and how to use mathematics terminology appropriately during instruction. About seven years prior to Maria’s arrival Leibniz lost its previous and only other mathematics teacher educator.

**Grace.** Grace was described by Emmy as a mathematics pioneer who brought reform mathematics to the Leibniz School. Until her retirement in 2006, Grace (pseudonym) was a generalist at the Leibniz School for about 35 years. During her time at Leibniz mathematics was for the most part focused on rote computation in arithmetic, worksheets, and independent student learning activities at their desks (seat work); most teachers disliked math. Grace was inspired by the work of Marilyn Burns (Math Solutions, 2014); she provided professional development and courses for teachers in the State and across the country. Grace was also a long time member of the NCTM. Grace brought reform mathematics to the Leibniz teachers during in-service sessions.
Figure 4. The solution process recommended by the math coach

SMP 1
I can think about how to solve problems and follow my plan. I will not give up. If I have trouble I will try another way.

SMP 2
I can use pictures and words in place of numbers. I can use numbers in place of pictures and words.

SMP 3
I can explain my ideas with words, objects, and pictures. I can use models such as words, objects, and pictures to find the solution to a problem.

SMP 4
I can tell when math will help me solve a problem. I can use models such as words, pictures, symbols, and manipulatives to find the solution to a problem.

SMP 5
I can choose and use the correct math tool to solve problems.

SMP 6
I can work and communicate well with strategies, vocabulary, symbols and labels.

SMP 7
I can locate patterns that help me make sense of problems.

SMP 8
I can see when patterns repeat and find shortcuts to solve problems.

Predominant habits of mind

Reason & Explain

Use models & tools

Recognize structure & generalize
Grace promoted mathematical discourse, the teacher as a facilitator of learning, getting students to explain their problem solving strategies and reasoning, authentic learning experiences and problems, the use of manipulatives, and a teaching for understanding approach. Grace also brought the reform mathematics program *MathLand* (Charles, 1996) to Leibniz and tried to change the dominant form of instruction from teaching as showing and telling toward a more student-centered approach with inquiry, active (hands on) learning, and guided discovery.

During professional development Grace wanted teachers to help students gain procedural fluency with conceptual understanding. Through professional development in the mid to late ‘90’s at Leibniz Grace provided Carl and Charlotte with an introduction to this new way of teaching mathematics that would later become a major focus of the CCSSM. Emmy also attended Grace’s professional development seminars at Leibniz where her commitment to teaching reform mathematics was strengthened. It would not be until 2012 when these three teachers would receive more reform mathematics professional development.

**Ada**

The three third grade teachers all stated that the mathematics teacher educator Ada did the most to advance their understanding of the CCSSM. Specifically, Ada helped them achieve a beginning understanding of the SMP.

Ada (pseudonym) is an associate professor of mathematics education at a nearby university where she teaches mathematics methods courses for elementary and secondary pre-service teachers. She also teaches courses for in-service mathematics educators. Carl, Emmy, and Charlotte took courses with Ada and participated in her eight day professional development CCSSM course in 2012 titled, Developing Mathematical Practices. This course focused on SMP
1, 2, and 7 through an active, problem solving approach. Each of these teachers stated that this course helped them gain a stronger understanding of the SMP.

**Summary of the Influence of Contexts on Teacher Understanding**

The diverse contexts within which the generalists learned constrained and supported their learning of the CCSSM. The lack of CCSSM related professional development during the 2011-2012 and 2012-2013 school years constrained the generalists’ understanding of the CCSSM. Most of the generalists’ professional development during the 2013-2014 year was related to reviewing test score data and the content of the tested curriculum (the content standards or SMC that are measured by high-stakes test questions) of the CCSSM. The district also provided three hours of time for teachers to find online Common Core resources (for ELA and mathematics) and made time for the generalists to participate in a SMP seminar with the math coach. The generalists stated that the type and amount of professional development offered by the Euler/Leibniz did little to advance their understanding of the CCSSM. The district also did little to build on the reform mathematics professional development provided by Ada and Grace.

**Generalists’ Cognitive Structures**

The first research sub-question was: what were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM? In order to answer this query the researcher collected data from observations, audio-visual materials (the generalists’ web pages), and one-hour semi-structured interviews with each participant focused on their respective backgrounds relative to mathematics. The following sections include details on the experiences, attitudes, beliefs, and knowledge of Carl, Emmy, and Charlotte. The minor themes that resulted from data analysis for Carl included accelerated traditional mathematics student, hybrid teacher, jack of all teaching, and math is fun.
Carl

Carl is a former Leibniz student in his 17th year as a Leibniz generalist teacher; prior to that he was a mathematics tutor at Leibniz for three years. Carl wanted to be a teacher since the fifth grade. He sees his role as to inspire, enrich, and challenge learners to achieve their potential in his inclusion classroom. Carl’s room appears as a typical generalist classroom.

There is a large wooden teacher’s desk, a sink and water fountain, five globes on a large bookcase, a 12 foot long white board, and a four-drawer file cabinet. The student desks are arranged in two groups of six, one group of five, and one set of four. There is also a long wooden table with six wooden chairs and a mailbox with compartments for student work.

Carl refers to his class as a team where all students have something meaningful to contribute and are responsible for contributing to the team’s success. There are many baseball related items for his team such as a pair of seats that were once a part of the local Major League Baseball team’s stadium with a desk that is the color of the outfield wall. There is a poster that contains nine innings of social and emotional cues such as work as a team, use your materials and time wisely, include everyone, and share. There is a two foot by two foot calendar with baseballs in each day and Major League Baseball tickets taped to it. Additionally, his class website contains many personal photos of the baseball stadium.

Carl’s room represents a generalist learning environment well equipped for mathematics. There is a five foot tall, seven shelf rack with 21 compartments for mathematics manipulatives. The compartments contain dice, cards, blocks of different sizes and shapes, calculators, and rulers. On the walls there are pictures of many two dimensional shapes that include triangles, rectangles, angles, ovals, and multi-sided shapes. There is a five by five foot poster of the multiplication table to nine and another three by four foot poster of the multiplication tables to ten. Below the posters there is a shiny red cape that Carl wears during mathematic lessons.
Above four white iMac computers the homework on the dry erase board asked students to complete their DCR (daily cumulative review of mathematics skills and concepts), complete a mathematics problem from the state’s high stakes test to solve, and read a story. Above the homework a poster identified a four step problem solving plan: understand, plan, try it, and look back.

The room is also decorated with objects from other subject areas. It has ELA posters representing parts of speech and informational writing, a science bulletin board showing a plant’s life cycle, and another board with pictures detailing the history of the town of Euler.

**Accelerated traditional mathematics student.** Carl experienced great success as a K-16 mathematics student. As a student attending the Leibniz Elementary School Carl was identified as a gifted and talented learner and placed in an accelerated mathematics program. He received advanced learning experiences with a group of peers three days each week through elementary school. As a Euler High School student Carl stated that he, “excelled at math.” He took algebra, trigonometry, algebra 2, honors algebra 2, pre-calculus, and calculus when the norm was to take only four mathematics courses in four years.

Carl’s teacher preparation program included three mathematics courses which he felt included too much emphasis on content and theory and not enough training on how children learn mathematics. Carl stated that these courses did not adequately equip him with the skills he would later need at Leibniz.

Carl also participated with great success in three of Ada’s professional development workshops including Developing Mathematical Practices. Ada’s courses provided learning experiences in examining student’s problem solving methods and learning how to help students solve non-routine problems through reasoning, discourse, and justifying answers.
Hybrid teacher. Carl’s experiences as a teacher have included a strong tradition of the use of reform mathematics. Carl has experienced the State’s mandated and district recommended reform mathematics curricula during his entire career as a teacher. Further, his beliefs in instruction reflect many of the aspects of the problem solving approach recommended by the SMP such as using different strategies as well as reasoning, sharing and defending solution pathways. He believes in using a non-routine problem solving approach with classroom discourse.

Carl described his mathematics instructional method by stating, “My style is crazy.” Carl believes in employing a mix of traditional (teaching for procedural fluency through teacher direction) for the first ten minutes of lessons and reform mathematics instruction during remainder of his daily one hour lessons. He begins units by orally introducing skills and concepts to the class with a corresponding teacher directed activity. This opening ten minutes also includes some teacher led instruction.

The remaining portion of the lesson includes Carl cooperative learning with hands-on activities and manipulatives; Carl assumes the role of facilitator during discourse. He then requires students to solve problems alone or in groups. Learners also go to the white board in the front of the room to show their solution pathways. Carl stated that he encourages his students to look for different ways to solve problems and present and defend solution strategies to a peer, group, or the entire class. He remarked that he has students come to the board and he often hears, “Oh, I found a way to do it or a different way, or Oh! I never thought of that.” Carl noted the importance of students defending their solution pathways by stating,
I will say I am not sure if that is right. How did you get it? Prove it. Show me. Quote fight with me to argue your answer and they really get it and I think they show some more ownership rather than doing basic computation.

Carl’s statements also represented the use of the third grade content contained in the CCSSM. Carl’s website, interview data, and curriculum resources point toward his use of instruction on multiplication, division of whole numbers and fractions, measurement and data, and geometry. This content reflects the SMC for grade three. His remarks also reflected the instructional balance of teaching for procedural fluency and conceptual understanding by the CCSSM. He uses a packet of worksheets called the daily cumulative review (DCR) to reinforce computational skills, conceptual understanding, and problem solving. Homework related to these areas is assigned Monday through Thursday.

Carl has gradually developed his understanding of reform mathematics content and teaching style through the use of the State’s three curriculum frameworks and textbooks he has used to guide his instruction such as Everyday Math (Bell & University of Chicago, 1998) MathLand (Charles, 1996), MathCentral (Boswell, Kanter, Gillespie, Kanter & Houghton Mifflin, 1999), Math Expressions (Fuson & Children’s Math World’s Research Project [CMWRP], 2006a, 2006b, 2006c, 2011), and On Core Mathematics (Houghton, Mifflin & Harcourt, 2012). See Appendix U for a history of Leibniz mathematics curricula.

**Jack of all trades.** Carl noted that his experiences with fragmented Leibniz professional development have neither equipped him with a sufficient feeling of competence or confidence in his skills and understanding nor a feeling of learning completion in any area. He stated that he feels like a jack of all trades without a feeling of mastery in any area.
Carl has a good understanding of the SMC from planning lessons, providing instruction, and reflecting on his teaching with reform mathematics curricula since 1996. However, his professional development has not equipped him with an understanding of the reform mathematics terminology within the SMP. This language barrier has prevented him from gaining an understanding of it. Moreover, the school’s method of delivering professional development has not promoted deep learning for Carl.

Carl described the usual style of school professional development as a transmittal of information (i.e., sit and get) by an administrator with insufficient follow up and support by saying it was, “listen and just remember and then try to apply and then we will get back to you at a later date. And in the past later date means never.”

Carl also noted that his lack of professional learning has been influenced by a lack of time for learning. The grade three generalists have not been given a daily common planning time period. They have only a once monthly 45-minute meeting (usually Monday mornings) to discuss all teaching related issues. Since they meet so infrequently they have had little discussion of the CCSSM. Their discussions have focused on planning ELA, social studies, science, and math; student management issues; field trip; special education issues; and scheduling.

The lack of time to complete professional learning activities was exemplified during a district organized Common Core professional development exercise for all elementary generalists in May, 2012. Carl stated that the teachers were told to unpack the CCSSELA content standards by using scissors and glue sticks to cut out standard statements from the previous ELA standards and attach them next to the new standards. Carl, Emmy, and Charlotte were not able to participate in this activity for mathematics since time expired and the third grade
teachers did not return to it. Carl stated that the only mathematics professional development (prior to the February 3 session on the SMP) was on October 15, 2013 when the teachers reviewed their students’ scores from the State’s high-stakes test.

Carl noted that many Leibniz professional development initiatives began with great enthusiasm and were dropped without warning. This occurred with two different writing programs. Carl felt that he did not finish learning either program. Further, Carl noted that a professional development calendar with diverse, weekly topics is distributed to teachers at the beginning of the year. However, many of the scheduled topics are dropped for more important initiatives. Finally, Carl highlighted his need for more mathematics professional development by stating,

Because hopefully with having a new math coach, she can influence our PD and make it more valuable, more worthwhile, because I don’t need to have bits and pieces. I think one of our goals she mentioned is that we need about eight weeks of intense training in this math.

Math is fun. The body of data related to Carl showed that he feels teaching and learning mathematics is fun. Carl takes pleasure in teaching and wants to learn the CCSSM so that he can improve his instruction and enjoyment of mathematics. When asked about the role of mathematics in the school curriculum Carl stated, “Because I love math; I think it is a huge piece.” Carl also entertains his students during mathematics lessons.

Carl noted that he often wears a shiny, red cape with a Mr. C (pseudonym) logo on the back in order to bring excitement to mathematics lessons. During the lessons he stated that he likes to joke and have fun with his learners. In addition to this merriment during teaching duties he operates the school store as a fun place for the enrichment of mathematics education.
Carl has created a pleasurable place where his students apply their computational skills and understanding while selling school supplies such as pencils, erasers, and small toys to Leibniz students before school begins. Carl puts many hours of work into stocking supplies and preparing the school store each day so that his students can increase their computation skills making transactions with coins and dollar bills and gain social skills interacting with student consumers.

Carl enjoys learning about mathematics. He has spent much of his own time trying to research the CCSSM (much of it online) in order to understand it. Carl identified the district’s inability to fund out of district teacher professional development as a reason why he has not had more mathematics professional development opportunities. He stated that funding for out of district professional development is often frozen in the fall.

Emmy

Emmy is in her 10th year as a third grade generalist at Leibniz. She spent her first six years in education as a special education classroom aide at Leibniz. After attaining her teaching credential she spent the next two years as a fourth grade generalist in the neighboring Noether (pseudonym) School District before coming back to the Leibniz School. Emmy’s favorite subject to teach is mathematics; her student-centered classroom is fortified for its teaching.

The classroom’s 22 student desks are in three rows with each containing a twelve by six inch laminated paper watermelon slice with each student’s name in cursive. Emmy’s walls are covered with her students’ photographs and posters. A large section of the wall contains student definitions in words and pictures of expanded and standard form, difference, product, estimate, addend, array, and fact family. There are eight posters showing the SMP with pictures and student-friendly language. Another poster shows the associative and commutative properties. More posters show various geometric shapes such as a square, rectangle and trapezoid, fraction
strips of various quantities, the Common Core domains (major content areas) of number and operations in base ten, measurement and facts, operations and algebraic thinking and fractions, and number and operations – fractions. A large poster on an easel proclaims that a student was the first third grader to achieve competency in division.

In the corner of the room there is a mathematics library that includes many books authored by mathematics teacher educator Marilyn Burns. There are about a dozen small plastic containers with math manipulatives (blocks, counting objects). In another corner there is a smaller library of mathematics textbooks and instructional guides. On a small desk there is a document camera/projector for highlighting mathematics problems and solutions. The room also contains material for the teaching of other subjects.

There is a 24 compartment organizer with student names and a mail center for delivery of school mail, ELA posters with definitions of terms, shelving with about 30 baskets labeled poetry, picture books, non-fiction, fiction, and short stories. Next to the sink/water fountain is a horseshoe shaped laminate table with six small chairs along the outer circle and a large padded metal chair near the center. Emmy also has an online learning environment that supports mathematics education.

Emmy and Charlotte have a shared website that contains dates, homework information, photographs of field trips and special events, weekly class reading log, classroom rules related to respect, effort, and manners. The site has a page that describes the content of their mathematics programs. This content includes multiplication, division, multiple step problem solving, mathematics vocabulary terms for solving word problems, number sense, place value, time, data and measurement, and addition and subtraction. The classroom and web site identify 30-40 minutes of homework for Monday through Thursday that includes reading and mathematics.
Finally, Emmy’s mathematics learning environment extends into the corridor with a display of her students’ pattern block designs (Emmy is the only teacher to have her students’ math work on any wall of the school’s halls).

The minor themes that surfaced for sub-question one for Emmy included getting-the-right-answer math student, a-ha reform mathematics learning, ELA-focused school, and student-centered teaching.

**Getting-the-right-answer math student.** Emmy’s K-16 experiences with mathematics education could be described as getting-the-right-answer mathematics to calculus. During these years Emmy gained procedural fluency or the ability to get the right answer quickly and efficiently without conceptual understanding.

Emmy remembered elementary school mathematics as a place with drills, worksheets, and textbook-driven instruction by stating that learning was, “marching through the textbook and I do remember that I liked that though, that it was just, because, it was another page; oh, you finished that page, here is another page and then you would successfully complete that one.” Emmy defined her high school experience with getting-the-right-answer mathematics by stating,

I remember that the teacher would teach a formula and it would be my job to plug it in and make it work . . . I never remember being pushed to figure out the reason behind the mathematics; but I was good at plugging in the numbers and I was successful.

During her undergraduate years Emmy was a business student at a private college where she took courses in accounting and statistics with more getting-the-right-answer by following step by step procedures (plugging in proper algorithms to get the right answer) learning experiences. She described this when she said, “But again it was more of the same driven facts, formulas, it was not deeper understanding at all.”
**Aha reform mathematics learning.** After beginning her aide position at the Leibniz school Emmy started graduate school in order to gain a teacher’s license. This is where she developed her attitude or disposition toward reform mathematics when she experienced an a-ha moment. She described this revolutionary experience by stating, “This was the first time that I made connections . . . why formulas worked . . . and it was (learning with) conceptual understanding for the first time it was hands on.” She described her graduate school instructor by saying,

She is by far my absolute favorite professor from kindergarten all the way through, it was her inspiration, that it all made sense to me and the light went on and I just want to do that for children, to have that a-ha moment.

In graduate school Emmy learned how to help her students think about mathematics, discuss their ideas, and apply understanding to solve real world, challenging problems. She was learning to guide them to construct meaning and understand mathematics rather than memorize procedural steps and rules.

In graduate school Emmy learned the reform mathematics style of teaching and student learning with manipulatives to engage in hands-on learning, student reasoning, solving non-routine problems, and defending and critiquing solution pathways. These practices were reinforced when she worked in Grace’s classroom as an aide and attended Grace’s professional development sessions. Grace showed Emmy active, hands-on student learning, mathematics games, discourse, perseverance, permeating the school day with mathematics, and mathematics as a fun place for learning.

During her two years as a generalist in grade four in the Noether School District Emmy learned more reform mathematics from her elementary mathematics specialist (EMS). The EMS
stressed mathematical discourse with students identifying solution pathways, explaining and defending their solutions and ideas to peers and groups, and listening to, appraising, and questioning the solution pathways of others.

At the Leibniz School Emmy has developed her understanding of reform mathematics teaching by using the following reform programs to guide her instruction: *MathCentral* (Boswell, Kanter, Gillespie, Kanter & Houghton Mifflin, 1999), *Math Expressions* (Fuson & Children’s Math World’s Research Project [CMWRP], 2006a, 2006b, 2006c, 2011), and *On Core Mathematics* (Houghton, Mifflin & Harcourt, 2012).

**ELA-focused school.** Emmy believes that the Leibniz School is focused on ELA education. She stated that she believes the concentration of instructional time and professional development on ELA has resulted in less time for professional development in mathematics. Emmy wants more mathematics professional development opportunities from the Leibniz School.

During her experiences as a grade three generalist teacher at Leibniz Emmy wanted to continue to develop her ability to provide instruction that develops student understanding along with computational fluency. Yet, the school was not oriented to such an approach. Shortly after Emmy returned to the Leibniz School Grace retired in June, 2006. The school had no one with expertise in reform mathematics teacher education. Emmy stated she believed that Leibniz was an ELA-focused school.

Emmy stated, “my passion is math.” She wanted her students to learn mathematics for understanding. However, Emmy stated that Leibniz had a predominant focus on ELA education by stating, “ELA is number one . . . math is below everything in my opinion as far as professional development as far as planning, discussion, passion, math is the bottom of the
barrel.” The reform mathematics professional development would not return until Maria’s arrival in the fall of 2013.

**Student-centered teaching.** Emmy’s knowledge on how to provide instruction could be best described as student-centered teaching. She described this environment by saying,

> The number one thing in my room is to have safety (for the students) and make sure that the students are willing to take risks. I feel the children have a natural curiosity and my role is to foster that curiosity and to reach kids where they are and to continue extending them . . . I want to push them forward so that everyone is a little bit out of their comfort zone just to keep learning at its optimum.

Emmy stated that her students need to gain computational skills in addition, subtraction, multiplication, and division while at the same timing gaining understanding of how these processes work and why their answers are correct. She knows that mathematics learning should be active where students build their understanding through hands-on and real world experiences with mathematics manipulatives while discussing problems and their solutions with peers. Emmy’s overarching understanding is that her students continuously improve their skills and conceptual understanding while refusing to be complacent with their achievements.

**Charlotte**

Charlotte is in her 19th year as a Leibniz educator. She was a teacher for six years in a few neighboring districts prior to coming to the Leibniz School. She spent the first two years of her career as a resource teacher for pre-kindergarten, kindergarten, and first grade; the following year as a pre-kindergarten special education teacher in an inclusion classroom; the next two years as a reading teacher; and the sixth year as a special education tutor.
Charlotte was a special educator in fourth and fifth grade supporting ELA and mathematics instruction during her first seven years at Leibniz. She is now in her 12th year as an elementary generalist teaching in third and fourth grade. At Leibniz Charlotte has created a classroom learning environment that is befitting of an elementary generalist.

Charlotte’s classroom is ready for mathematics education with posters of the SMP with cartoon-like pictures and “I can” statements aligned to second and third grade content. There are also posters of the SMC emphasizing addition, multiplication, subtraction, and division and three digit subtraction problems written on chart paper. The remaining mathematics resources include a poster of the multiplication tables to 12, several math books student textbooks and workbooks, and many mathematics textbooks in a plastic crate.

Charlotte’s classroom is also focused on her students. More posters contain inspirational quotations such as follow your conscience instead of the crowd, life has rules play fair, the journey is the prize, and believe you can. Near the four white iMac computers is a small bulletin board highlighting the lifetime achievements of a student and photographs of all Charlotte’s students on a calendar. The student desks are clustered in four groups of four and one group of five. There is also a comfortable place to enjoy literature.

There is a large reading area that includes 18 baskets of small paperback picture and chapter books with a beanbag, a miniature garden containing beach sand and a tiny shovel, and a rocking chair with a sea cushion. The homework on the large dry erase board requires students to: practice skills online at *Symphony Math* (Symphony Learning, 2010), *XtraMath* (2014), and *EducationCity.com* (2012); read for 20 minutes; and complete a practice question from the State’s high-stakes standardized test.
The following minor themes emerged from data analysis relative to Charlotte’s cognitive structures associated with mathematics: traditional mathematics student, developing reform mathematics understanding, ELA focused teacher, technology infused, and active student learning.

**Traditional mathematics student.** Charlotte’s experience with K-16 mathematics education was traditional, strict, textbook driven mathematics to honors Algebra during a K-12 mix of public and Catholic education. She described her private elementary school traditional mathematics learning experience by stating, “It was very rote; we said a lot of things out loud, we repeated a lot of things. There was not a lot of exploration.” Charlotte said that her high school experiences also emphasized getting the right answer and textbook-driven instruction.

Charlotte’s teacher preparation program at a private university focused on special education pedagogy with little mathematics. Additionally, a minor in ELA provided Charlotte with preparation for the teaching of reading, writing and literature. Charlotte increased her content knowledge in graduate school by taking a combined and traditional Algebra 1/2/Pre-calculus course. Charlotte noted that her daughter who would later become a high school mathematics teacher helped her through this challenging course.

**Developing reform mathematics understanding.** Charlotte is developing her knowledge of reform mathematics content and pedagogy. Charlotte’s experiences with reform mathematics began at the Leibniz School. Charlotte did not experience reform mathematics instruction until she became part of a team of grade level teachers at Leibniz. Charlotte did not gain her first experience with reform mathematics until she participated in Grace’s professional development sessions at the Leibniz School. She described this learning as very hands on, student explanations of their solution strategies, partner discourse, and active learning. Charlotte
also noted that she provides students with some experience doing independent computation so her students can develop fluency adding, subtracting, multiplying and dividing.

Charlotte later took three courses with Ada. During Ada’s courses Charlotte stated that she learned much about the use of reform mathematics vocabulary such as reasoning, discourse, and conjecture. She noted that Ada’s course provided her with energy and enthusiasm to continue learning about reform mathematics and how to implement it within her classroom. Charlotte was inspired by Ada to read more about reform mathematics instruction (Greenes, Findell & Tsankova, 2006; Greenes, Tsankova, & National Council of Supervisors of Mathematics, 2004).

Charlotte also gained experience with reform mathematics teaching and student learning from her use of three State curriculum frameworks and the varied reform mathematics programs she has used to facilitate her teaching such as MathLand (Charles, 1996), MathCentral (Boswell, Kanter, Gillespie, Kanter & Houghton Mifflin, 1999), Math Expressions (Fuson & Children’s Math World’s Research Project [CMWRP], 2006a, 2006b, 2006c, 2011), and On Core Mathematics (Houghton, Mifflin & Harcourt, 2012).

**ELA-focused teacher.** Charlotte’s attitude relative to the purpose of education is that it should be primarily focused on ELA education. Charlotte minored in ELA instruction during her teacher preparation and feels that an elementary school should have an overarching focus on reading and writing. She also remarked that her background as a special educator has led her to believe that students must be able to read to succeed. She noted the importance of ELA in mathematics word problem solving by saying, “If they cannot read it they can’t solve it.” Charlotte also noted the Euler and Leibniz professional development has emphasized two areas
that she feels are important ELA and in the last few years the use of instructional technology to enhance teaching.

**Technology infused.** Charlotte’s believes in using instructional resources from the internet to teach and learn about mathematics education. She described her internet using by saying, “I use a lot of websites for different lessons . . . some of mine come from Teachers Pay Teachers (2014).” She identified the role of the internet in her planning by stating, “when you get to a concept or something that you are not sure of or, I just go to a website, different websites, and start researching.” Charlotte noted that she spends time visiting the online home of the CCSSM (corestandards.org), visiting the departments of education from other states to find mathematics lesson plans. Charlotte also regularly uses other forms of instructional technology to enhance her instruction such as a document projector and desktop and mobile applications for use during planning, instructing, and assessing.

**Active student learning.** Charlotte’s knowledge about how to go about teaching and learning are concentrated on active student learning. She noted that during mathematics lessons her students discuss their reasoning by saying, “it is okay to have the wrong answers here, it is okay to correct your answer . . . you need to explain how you got there.” Charlotte remarked that she has taken three other mathematics professional development courses with other teachers that did not match Ada’s emphasis on and Charlotte’s preference for active learning.

Charlotte stated that she knows her third grade students need to be active physically and cognitively. She said that students need to be standing up, walking, and actively engaged in learning. Charlotte also stated, “third grade becomes let’s explore this a little bit more, let’s think a little bit more on our own, explain it . . . There are days that we do not do any paper and pencil for math. It is just math games and exploration with manipulatives.” Charlotte followed
this statement by describing the full bookcase and storage areas full of mathematics manipulatives that her students use during hands-on problem solving experiences.

Charlotte encourages active student learning through music. She developed a mathematics problem solving mnemonic in the form of a song sung to the tune of Y.M.C.A. (Belolo, Morali, & Willis, 1978) called KQSA. She described the song by stating, “the K is what do you know? The Q is what is the question? The S is what is your strategy? The A is does your answer make sense?”

Charlotte’s reform mathematics learning and commitment to active learning was fostered by the team teaching she did in the mid to late 1990’s. She described her teammates’ commitment to exploration by remarking, “they were very much open to trying new things and that was the constructivist approach that was really flourishing and forming.”

Charlotte stated that State and Euler mathematics testing is, “cutting into the time that we could be exploring and hands on.” She went on to say that the teacher knows their strengths and weaknesses without the aid of external tests.

**Content and Type of Messages Presented to Teachers**

The second research sub-question was: what has been the content and type of the CCSSM messages presented to teachers during professional development? The third grade generalists have received many diverse messages from independent research of the CCSSM, discussions with peers, monthly 45-minute grade level meetings, mathematics courses with Ada, and Leibniz professional development. Common, minor themes emerged from data analysis of interviews, document analysis, and observations in these professional development contexts for Carl, Emmy, and Charlotte. The minor, shared themes were test score messages, miscellaneous messages, basic messages, and few CCSSM messages.
Test Score Messages

The generalists received test score messages related to the CCSSM during district provided professional development. These sessions offered a review of the tested CCSSM curriculum. This provided an opportunity for teachers to make sense of the instructional intents of the SMC since they reviewed each test item and task with its associated content standard. However, the messages from the administration did not contain interpretations of the guiding principles of the CCSSM, the SMC, or the SMP.

Almost all of the time allocated for mathematics by the Leibniz School included presenting and analyzing test score data. During the data collection period of this study the generalists experienced about eight hours of district in-service time reviewing information on student high-stakes and benchmark test scores related to the CCSSM. They spent most of a full day (10/15/13) and two other in-service Tuesdays (10/22/13 and 2/11/14) reviewing State high-stakes test scores and benchmark test scores. These messages were presented as raw scores for the State’s high-stakes test and (twice quarterly) benchmark tests connected to content standards.

Another message related to the CCSSM that was occasionally discussed during the three generalists’ monthly meetings was related to the pilot test from PARCC. The messages from state level memos were text-based. They noted that the State is conducting pilot testing of a new high-stakes test for two years. In the fall of 2015 the State will determine whether to maintain the current high-stakes test or replace it with the test developed by PARCC. The mathematics test will include the SMC. All three generalists are concerned with the type of test that the state will impose on the school and the mathematics content that it will focus on.

Carl, Emmy, and Charlotte also received messages related to the school’s use of an online diagnostic assessment and remediation program for mathematics called Symphony Math. This program is used as a CCSSM instructional resource. This program was discussed during in-
service time on October 15th and January 7, 2014. The generalists received verbal and written messages from Maria on how students can best use this program and how to run reports showing student achievement. These messages were largely technical and related to how to implement the test (procedural).

**Miscellaneous Messages**

Carl, Emmy, and Charlotte have received many miscellaneous messages related to the CCSSM from Sophia, Elena, and Maria. The generalists also received miscellaneous messages from their respective independent, online research efforts of the CCSSM. These messages have been unrelated to any other messages or district (in-service) professional development. The Euler administrators’ miscellaneous messages were all sent as e-mail messages (i.e., memos and attachments). Only the messages from Maria related to teacher understanding of the CCSSM.

Charlotte described the mathematics messages from the administration since the release of the CCSSM by the State in 2011 by stating,

> It was very splintered messages maybe due to changes to so many administrators especially with me in my grade level, especially with me switching grade levels by looping. I would get a message in fourth grade and when I would get to third grade there would be different messages. Everyone was not given the same message.

Messages from Sophia (Appendix R) have included an offer to all teachers to take courses related to the type of problem solving promoted by the SMP at a city university, an invitation to all mathematics teachers to take the Vision 2020 survey, and a reminder to complete this survey. Elena’s CCSSM related messages (Appendix S) included two reminders to turn in mathematics benchmark test data, an offer for teachers to participate in a family math night in January or February (this event never occurred). Charlotte and Emmy noted that over the last
several years there have been few mathematics messages. This has changed with Maria’s arrival as the new math coach.

Maria has sent many miscellaneous messages (Appendix T) to promote teacher understanding and implementation of the CCSSM. Maria sent lesson plan ideas from a variety of internet sources (e.g., betterlesson.com, Educore.ascd.org, Learnzillion.com, the Math Design Collaborative [Gates Foundation], Teachingchannel.org, NEA.org/commoncore, and Tncore.org). She also sent an article on how to use math language during CCSSM instruction (Faulkner, 2013), a request for student participation in a math competition (mathkangaroo.org), and resources on how teachers can use questioning during mathematical discourse (montemath.com).

The messages that the generalists received during their internet searches included desktop and mobile applications, lesson plans, websites (e.g., Illustrativemathematics.org, teacherspayteachers.com, and corestandards.org), and articles.

**Basic Messages**

The generalists received specific, focused, yet basic SMP messages on one occasion to help them increase their understanding of these student habits of mind for mathematics problem solving.

During the morning of February 3, 2014 the math coach provided a 39-minute seminar on the SMP to the third grade generalists. The presentation portion of the seminar offered the generalists SMP information from ten sources (See Appendix P). The focal point of these documents and the presentation was a set of nine posters representing each of the SMP. These graphic organizers contained cartoon like pictures of students, the title statement of the SMP, and a one or two sentence description (using between 11 and 26 words) of the SMP. For example the
The title of SMP seven is look for and express regularity in repeated reasoning. This standard was represented as look for and make use of structure with the following explanation statement: I can find patterns that help me understand numbers and shapes.

The generalists agreed that the SMP are difficult because the reform mathematics language within them has made them hard for many teachers to interpret. They all expressed their desire for more teacher and student friendly language. Carl, Emmy, and Charlotte noted that the SMP description sentences offered by Maria were written in uncomplicated language that any K-4 student could understand. The math coach remarked that she wanted to begin discussions on the SMP with a basic message since many Euler teachers have had no experience trying to interpret them. She stated that many teachers have never opened their blue books.

Maria provided the generalists with many handouts; each contained an interpretation of the SMP. One included questions for teachers to ask relative to each SMP such as what is the problem asking? for SMP one and what generalizations can you make for SMP seven. Carl, Emmy, and Charlotte were also given a representation of the SMP that related to the content for grade three. Maria’s PowerPoint presentation represented the SMP as a connected method for solving problems that she called the solution process (see Figure 4). Maria stated that SMP one and six should be present in all lessons.

Few CCSSM Messages

Since the release of the CCSSM by the State in March, 2011 the Leibniz’ generalists have received few messages that have helped them make sense of the CCSSM. During this time the third grade generalists have received professional development during independent research, participated in grade level gatherings and coursework, and engaged in school in-services.
However, they only received messages that helped them interpret the CCSSM from Ada and Maria.

The messages from Ada to the three generalists occurred during Ada’s eight lesson course on Developing Mathematical Practices K-5 that the three generalists took in 2012. The teacher participants spent time solving non-routine problems that their students might solve and using the SMP to solve them. However, the course focused on problems that teachers in five other grade levels might encounter in addition to third grade. Further, the course focused only on SMP one, two, and seven. The teachers experienced how these three SMP “live” within lessons. Thus, they learned how their students would experience them.

Maria’s seminar focused on all of the SMP; nevertheless, it lasted only 39 minutes. Time could not be found to extend this learning experience that the three generalists greatly valued. The generalists all stated that they needed more time and support in order to gain a greater understanding of what the SMP are asking them to do.

**How and With Whom Teachers Engaged in Sense-making**

The third research sub-question asked: how and with whom teachers have engaged in sense-making of the CCSSM during professional development. The generalists made sense of the CCSSM during independent research, monthly grade level meetings, discussions with peers, a mathematics course with Ada, a seminar with Maria the math coach, and Leibniz professional development. The data used to determine the corresponding minor themes for this question included observation of professional development, interviews, and document analysis. The minor themes that surfaced from data analysis were shared among Carl, Emmy, and Charlotte; they included team data review, solo interpretation online, interactive problem solving, and group interpretation.
Team Data Review

Carl, Emmy, and Charlotte spent about eight hours during in-service time listening to administrators’ interpretations of student high-stakes and benchmark test scores. This was the largest amount of mathematics related professional development that the generalists received (See Figure 3). During the review of the State test data Carl and the other teachers listened to grade level test score report presentations by administrators with little discussion. Benchmark test score data were also discussed during a grade level meeting by Carl, Emmy, and Charlotte with their peers from Euler’s other elementary school. During this meeting scores for test items and tasks were matched to the SMC. The teachers discussed how they could raise the scores and did not make any interpretations of the CCSSM. There was no effort made to make sense of the CCSSM at any of these teacher gatherings.

Solo Interpretation Online

Carl, Emmy, and Charlotte have spent a great deal of their CCSSM sense-making time engaged in solo interpretation on the internet. Among all professional development activities related to the CCSSM Carl has spent most of his time trying to interpret the CCSSM independently online.

Carl has spent about 40 hours on his own time searching the internet for CCSSM related resources such as lesson plans, interpretations of the SMP, and ideas for student learning experiences during lessons and as homework. His sense-making style included reading, sorting, and evaluating the quality of information related to the CCSSM. He noted that as a result of these efforts he found software and smart phone applications but he has not had the necessary interpretive support from an expert to help him gain a complete understanding of the guiding
principles, SMC and SMP of the CCSSM. Emmy has also spent time online looking for CCSSM information.

Emmy received web-based CCSSM information from her daughter. Emmy’s daughter is an elementary generalist in a nearby city who took a course in 2011 to help her understand and implement the CCSSM. She forwarded the addresses of several CCSSM related websites she got from the course to Emmy. Emmy has been careful to visit websites that will provide her with quality information such; she noted that she has spent time looking for information at the NCTM (2013) web site and the Illustrative Mathematics (2013) web page.

Emmy noted in addition to internet exploration she spends about an hour each day during her mathematics lesson planning trying to interpret the CCSSM. She described these efforts as somewhat helpful in promoting her understanding of the CCSSM. This lesson planning has included reading the “blue book,” searching online, and considering how the SMP relate to student learning experiences. Emmy’s plans included informing students when and how they might use each SMP during the lesson. Emmy also purchased and read two mathematics books (Mirra, 2008; Ronfeldt, 2003) to help her understand the grade three SMC and SMP.

Charlotte conducted her independent study of the CCSSM online. Here she found two basic interpretations of the SMP on the internet which she has posted on her walls. Charlotte spends time during mathematics lesson planning and at various other times looking for CCSSM related lesson plans. She reads and interprets the messages and looks for language that will resonate with her students (many of whom are special education students). Charlotte repeatedly stated that she needs more time and support in order to gain a sufficient understanding of the SMC and SMP and to translate these standards into learning experiences for students.
The Leibniz principal, Elena, encouraged and provided time for the generalists to search cyberspace for CCSSM teaching resources. Carl, Emmy, and Charlotte were given three hours of time by Elena during Tuesday afternoon in-service time on December 3 (two hours) and December 17, 2013 (one hour) to search the internet for Common Core related resources. The three generalists employed the cognitive processes of reading and evaluating the quality of Common Core related resources to support their instruction of ELA and mathematics. The representations they found were of varied quality and quantity. The generalists believed that these efforts did little to advance their understanding of the CCSSM.

**Interactive Problem Solving**

The generalists engaged in interactive problem solving to interpret the CCSSM and especially the SMP with Ada during her course on the SMP. Carl, Emmy, and Charlotte stated that this course taken in 2012 was their first significant learning experience related to the SMP. The generalists participated in Ada’s SMP course for eight lessons with kindergarten through fifth grade teachers from the Noether School District (pseudonym).

During this highly interactive course the teachers cooperatively developed and solved non-routine challenging problems (most of the problems were aimed at third to fifth grade instruction), explained and justified answers, modeled instruction, unpacked some of the SMC, assigned group projects, reviewed student work samples showing their solution pathways, watched video vignettes of student teacher interactions with the SMP, engaged in partner and group math discourse, and developed understanding of the SMP by applying their understanding through problem solving, and unpacked the SMP. Carl stated that Ada tried to get you to think and solve problems as your students would. Carl stated described Ada’s mathematics instruction as, “it was exactly how you want to teach a (mathematics) classroom.” The generalists
appreciated Ada’s instruction and learning experiences on how to help students remediate their wrong answers.

Charlotte stating that the interactive nature of the course bolstered her understanding of the SMP. She attributed this to Ada’s teacher guidance and employment of active learning experiences by saying,

Until you are living it and immersed in it you know you can, it is like talking or studying for a test and you are given all of this information, but unless you are living it and practicing it daily and being supported . . . she immersed us in it. Emmy stated that, Ada (pseudonym) is amazing and any time she offered anything I took it.

Emmy stated that all of Ada’s courses required rigorous problem solving through social interaction, discussion, and critique of others’ problem solving methods.

**Group Interpretation**

The generalists interpreted the CCSSM during the 39-minute SMP seminar with Maria, during their monthly meeting, and in partner discussions. Carl, Emmy, and Charlotte attempted to interpret the SMP as a group during Maria’s SMP seminar in her office before school from 8:06 to 8:45 a.m. on February 3, 2014. The generalists listened to Maria’s explanations during a 20-minute PowerPoint presentation that was followed by a group discussion and review of SMP handouts.

Maria provided her interpretations of each of the SMP and supported her interpretations (synthesized in Figure 4) with several interpretations of the SMP used in other states by varied groups (see Table P.1 in Appendix P). Carl, Emmy, and Charlotte read and tried to interpret the statements for each SMP directly from the CCSSM. This was a problematic undertaking.

Charlotte noted the vocabulary used in the SMP was difficult to make sense of by stating that she had to put forth a great deal of interpretive effort in order to comprehend what they are
telling her to do. She also stated that the terms “decontextualize” and “contextualize” from SMP two were hard for her to understand. Charlotte remarked that the word “structure” should be replaced with the word pattern. She stated that using only the word pattern would enable her to have greater understanding of SMP seven. At 8:45 the bell sounded marking the beginning of the school day; as the teachers gathered their notebooks and CCSSM handouts they all agreed that this time was not enough to help them feel they had achieved a sufficient understanding of the SMP. They agreed to identify a time for a follow up meeting. However, the time to conduct this meeting was not found. The generalists’ meetings continued the following Monday.

Carl, Emmy, and Charlotte spent one morning (usually on Monday) each month for 45 minutes in a meeting where they discussed teaching and housekeeping issues. These meetings included discussions related to housekeeping (e.g., scheduling of special education services, field trip planning, sharing instructional resources), lesson planning in all four subject areas (i.e., mathematics, ELA, social studies, and science), and all other aspects of teaching. There was little to no group sense-making of the CCSSM during this time.

Finally, Charlotte engaged in CCSSM related discussions with her daughter. Emmy and Charlotte participated in similar discussions with each other. Charlotte has a daughter who is a teacher of mathematics (high school). They have regular discussions about teaching which sometimes include the CCSSM. Charlotte remarked that these discussions have emphasized mathematics language that teachers use during lessons. Charlotte described a typical talk with her daughter by saying,

She will say things like, “mom, don’t teach them greater than less than the symbol eats the fish thing. Teach them the right way.” She gives me math terms that I should (use), make sure you are using these terms, (not) like the big fish opens and eats the little fish.
Charlotte also spends time conversing about mathematics with Emmy.

Classroom neighbors Emmy and Charlotte also exchange teaching related ideas and issues after school on a regular basis. Among their discussions of all teaching related issues they have shared mathematics articles, planned mathematics lessons, and struggled to learn what the CCSSM is asking them to do differently

Carl, Emmy, and Charlotte stated that during all of their discussions and meetings they did not feel comfortable challenging each other’s assumptions and ideas about the CCSSM or attempting to make their CCSSM related ideas visible in order to improve their understanding.

**Common Core Mathematics Ideas**

The final research sub-question inquired about the ideas that teachers have constructed relative to the CCSSM and the aspects of the CCSSM that teachers have found most difficult to comprehend. The data that provided insight into this research question were obtained from interviews and observation of professional development. The minor themes were shared by the three generalists. These themes included the tested curriculum, experienced yet inexperienced, beginning understanding, and overlooked principles.

**Tested Curriculum**

The three generalists connected the upcoming test being developed by PARCC as an important part of the CCSSM. They noted that the test will create a tested (assessed) curriculum that they must learn to understand so that their students can achieve at high levels (Glatthorn, 2000).

Carl repeatedly referred to the upcoming piloting of and subsequent implementation of the PARCC testing. He stated that the Leibniz School might not be prepared with infrastructure to implement this test due to a lack of computers and a reliable network server. Carl and
Charlotte were asked to pilot the ELA version of PARCC in the spring of 2014. Carl said that there has been no discussion of the content of the test or how the test will be administered to students. He is concerned about the CCSSM content that will be on third grade tests (the tested curriculum).

Charlotte and Emmy also remarked on their concerns and lack of clarity she had relative to the PARCC. They felt that the district has not done enough to keep them informed on what will be tested, when students will be tested, and how they will be tested.

**Experienced Yet Inexperienced**

The generalists experience using reform mathematics programs allowed them to understand the most outstanding content contained within SMC 3.NF.A.1. However, the teachers’ lack of experience with the use of advanced reform mathematics language – the use of variables to represent and emphasize unit fractions and a combination of unit fractions caused them to miss this aspect of SMC 3.NF.A.1. The generalists were asked to interpret SMC 3.NF.A.1 (from number and operations – fractions) and explain how they might use this standard to teach their students.

This standard states, “Understand a fraction 1/b as the quantity formed by 1 part when a whole is partitioned into b equal parts; understand a fraction a/b as the quantity formed by a parts of size 1/b” (CCSSI, 2014, para. 1). The generalists stated that the variables (1/b and a/b refer to a unit fraction and some combination of unit fractions respectively) made it difficult to understand what the SMC was asking them to teach. They noted that the standard implied upper level mathematics (algebra or calculus). They also felt that the standard would be difficult for their students to understand what they should learn.
Carl had trouble understanding the intent of this standard even though he has taught fractions for almost 20 years. Carl noted that 3.NF.A.1, “makes it look like you have to teach honors algebra and have a Rosetta stone to translate.” Carl elaborated further on his feelings of 3.NF.A.1 by stating,

Just the wording itself is very involved… I wouldn’t be able to do it . . . could you give me this in the child terminology. If I posted this standard as it says … they would be totally overwhelmed and I would be putting out fires in my room rather than teaching.

Carl was able to explain major skills that students need to be equipped with in order to understand fractions.

Carl said that he has taught fractions as numbers that can be counted and equal parts of a whole or a set. His students learn what the numerator and denominator are and use a variety of representations of fractions such as graham crackers, tiles, pictures, numbers, shapes, and locations on a number line. Carl stated that he would teach to this standard with learning experiences that include dividing objects into equal parts, connecting fractions to pictures, words, and things, working with different representations of fractions, counting portions, and recognizing that the parts of the fraction are of equal size. However, he did not mention the special emphasis that 3.NF.A.1 places on unit fractions.

Carl noted that his students study fractions for several weeks each year. Yet, he has not had trouble understanding the meaning of a fraction standard until he encountered the CCSSM.

Emmy stated that she found the wording of 3.NF.A.1 troublesome. She said that teaching to this standard requires that students understand that the bottom number of a fraction is how many equal parts are in the whole. Emmy requires students to fold paper and label the portions as fractions. The students manipulate the fraction strips to understand their relationship to each
other (e.g. halves to thirds to fourths), identify a fraction’s location on a number line, and learn that pieces of a fraction (of the numerator) are equal. The students also play fraction games such as cover up and war (similar to the card game but with fraction cards) where students collaboratively identify and combine fractions, identify larger and smaller fractions from a group of fractions, and explain and defend their solutions. Emmy has taught to this same standard since 2004 as a third grade generalist. Yet, she did not recognize the special emphasis on unit fractions.

Charlotte stated that the use of variables in 3.NF.A.1 made it, “difficult to even read.” She went on to say a content standard should simply, “tell me what I have to teach and my students need to learn” and that interpreting a standard “should not be rocket science.”

Charlotte identified the focus of this standard to be on recognizing a unit fraction to be a unit to a whole and used the example of 1/10. Charlotte said that she would teach to this standard by using fraction bars, shapes, unit fractions, and manipulatives. She would ask students to identify a given fraction among varied fractioned shapes. Students would learn part to whole, play fraction games, relate fractions to locations and numbers on a number line, dividing shapes into fractions, drawing figures to represent fractions, and reinforce concepts with worksheets.

The teachers stated as far back as they can remember the third grade mathematics curriculum has always included the teaching of fractions. Their long time mathematics education guidebook, *Math Expressions* (Fuson & CMWRP, 2006a, 2006b, 2011) has directed them to teach students to understand fractions as numbers and parts of a whole. *Math Expressions* and the other reform mathematics programs the generalists have used employed plain language to explain student learning goals and how to teach fractions. The teachers have
used these programs to dictate their planning, instruction, and assessment practices since 1996 (See Appendix T).

*Math Expressions* calls for instruction on fractions from first through fourth grade (Fuson & CWWRP, 2006c). The *Math Expressions* program recommends 20 lessons for fractions instruction in third grade. During the unit students learn: about the meaning of fractions, to see fractions as equal parts of a whole or set, the number under the fraction bar is the number of parts the fraction is divided into and is called the denominator, the number above the fraction bar is the number of parts we are dealing with and is called the numerator, and that fractions can be constructed from unit fractions (e.g., $\frac{1}{4}$, $\frac{1}{2}$). This mathematics program stresses conceptual understanding of fractions. The teachers’ guide encourages teachers to use a variety of representations for fractions such as drawings, pictures, shapes (e.g., circles, hexagons, squares, rectangles, and pentagons) manipulatives, and as places on a number line. The first third grade lesson for fractions directly relates to 3.NF.A.1. *Math Expressions* offers learning experiences that ask students to identify a unit fraction ($\frac{1}{b}$) such as $\frac{1}{6}$ and recognize it as an amount that can be counted. Students should also be required to divide a figure or object into equal parts, connect fraction symbols to pictures, words, and objects (manipulatives), work with these varied representations of fractions, discuss equal parts, counting portions, recognize that parts of the fraction are of equal size, and identify the numerator and denominator. This instruction is in harmony with that recommended by experts in CCSSM mathematics instruction (Barlow & Harmon, 2012).

Barlow and Harmon (2012) noted that instruction relative to 3.NF.A.1 ought to include many lessons on problem solving that require dividing shapes (wholes) into equal parts and representing these parts as fractions; representing fractions with pictures and manipulatives;
helping students recognize that equal portions of like wholes do not have to have the same shape; identifying a numerator as the top number of the fraction that identifies the amount of parts of a given size; identifying the denominator as the bottom number that identifies the number of equal portions a whole is divided into; counting the parts of a whole (i.e., \(1/b\) a unit fraction) and representing the solution in the language of fractions \((a/b)\).

**Beginning Understanding**

The foreign and abstract reform mathematics vocabulary in the SMP caused these standards to be difficult for the generalists to interpret. As a result of their inexperience with the terms *decontextualize, contextualize, model, precision, structure*, and the foreign example of the calculation of slope in SMP eight the teachers were not able to explain the complete intent of SMP two, four, six, seven, and eight. Table 4 shows how each generalist interpreted each SMP with a unique explanation. When asked to explain the SMP they were able to see the most outstanding or superficial aspects of the SMP but missed the deeper meanings.

They all recognized persevering and sense-making during problem solving (SMP one), building, presenting, justifying, and critiquing solution strategies (SMP three), and using the proper tool to solve problems (SMP five).

The generalists could not explain the processes of decontextualization and contextualization, and the use of representation in SMP two. They also missed a deeper aspect of SMP two - students relating representations and procedures to each other. Emmy and Charlotte could not explain what modeling with mathematics meant (SMP four). In SMP six the generalists missed the importance of precise calculation in order to support precise communication. In other words, they did not grasp the full meaning of the word precision. The seventh SMP was misunderstood by the generalists as a result of their lack of understanding of the term structure (seeing the big ideas and operations and their connections within a problem).
### Table 4

*Ideas Constructed of the SMP by Third Grade Generalist Teachers*

<table>
<thead>
<tr>
<th>SMP #</th>
<th>Carl</th>
<th>Emmy</th>
<th>Charlotte</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perseverance during problem solving, showing your work, understanding the problem</td>
<td>Students persevering during problem solving, making sense of the problem</td>
<td>Making sense of problems, persevering in problem solving, self-explanatory</td>
</tr>
<tr>
<td>2</td>
<td>Understanding solution strategies, knowing more than one way to solve a problem, recognizing when more than one operation is needed</td>
<td>Using different strategies to break apart and make sense of problems</td>
<td>Know the different properties of operations, make abstract concrete, application</td>
</tr>
<tr>
<td>3</td>
<td>To critique, support, and justify your answer</td>
<td>Having discussions where students ask and challenge each other to explain their solutions strategies</td>
<td>Being able to argue their solution, critique the reasoning of others</td>
</tr>
<tr>
<td>4</td>
<td>Using mathematics during everyday life</td>
<td>Using manipulatives to prove and explain your thinking</td>
<td>Representing solutions with different tools, graphs, &amp; tables in addition to words</td>
</tr>
<tr>
<td>5</td>
<td>Using the proper tools such as a ruler, computer at the right time</td>
<td>Using different strategies to solve problems such as drawings, acting it out</td>
<td>Being able to use tools such as ruler, compass, calculator, and draw geometric shapes</td>
</tr>
<tr>
<td>6</td>
<td>Solving a problem and teaching a peer in student friendly terms (difficult)</td>
<td>Making sure you get the right answer through efficient calculation</td>
<td>Getting the right answer and proving it is correct, related to number sense</td>
</tr>
<tr>
<td>7</td>
<td>See an answer as one of many ways to solve a problem</td>
<td>Difficult to understand what it is asking students to do</td>
<td>Relates to commutative and distributive properties, algebra (difficult for students)</td>
</tr>
<tr>
<td>8</td>
<td>Being able to solve the same type of problems, see shortcuts, recognizing the algorithm to solve problems</td>
<td>Finding the patterns of numbers within problems</td>
<td>Looking for patterns and geometric series, related to reasoning</td>
</tr>
</tbody>
</table>
The generalists thought structure should be replaced with pattern. Emmy struggled and was unable to provide any clarification of SMP seven. This was the result of her inability to interpret the term structure; she felt its meaning was identical to pattern. The use of the sophisticated and foreign example of the calculation of slope from middle school mathematics in SMP eight clouded their understanding of this process standard. Carl described SMP eight as “very confusing.” Last, the generalists failed to see the more arcane aspects of SMP eight, the importance of maintaining oversight of the entire problem (maintaining a big picture view) while attending to details and students gaining procedural fluency with conceptual understanding through problem solving.

Carl simply described the entire SMP as, “ambiguous” and noted that the language in the SMP as not teacher friendly. Carl remarked that a beginning teacher should approach the learning of the SMP by stating, “You need to stop and take a deep breath… I would say maybe do one or two, attack even though you need to do all eight and apply all eight, I would say you can’t as a new teacher there is going to be so much on your plate.” Charlotte found the SMP to be dense and difficult for her to unlock its meanings. She described the terminology within the SMP as a major source of difficulty and in need of revision by stating,

I think the vocabulary is really difficult to understand. It is wordy, it is more complex. I would rather see it stated in more kid friendly terms. The ones I found (through an internet search) and I printed out are more bulleted and they are bright, and more colors, and examples with them. It gives them (students) this is what we are talking about.

Emmy elaborated on her understanding of the SMP when she said, “I am trying to wrap my brain around them.” She also noted that the SMP are new. However, the last two State frameworks contained process standards.
Overlooked Principles

The generalists failed to see the guiding principles of the CCSSM: focus, coherence, and rigor. Yet, they achieved uniformity in their grasp of the meaning of what the student learning goal understand means.

The generalists failed to identify the CCSSM guiding principles (the key shifts of the CCSSM). None of the generalists noted the importance of all three guiding principles (Emmy recognized coherent nature of the CCSSM). These key shifts are essential for educators to understand in order to implement the CCSSM (CCSSI, 2010).

The generalists missed the four major areas of instructional focus: building skill for multiplication and division within 100; achieving understanding of fractions with an emphasis on unit fractions; gaining understanding of the structure of rectangular arrays and area; and defining and examining two-dimensional shapes (CCSSI, 2010). Only Emmy recognized the importance of coherency or the connected and cumulative nature of the SMC and SMP. They also neglected the importance of cognitively demanding learning with procedural fluency, conceptual understanding and application of skills and understanding – rigor.

Five grade three content standards including 3.NF.A.1 stated that students should learn with understanding. The CCSSM require students to demonstrate understanding more than previous State standards did (Porter et al., 2011). Mayer (2002) defined understanding as the ability to explain, interpret, give examples, make comparisons, categorize, and make inferences. The generalists had a common interpretation of this competency.

The third grade teachers described understanding as being able to explain and defend a solution pathway to a peer or teacher in terms that will be understood. The CCSSM noted that the SMC that begin with understand are places where students should demonstrate the competencies identified in the SMP (CCSSI, 2010).
Carl identified the CCSSM content that will be tested by the PARCC high-stakes standardized test as a key aspect of the CCSSM. He also identified number sense as the most essential skill for students to gain.

Charlotte described the CCSSM as involving a focus on the problem solving process, explaining solution strategies, exploration, and student learning for deep understanding. She pinpointed learning many ways to solve multiplication and division based problems as the CCSSM’s most important third grade content.

Emmy described the CCSSM as requiring student learning for understanding as well as a problem-solving based and a cumulative progression where skills learned in a previous grade are built upon in subsequent grades. She stated that the most important content was multiplication followed by fractions and two-dimensional shapes.

How the Reform was Understood

The central research question for this research asked how third grade generalist teachers at the Leibniz School learned from and about the CCSSM and their perceptions of what the CCSSM is asking them to do. Four major themes shared by the three generalists resulted from data analysis of all of the minor themes. These themes included developing understanding; few and basic messages; inadequate, insufficient learning; and foreign terminology, superficial understanding (shown in bottom box of Figure 5). Figure 5 provides an overview of the Leibniz context, how the CCSSM was represented, how the teachers engaged in sense-making, the teachers experiences with reform mathematics, and the ideas the teachers constructed about the CCSSM.
State version of CCSSM: Guiding principles, SMC, & SMP released March, 2011
Expressed in abstract, wordy, ambiguous, and foreign reform mathematics language

**Euler School District**
Distributed CCSSM December 2011; Created and implemented benchmark assessments, Began Vision 2020 initiative to adopt math program; Implemented online diagnostic assessment and remediation program; recommended math courses

**Leibniz Elementary School**
ELA focused; nine initiatives competing for PD time; 18 years of reform mathematics curricula

<table>
<thead>
<tr>
<th>Test Score Messages</th>
<th>Miscellaneous Messages</th>
<th>Basic SMP Messages</th>
<th>Few CCSSM messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpretation of State and district test scores, future PARCC, Symphony Math</td>
<td>Lesson plans, math language &amp; questioning, math competition, math night, test data, websites, courses</td>
<td>Maria’s SMP Seminar</td>
<td>SMP course from Ada - SMP 1,2 &amp; 7 Maria’s SMP seminar</td>
</tr>
</tbody>
</table>

**How teachers have engaged in sense-making of CCSSM messages**
Team Data review
Solo Interpretation
Interactive Problem Solving
Group Interpretation

<table>
<thead>
<tr>
<th>Carl</th>
<th>Emmy</th>
<th>Charlotte</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accelerated math student Hybrid teacher Jack of all trades Math is fun</td>
<td>Getting-the-right-answer math student A-ha reform mathematics ELA-focused school Student-centered teacher</td>
<td>Traditional math student Developing reform math understanding ELA-focused teacher Technology infused Active student learning</td>
</tr>
</tbody>
</table>

**CCSSM Ideas Constructed**
Tested curriculum Experienced yet inexperienced Beginning understanding Overlooked principles

**Aspects of CCSSM difficult to understand**
Tested curriculum Experienced yet inexperienced Beginning understanding Overlooked principles

**How teachers learned about the CCSSM**
Developing understanding Few and basic messages inadequate, insufficient learning
Foreign terminology, superficial understanding

**Perceptions of the CCSSM**
Developing understanding Few and basic messages inadequate, insufficient learning
Foreign terminology, superficial understanding

Figure 5. How the CCSSM means to Carl, Emmy, and Charlotte
Developing Understanding

The generalists’ experiences with reform mathematics as teacher learners and teachers have equipped them with a developing understanding of the reform mathematics content and process standards in the CCSSM.

As mathematics (K-16) students none of the generalists (and administrators) participated in learning reform mathematics. The teachers first participated in reform mathematics (teacher) learning during Grace’s professional development at the Leibniz School throughout the mid to late 1990’s. They also learned about the content, pedagogy and language of reform mathematics from many years of teaching with reform mathematics curricula.

Carl has used the State’s reform mathematics curriculum frameworks and reform textbooks to direct his teaching for 19 years. Charlotte has taught with these curriculum and teaching guides for 18 years as a generalist and special educator; while Emmy has worked with these reform mathematics curricula for 11 years as an elementary generalist.

The teachers also received some reform mathematics professional development in 2012 and 2014 from a reform mathematics professional development provider’s (Ada) courses and a 39-minute seminar on understanding the SMP respectively. Additionally, Emmy worked with a math coach as a generalist in the Noether District for two years and received graduate level training in reform mathematics while she was working toward her generalist teaching credential. The cumulative effect of these professional development sessions provided the teachers with a developing understanding of the CCSSM.

Few and Basic Messages

Since the CCSSM were released by the State in March, 2011 the teachers have obtained many messages related to the CCSSM. Yet, they have received few and basic messages that
have helped them understand the CCSSM and translate its content into instruction. The generalists received a wide variety of messages about the CCSSM from district professional development, Euler administrators, independent searching of the internet, Ada’s SMP course, and Maria’s SMP seminar.

The messages that the teachers received from administrators during the whole day in-service on October 15th and two Tuesday afternoons focused on improving test scores. During these meetings there was no sense-making of the standards related to scores/items since it was assumed that teachers understood them. Other district in-service sessions focused on helping teachers implement a using a web-based mathematics diagnostic assessment and remediation program.

The teachers got many miscellaneous CCSSM related messages from administrative memos. These messages included an offer to take mathematics courses, lesson plans, recommendations for using mathematics language and questioning styles, an invitation for students to join a mathematics competition, and to teachers to plan a mathematics night, and reminders to turn in test data. Other assorted messages came from the generalists’ independent online searches such as desktop and mobile software applications, websites, and lesson ideas.

Finally, the teachers received messages that helped them make sense of the SMP from two mathematics teacher educators. Ada’s course helped teachers understand SMP one, two, and seven through interactive problem solving. Maria’s course provided basic interpretations of the SMP.
Inadequate, Insufficient Learning

A hodge-podge of professional development activities with an insufficient focus on the CCSSM, inadequate instruction, and limited time for helping teachers understand the CCSSM at the Leibniz school has limited understanding of what the CCSSM is asking them to do.

The third grade teachers participated in nine initiatives that competed for their professional development time during the 2013-2014 school year (see Figure 3). The greatest portion of professional development time was dedicated to teacher evaluation protocols, student grading, and parent conferences (about half of the total time). Within this potpourri of professional development the generalists were provided with one 39-minute seminar on the SMP, training on the new teacher evaluation program, and a large amount of time for reviewing student assessment data. Further, Carl, Charlotte, and Emmy each stated that they have not received professional development from any source that addressed how English language learners and special education students can best learn the CCSSM.

The type of instruction regularly provided to teachers at the Leibniz School could best be described as a transmission (teaching as telling) of information, concepts, and procedures to teachers and not active learning. During normal Euler professional development there is little to no sustained active learning and instruction designed to help teachers construct understanding that starts from what they understand and assists them in constructing understanding of the unfamiliar elements of the CCSSM.

Other than reviewing test scores, items, tasks, and related standards the generalists could not recall any mathematics professional designed to promote teachers ability to provide mathematics instruction since Grace’s retirement. The teachers could not identify any district developed professional development in the area of mathematics from 2004 (when Emmy
returned to the Leibniz School) to 2012 (when they attended Ada’s math practices course). Emmy described her district provided professional development for mathematics as, “absolutely insufficient, I would say almost nonexistent.” Emmy went on to remark, “we need all the support we can get.” The generalists concurred that Leibniz needs a full time math coach who can help the school’s teachers promote their understanding of reform mathematics and the CCSSM.

Maria the math coach has attempted to help; however, her one day a week service at Leibniz and the lack of time for mathematics within the Leibniz professional development schedule has limited her ability to assist the generalists in decoding the foreign words, examples, and phrases within the CCSSM. Further, the generalists lack of time (one 45-minute meeting per month) to meet and discuss teaching related issues has also inhibited the time they have to make sense of the CCSSM.

**Foreign Terminology, Superficial Understanding**

As a result of their lack of experience with reform mathematics terminology as well as the abstract language and complex examples used in the SMC and SMP the generalists have attained a superficial understanding of what the CCSSM is asking them to do in terms of providing instruction and student learning experiences. The abstract, unfamiliar reform mathematics terms used in the SMP blocked the generalists’ understanding of the full intent and significance of SMP two, four, six, seven, and eight. These unfamiliar words included contextualize, decontextualize, model, precision, and structure. Additionally, the middle school example of the calculation of slope used in SMP eight and its nonconcrete language caused the generalists to miss its overall intent. In the SMC the use of variables to show how unit fractions can be used in the number and operations - fractions standard 3.NF.A.1 constrained the generalists’ sense-making efforts of this standard. Finally, the generalists failed to see the guiding principles of rigor, coherence, and focus as guiding principles of the CCSSM. The
generalists stated that they need greater access to and time to spend with an expert in reform mathematics education who can assist them in deciphering these demanding aspects of the CCSSM. Charlotte elaborated on the generalists need for time and support by noting,

I think we need support, we need professional development, I think we need the math coach working with us as with the students. I think we need someone to come in and model some of these things for us. I think it is the same concepts that we have taught year after year but the vocabulary has become so enriched . . . I would like someone to come in here with those eight standards and tell me how this would look in the classroom.

The generalists are willing to put in the effort required to translate the CCSSM into teaching and learning. When describing her understanding of and desire to learn the SMP Emmy said,

I am not comfortable with the math practices yet to be perfectly honest with you but I do want, I believe in them, the Common Core and the math practices as they are written only will bring out a deeper understanding and bring out exactly what my philosophy is, push kids wherever they are to go forward. So it is my job to make sure that I am following the curriculum.

Emmy also underscored why it is important to learn what the CCSSM are asking her to do by stating, “I need to know the Common Core so that I know what is going to be assessed on the state test or the new state test . . . I need to know what they need to be able to understand.”

**Summary of Findings**

This research found that the elementary generalists are developing their understanding of reform mathematics, have received few and basic messages about the CCSSM from professional
development, have received inadequate and insufficient professional development to help them learn about the CCSSM, and the foreign terminology in the CCSSM caused them to miss these unfamiliar elements of the reform leaving them with an understanding of the most superficial aspects of the reform.
Chapter V: Discussion of the Findings

The purpose of this chapter is to discuss the major findings of the research, the practical implications for developing reform curricula, and strategies for improving the response of school districts and teachers’ understanding of reform curricula. This chapter’s contents contain a review of the problem of practice, the research purpose and questions, the research methodology, a discussion of the findings, practical implications, limitations of the study, conclusions, and suggestions for future research.

The Problem of Practice

The CCSSM is asking teachers to change and improve the teaching of mathematics. This reform curriculum identifies content and implies instruction with language that is abstract, foreign, and challenging for elementary generalists to understand. Teachers must engage in learning about the CCSSM in order to transform the reform message into an understanding of: what is to be taught (i.e., content), the pedagogy that the reform implies (by the SMP), and the major ideas that underpin the curriculum (Elmore & McLaughlin, 1988; Fullan, 2007; Lawrenz, Huffman, & Lavoie, 2005).

Teachers and schools need to construct their implementation of the reform based upon their understanding of these three parts of the innovation (Cohen & Ball, 1990a; Fullan & Stiegelbauer, 1991; Weatherly & Lipsky, 1977). However, an ongoing problem, and the research problem of this study, is that teachers who are expected to implement curricular reform often misunderstand or do not gain an adequate understanding of the reform even when they make great efforts to make sense of it (Cohen & Hill, 2000; Firestone et al., 1999; Fullan, 2007; Gross et al., 1971; Hall & Hord, 2006). Further, sense-making of the CCSSM may be more difficult for elementary generalist mathematics teachers since they may neither have the time nor
sufficient experience with reform mathematics needed to understand what the CCSSM is asking them to do.

**Research Purpose**

Teachers cannot implement a curriculum reform that they do not understand (NCSM, 2013). Given the likelihood that educators may not understand parts of a curriculum framework that requires changes to what students will learn, how students should learn, and the instructional behavior of mathematics teachers in at least 87% of the schools in America (Dingman et al., 2013, p. 561) it is important for policymakers, professional development providers, and school leaders to learn about the ideas that teachers are constructing about the CCSSM (Achieve & U. S. Education Delivery Institute, 2012). Little is known about how teachers are learning about the CCSSM and the interpretations they have constructed from the CCSSM. Thus, the purpose of this study was to explore how elementary generalists are engaging in making sense of the CCSSM and the ideas they constructed relative to the CCSSM. An understanding of teachers’ ideas of this reform message can assist in the planning of professional development that promotes teacher understanding of the CCSSM.

**Research Questions**

The central research question for this study explored how three elementary generalists at the Leibniz Elementary School in the State learned from and about the CCSSM and what their perceptions were of what the CCSSM is asking them to do. This research included four sub-questions. The answers to the sub-questions informed the overarching question. Sub-questions for this research included:

1. What were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM?
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?

3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?

4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

Revisiting the Research Methodology

Instrumental case study methodology was used to explore the central phenomenon – teacher understanding of the reform curriculum (unit of analysis). The participants included three elementary generalists, a retired generalist/mathematics educator, two administrators, and the math coach. The data sources included semi-structured interviews, observations of professional development, and document collection. Minor themes were identified for each sub-question from codes using constant comparison. The researcher developed the minor themes into four major themes through constantly moving back and forth between interviewee quotes, codes, memos, the sense-making theoretical framework, the literature base, and minor themes (Creswell, 2012; Glaser & Strauss, 1967/1973).

Discussion of the Findings

What teachers comprehend from a reform message depends upon the interaction of the educator’s cognitive structures, the social context, and how the reform message has been represented (Spillane et al., 2002; Yanow, 1996). The following paragraphs show how the findings relate to the literature review, theoretical framework, and the problem of practice.

Developing Understanding

What and how the generalists learned from and about the CCSSM related to their experiences with reform mathematics as teacher learners and teachers. These experiences from
in and out of district professional development, grade level meetings, and independent learning equipped them with a developing understanding of the reform mathematics content and process standards in the CCSSM. This suggests that the teachers may be slowly developing an understanding of this reform. It can take districts between five and 10 years to fully implement a curriculum reform (Collins, 1997; Fullan & Stiegelbauer, 1991).

The literature review and theoretical framework demonstrated that teachers build their understanding of reforms upon their cognitive structures (experience, beliefs, attitudes, and knowledge) (Bransford et al., 2000; Spillane et al., 2002). In other words, what elementary teachers learn from the CCSSM depends on what they have gained from their experiences (Majone & Wildavsky, 1978). The elementary generalists had little experience with reform mathematics terminology to build an understanding of the CCSSM. Some of their experiences supported their understanding while others constrained it.

A major supporting element is the generalists desire to learn the CCSSM. The three generalists stated that they will continue to try to learn the CCSSM for a variety of reasons (e.g., CCSSM content will be tested, it is important for student learning). This finding is consistent with research that stated generalists want to learn and implement the CCSSM (Gewertz, 2012b; Hart Research Associates, 2013). Additionally, unlike their national peers who are for the most part providing traditional mathematics instruction the Leibniz third grade teachers have already been providing reform mathematics instruction for their entire careers as generalists (NCSM, 2013). Yet, their commercially developed mathematics program may be both a support and a constraint toward their understanding.

The CCSSM is not an enormous instructional shift for the State. The generalists have worked with rigorous State mandated and commercially developed reform mathematics curricula
for their entire careers as generalists. This has allowed them to gain some familiarity with the content and pedagogy of the reform mathematics contained in the CCSSM. However, this long experience of being directed by curriculum resources may be constraining their efforts to understand the CCSSM.

Remillard (2005) stated that teachers often evade the work of trying to interpret a curriculum reform when their school adopts a commercially developed textbook or program. The textbook becomes the default curriculum for teachers to use like a recipe to provide instruction (Gross et al., 1971; Lloyd, 2002; Remillard, 2005; Sosniak & Stodolsky, 2000). Teaching in this manner blocks sense-making efforts of the CCSSM and may not prepare students for college and careers. Last, the commercially developed program may not include the emphasis on rigor, coherence, and focus that the CCSSM contains (CCSSI, 2012d; NCSM, 2013; Wu, 2011).

Similarly, accountability pressures for high student test scores often result in districts promoting teaching as implementing a curriculum program and pressuring teachers to implement them with fidelity according to a pacing guide (Talbert, 2010). Elena, the Leibniz principal stressed the importance of the generalists following the textbook or curriculum program with a high level of fidelity. The fidelity mandate might prevent teachers from taking the time to understand the CCSSM since they will simply be following a program.

Other constraining structures include teacher preparation and the role of the generalist. The Leibniz generalists all had weak teacher preparation experiences in mathematics. Most elementary teachers are not prepared well to teach reform mathematics since they usually take only two or three mathematics courses as part of their teacher preparation (Fennell, 2006; Greenberg & Walsh, 2008; Michigan State University, 2006; EPERC, 2013).
The Leibniz generalists teach ELA, mathematics, science, and social studies with a strong emphasis on ELA instruction. The third grade generalists spend an average of 105 minutes per day providing instruction in ELA versus 60 minutes providing mathematics instruction. Further, Leibniz was described as an ELA focused school. Charlotte and Carl believed that ELA education was more important than mathematics education. Ball and Cohen (2006) noted that most elementary schools are more focused on ELA than mathematics education. The robust emphasis on ELA may be a reason why it is unusual for a generalist to have a robust understanding of reform mathematics content and pedagogy (AMTE, 2010; Wu, 2009).

**Few and Basic Messages**

Since the CCSSM were released by the State in March, 2011 the teachers have obtained many messages related to the CCSSM. Yet, they have received few and basic messages that have helped them understand the CCSSM in order to translate its content into instruction.

The generalists received mathematics student test score related messages, miscellaneous CCSSM related messages from administrative memos and internet searches, basic messages on the SMP, and few messages directly related to helping the teachers understand the CCSSM. Only Maria the math coach and Ada the reform mathematics educator provided the teachers with messages congruent with the CCSSM designed to promote their understanding of the SMP. There were little to no messages sent to the generalists intended to advance their understanding of the SMC. Further the Leibniz School did not offer any professional development to the generalists during Tuesday or full day in-service times from November, 2013 through February, 2014.

Most teachers are learning about the CCSSM from their district and school level administrators who do not possess a strong understanding of the CCSSM (ASCD, 2012; EPERC, 2013). This was true for the principal Elena who repeatedly stated that mathematics was always
difficult for her. She may not have felt comfortable providing mathematics professional development. Further, Elena held a behaviorist view of mathematics instruction (e.g., teachers should show and tell students how to solve problems) which is not congruent with the type of instruction implied by the SMP (CCSSI, 2010). This finding is consistent with Coburn (2005) and Spillane’s (2002) findings that administrators attempting to implement reform curricula often possess behaviorist beliefs about instruction. The district level administrator (Maria) and the Leibniz principal (Elena) designated the math coach to help teachers understand the CCSSM. However, Maria’s schedule allowed her to be at the Leibniz School only on Mondays. Finally, the teachers seemed most interested in the tested curriculum or the content standards that will be tested (Herman & Linn, 2013). This finding was in line with a study of educators in four states whose greatest concern was the tested curriculum (ASCD, 2013).

Inadequate, Insufficient Learning

A hodge-podge of nine professional activities with an insufficient focus on the CCSSM, inadequate instruction, and limited time for helping teachers understand the CCSSM at the Leibniz school has limited teacher understanding of what the CCSSM is asking the Leibniz generalists to do. In other words, professional development has largely been a constraint toward teacher understanding of the CCSSM.

Many curriculum reforms are accompanied by insufficient professional development (Stephen & Varble, 1994). Successful implementation of a curricular reform should be an ongoing process of learning about the innovation through professional development (Fullan, 2007).

The Leibniz generalists participated in traditional professional development on nine topics with little follow-up and support during the 2013-2014 school year. Such traditional
professional development can be an obstacle for elementary generalists to learn about the CCSSM (Loveless, 2013). The Leibniz School commonly offers traditional professional development (Handal & Herrington, 2003). This occurs when teachers receive information from a hodge-podge of topics of insufficient duration to permit learning with little or no follow up and support to help them learn (Garet et al., 2001; Little, 1993). Like Euler, districts across America are simultaneously trying to use professional development to support the implementation of the CCSSM as well as the CCSSELA and educator evaluation policies (ASCD, 2012). The demand for professional development has surpassed the ability of many districts to implement it (ASCD, 2012). The Leibniz teachers regularly received passive, teacher-centered, transmission style (teaching as telling) instruction during professional development (Kyriacou, 2012). This type of professional development that has been described as fragmented, low level of cognitive demand, and does not consider how teachers learn is insufficient (Borko, 2004).

The generalists need to learn how to teach the inquiry-based, active problem solving methods implied by the SMP. Yet, these Leibniz third grade teacher learners are not becoming engaged in continuing, active problem solving, collaborative learning (with access to an expert in reform mathematics content and pedagogy such as Ada, Grace, or Maria), connecting new ideas to what they know, and critically reflecting on their practices and assumptions (Bransford et al., 2000).

The lack of time for CCSSM related professional development may have been the result of a misalignment between district and school goals and professional development planning and implementation. The 2013-2014 Leibniz school improvement plan had no mathematics goal other than the review of test scores. The district identified the need for a Common Core
implementation plan in 2011, but never created it. The Leibniz School identified the need for giving teachers time to learn the CCSSM in two school improvement plans, but CCSSM learning time was not provided to the third grade generalist teachers from 2010 to the completion of data collection for this study.

The Leibniz generalists did not receive professional development to help them understand the SMC; the guiding principles of focus, coherence, and rigor; or how English language learners and special education students can best learn the CCSSM. Relatedly, a national survey of teachers found that about three fourths of mathematics teachers stated that their district has provided insufficient professional development time for teachers to gain an adequate understanding of the CCSSM (Hart Research Associates, 2013). Other research found that most teachers have engaged in Common Core related professional development for three days or less; two-thirds stated that they were not well enough prepared to teach the standards to students with disabilities or English language learners (EPERC, 2013). Finally, professional development has focused on ELA over mathematics (EPERC, 2013).

**Foreign Terminology, Superficial Understanding**

Representations of the CCSSM enabled and constrained teacher understanding of the CCSSM. As a result of their lack of experience with reform mathematics terminology as well as abstract language and the complex examples used in the SMC and SMP the generalists have missed the unfamiliar aspects of the CCSSM and attained a superficial understanding of what the CCSSM is asking them to do in terms of providing instruction and student learning experiences. This finding relates to the literature on teacher understanding of reform policy.

Ben-Peretz (1990) found that what teachers interpret depends on their content knowledge, teaching experiences, classroom reality, pedagogical content knowledge, willingness
to accept ideas, and interpretive skills. If the change is represented too abstractly, the reform message is often misunderstood (Spillane et al., 2002). The more complex the reform the more likely teachers will misunderstand it (Fullan, 2007). Gross et al. (1971) found that teacher understanding diminished with the complexity of the innovation. Remillard and Bryans (2004) emphasized the importance of teachers receiving assistance in order to understand the difficult aspects of reform curricula.

The body of literature on the CCSSM noted its sophisticated language. The SMP use highly abstract, nebulous, and complex language that may be challenging for elementary teachers to interpret (Carmichael et al., 2013; Hull et al., 2012; McCallum, 2013; Wiggins, 2011). Hull et al. (2012) noted that they do not provide adequate guidance on how students are supposed to do mathematics. The SMC lack specificity and clarity and are long and verbose (Carmichael et al., 2013; Stotsky & Wurman, 2010; Thomas B. Fordham Institute, 2011; Wurman & Wilson, 2012).

As teachers of all subject areas elementary generalists such as Carl, Emmy, and Charlotte have not been equipped with the deep and specific knowledge of reform mathematics needed to make sense of the reform mathematics jargon and sophisticated examples in the CCSSM (Ma, 1999; Wu, 2009). Hope (2002) stated that teachers do not put forth the effort necessary to interpret the CCSSM. This is not true for the Leibniz generalists who continue to try to make sense of the CCSSM.

**Missed unfamiliar aspects.** Past studies have also shown that teachers may have missed or misunderstood this reform curriculum as a result of their cognitive structures not supporting their ability to recognize, connect, and interpret these reform messages (Firestone, 1989; Spillane et al., 2006). The generalists’ sense-making efforts resulted in their failing to understand the unfamiliar and complex aspects of the CCSSM.
The Leibniz teachers missed aspects of the reform such as the number and operation – fractions standards that included foreign examples (i.e., those with variables) and abstract terms such as model, decontextualize, contextualize, precision, and structure in the SMC and SMP respectively. These findings are in harmony with those of the body of reform policy as perceived literature.

Several studies have found that teachers miss the intent of the unfamiliar aspects of reform policies. Cohen (1990) found that a reading teacher missed the unfamiliar aspects of a new reading reform. Beck et al., (1990), Czerniak and Lumpe (1996), and Vesilind and Jones (1998) found that teachers failed to notice the foreign aspects of science education reforms. Finally, Spillane (2004) noted that teachers did not recognize the unfamiliar elements of mathematics and science standards. However, the generalists recognized the familiar portions of the CCSSM.

**Recognized familiar aspects.** The generalists understood the familiar and most superficial portions of the CCSSM (e.g., persevering during problem solving, constructing and critiquing arguments, using appropriate tools strategically) (Spillane et al., 2002). This finding was also aligned with previous research.

Research has stated that educators and mathematics teachers comprehend the most outstanding elements within reform policy. Gross et al., (1971) found that educators understood the most superficial aspects of whole school change. Obara and Sloan (2009), Spillane and Zeuli (1999), Marsh and Odden (1991), and Guthrie (1990) all found that teachers comprehended the superficial parts of mathematics reforms.
Complex Representation

The sense-making framework stated that how a reform policy is represented can influence what educators understand from it (Spillane et al., 2006). The words used in the CCSSM came from its three authors: William McCallum, Phil Daro, and Jason Zimba (Daro, McCallum, & Zimba, 2010). William McCallum is a professor of mathematics (Arizona Board of Regents, 2014). Jason Zimba is a mathematics educator and former mathematics and physics professor (Student Achievement Partners, n.d.). Phil Daro is a director of mathematics professional development (Strategic Education Research Partnership [SERP], 2014). The words from their contexts had different meanings to the elementary generalists at the Leibniz School. Further, prior to writing the CCSSM they had little experience writing standards (Wurman & Wilson, 2012). Ravitch (2012, 2013) noted that the CCSSM were not field tested in classrooms prior to their release. Some period of piloting in a variety of elementary school contexts with the CCSSM might have allowed a revision that would have made the standards easier for elementary teachers to interpret.

A variety of groups provide different representations of policymakers’ reform messages (Spillane et al., 2002). Educational organizations such as members of state departments of education, professional organizations, school administrators, and textbook publishers make sense of policymakers’ reform ideas and re-create or re-represent the reform in diverse ways to teachers. In the Leibniz School Maria was the only professional development provider who represented the CCSSM to the teachers.

Basic Representation

Maria represented the SMP with a variety of basic, pictures, tables, and graphics. The generalists stated that her elementary representations written for elementary students helped
them understand the CCSSM (see Figure 4 and Appendix P). The generalists also wanted to know how the CCSSM would be represented on the new upcoming high-stakes test (by SBAC or PARCC).

**Testing Takeaway**

The teachers were attracted to the assessed (tested) curriculum since student test scores will be factored into their annual evaluations (ASCD, 2013; Glatthorn, 2000; Klein, 2013; McNeil & Gewertz, 2013). A study of teachers in four states found that their greatest concern relative to the CCSS was the high-stakes testing that will measure student achievement of the standards (ASCD, 2012). However, the professional development provided to the Leibniz generalists did not provide learning experiences related to the new high-stakes test.

**Practical Implications**

The following paragraphs offer an explanation by the researcher from a scholar practitioner perspective on how the major findings provide a stronger understanding of the problem of practice. Each of these insights includes recommendations for curriculum reformers (i.e., policymakers), school leaders, or teachers.

High level mathematics curriculum standards are needed to prepare our students to be college and career ready. Moreover, the well-being of a nation is in part related to the ability of its citizens to understand and use mathematical ideas. The CCSSM seeks to promote student learning in mathematics and requires that the key implementing agents, teachers in 87% of American schools (Dingman et al., 2013, p. 561), understand this reform and transform their understanding of it into appropriate instruction in order to realize the potential of the CCSSM to promote student learning.
The problem of practice for this study was that teachers who must gain an understanding of a curricular reform in order to implement it frequently do not. The generalists in this study did not fully understand what the CCSSM was asking them to do as a result of a lack of experience with reform mathematics terminology, insufficient time for clarification of the standards during professional development, and poorly communicated standards with complex reform mathematics language. The generalists have only been able to gain a developing understanding of the reform.

**Developing Understanding**

The generalists’ experiences with reform mathematics as K-16 students and during their professional development as teachers have equipped them with cognitive structures so that they could gain a developing understanding of what the CCSSM are asking them to do.

The generalists’ overall experience with reform mathematics provided them with a small foundation upon which to build an understanding of the CCSSM. The teachers had no experience with reform mathematics as K-16 students. Their major experience with reform mathematics was using the four reform mathematics textbooks (see Appendix T) required for mathematics education by the Euler district and State issued mathematics curriculum frameworks since 1996. The generalists also participated in about a dozen piecemeal professional development sessions in reform mathematics provided by Grace, Ada, and Maria over the last ten years.

The generalists missed or did not understand the more complex reform mathematics terminology and examples as a result of a lack of experience with and knowledge of reform mathematics language. Even though the previous State mathematics curriculum framework was quite rigorous and similar to the CCSSM; the generalists did not see this. They were unsure that they understood and were implementing the CCSSM as a result of the abstract and complex
language in the SMC and SMP. Thus, I recommend that the generalists spend time taking apart the SMC and receive assistance interpreting the SMP.

**Breaking down the SMC.** In order to understand what the SMC require students to learn the third grade generalists need to dissect and rebuild (in user-friendly language) each of the third grade content standards (Wiggins & McTighe, 2005). Such a process would include understanding the skills, attitudes, dispositions that students need to be equipped with in order to achieve a given content standard. This breaking down of the SMC can also promote understanding of how these content standards relate to each other to form a coherent whole. Further, it would be helpful for them to learn about the SMC for grades K-2 and 4-12 in order to gain insight into all the skills and understanding that their students need to acquire.

**Interpreting the SMP.** Successful interpretation of the challenging reform mathematics language in the SMP will necessitate that elementary mathematics specialists (e.g., Maria) collaborate with elementary generalists to facilitate understanding. Teachers need help in order to make sense of the complex terminology in the SMP and throughout the CCSSM. This research report includes a glossary (see Appendix A) of all the reform mathematics terms found in the SMP to help all educators interpret the abstract language in these process standards.

**More Time for Learning**

The second and third major findings of this research showed that teachers received few and basic messages related to the CCSSM as a result of too little time spent learning about the standards during district provided traditional professional development. The Leibniz School had nine professional development initiatives competing for time during the 2013-2014 year. There was no district provided professional development time for the teachers to make sense of the
The generalists were provided with 39 minutes to interpret the SMP. Teachers need to be given sufficient time to understand curriculum reforms.

The generalists spent most of their CCSSM related professional development time trying to interpret this curriculum reform independently. The generalists received few messages because they belonged to only a few mathematics professional development groups. They did not participate in alternative forms of professional development such as action research, lesson study, study groups, mentoring, peer coaching, or professional association conferences in order to gain diverse ideas on what the CCSSM is asking them to do in terms of instruction and student learning experiences. They received CCSSM related professional development from the Euler School District and Ada’s courses (who was contracted by the Euler School District). Much of the generalists’ independent study of the CCSSM was done in order to plan mathematics instruction each day. Elementary generalists need to be provided with more time with access to reform mathematics expertise during professional development. School administrators can be instrumental in helping teachers learn about curricular reforms.

Administrators are largely responsible for providing time during the school day for teachers to learn about State mandated reforms (EPERC, 2013). Furthermore, the success of a reform’s implementation depends upon the administration’s understanding of the reform. The decision on what professional development topics and the duration of these teacher learning experiences rests with district and school level administrators. Thus, school leaders must recognize the need and provide sustained professional development time for robust teacher understanding of reform curricula. Unfortunately, rather than trying to provide time for CCSSM learning the Euler administrators (and school district leaders across the country) are planning to adopt a textbook to represent the CCSSM.
A textbook adoption will allow administrators and teachers to avoid the work of trying to make sense of the instructional intents of the CCSSM (Remillard, 2005). When the textbook is adopted it can serve as a proxy for the CCSSM; teachers may follow its lessons like recipes in a cookbook. Therefore, teachers may not make an effort to make sense of and learn about the CCSSM.

If and when a textbook is adopted schools need to provide a sufficient amount of professional development time so teachers can learn about the CCSSM. Such learning requires that teachers understand what students need to learn (content standards), how students should learn that content (pedagogy implied by the SMP), and the guiding principles of focus, rigor, and coherence that underpin the CCSSM (Fullan, 2007).

A Mathematics Teacher Learning Environment

The third major finding stated that the way the Leibniz School implemented professional development was insufficient for helping teachers gain an adequate understanding of the CCSSM. The professional development that was offered relied upon transmission of information (sometimes called sit and get professional development) with little or no follow up and support to teachers. School districts are the major providers of professional development (Fullan, 2007). As such they should make an effort to provide high quality professional development. In order to improve the quality of mathematics professional development schools need to offer active reform mathematics teacher learning experiences and create teacher learning communities.

Active teacher learning. Teachers who need to implement the CCSSM should learn to understand its goals through active learning since this is the type of mathematics learning that this reform demands (Guskey, 2000). The Leibniz generalists stated that the reform mathematics
teacher educator Ada provided them with the strongest foundation of reform mathematics understanding. She did so by providing the generalists with active learning experiences. This professional development requires teachers to reflect on their assumptions, experiences, beliefs and understanding of mathematics (Spillane et al., 2002). Thus, professional development learning experiences can include hands-on activities using mathematics manipulatives; reflections; non-routine, real world problem solving; explaining, justifying, and defending strategies for solving problems; and solving problems collaboratively (Hill et al., 2008; NCTM, 2000). Social constructivism can be a key element in reform mathematics professional development.

A teacher learning community. The generalists did little as members of a teacher learning community to interpret and understand the CCSSM. The only time they learned as a third grade team was during Maria’s 39-minute SMP seminar. More collaborative learning could help teachers make sense of the CCSSM. Mathematics teachers can gain unique experiences, expectations, and assumptions on reform messages largely as a result of being members of diverse groups at national, state, and local levels. A mathematics teacher learning community could create a stronger mathematics culture within the school.

In a reform mathematics teacher learning community teachers could interact regularly to solve teaching and learning problems, share leadership, exhibit a willingness to confront others’ mathematics beliefs and assumptions and their own in a respectful manner, gain access to diverse mathematics resources, and maintain focus on promoting student learning in mathematics (McLaughlin & Talbert, 2006).

Providing sustained and robust mathematics professional development within a mathematics teacher learning community could go a long way toward helping teachers
understand reform mathematics language and the CCSSM. Such professional development could also move the school toward a greater focus on mathematics education.

The organizational history of professional development in the Leibniz School and in many elementary schools is more focused on ELA education than on mathematics education (Fennell, 2006; Wu, 2009). The skill sets of the staff, curriculum resources, professional development, and the school curriculum were oriented toward ELA. The School’s history of emphasizing ELA over math may have constrained the generalists’ sense-making opportunity by limiting mathematics professional development.

**Communicating Student Learning Goals in User-friendly Language**

The final major finding revealed that the generalists had a difficult time making sense of the CCSSM largely because of the complex, abstract, and foreign reform mathematics terminology used by the authors of the CCSSM. The words such as precision, model, structure, contextualize, and decontextualize in the SMP and the use of variables and problematic phrasing in SMC 3.NF.A.1 meant one thing within the authors’ community but were not understood in the teachers’ community of practice.

The CCSSM were developed by three mathematics scholars who had little experience writing standards. The State added some content standards (15%) to the CCSSM but did not change any of the abstract, complex language from the original standards developed by the authors. The CCSSM are based on the social constructivist reform mathematics ideas put forth by the NCTM. These ideas have existed for many years yet the generalist are not familiar with the reform mathematics terminology. The generalists need a “rocket scientist” (Charlotte’s words) or someone with the reform mathematics “Rosetta Stone” (Carl’s words) to translate the dense reform mathematics language into more teacher friendly language.
The CCSSM could have been written and organized in a manner that would have made them easier for elementary generalists to interpret. Charlotte stated that the SMC would be more easily interpreted and implemented if they were written with color coded domains in a bulleted format. Such a format would allow the content standards for each grade level to be printed on one page in teacher-friendly language that the State used previously.

Since 1996 the State employed user friendly terminology to communicate reform mathematics student learning goals in its mathematics curriculum frameworks. The State and the nation would do well to return user-friendly terminology in a revised CCSSM to teachers. The 1996 framework included habits of mind (student behaviors that support learning) in one or two sentences free of jargon that were readily understood by the generalists. For instance, one of these habits of mind stated simply, “Do I communicate to others how I solved a problem or justified my solution?” and another indicated, “In what ways do I reflect confidence in my ability to do mathematics? Confidence in mathematical ability brings with it an attitude of persistence when solutions are not apparent.” The Leibniz generalists stated that these former standards were easy for them to comprehend and implement.

The State’s second (2000/2004) framework contained more specific content and process standards written in terms that were readily understood by the Leibniz generalists. For example, the standard that 3.NF.A.1 replaced what was written in more concrete language. The former standard was written as follows,

Students engage in problem solving, communicating, reasoning, connecting, and representing as they: identify, and represent, and compare fractions (between 0 and 1 with denominators through 10) as parts of unit wholes and parts of groups. Model and
represent mixed numbers (with denominator 2, 3, or 4) as a whole numbers and a fraction e.g., 1 ⅔, 3 ½.

The 2000/2004 State curriculum framework also suggested process standards (habits of mind) for students to demonstrate in order to support and enable their learning of its content standards in its guiding philosophy (problem solving, communicating, reasoning and proof, making connections, and representations) and guiding principles (learning, teaching, technology, equity, and assessment). These behaviors were written in plain language that the Leibniz generalists understand effortlessly. For example, communicating stated,

Students develop this skill and deepen their understanding of mathematics when they use accurate mathematical language to talk and write about what they are doing. They clarify mathematical ideas as they discuss them with peers, and reflect on strategies and solutions.

The Common Core State Standards Initiative should consider rewriting the SMC more succinctly and removing the reform mathematics jargon from the SMP in order to make them both more user-friendly for teachers across America.

Limitations

The findings of qualitative research such as this with a small sample size do not generalize or transfer to other settings (Merriam, 2009). Therefore, the findings simply relate to the third grade generalists at the Leibniz School in the State. Another limitation of the qualitative research process is that researcher biases can influence the results of the study (Stake, 2010). Therefore, the researcher clarified his biases in the positionality statement (in chapter one). A final limitation relative to the researcher was that this was his first large scale research effort. There were other limitations associated with data collection.
The teacher’s understanding of the SMC was based on their interpretation of one major content standard. During data collection the researcher sampled the generalists’ understanding of all the grade three content standards by tapping into their understanding of one content standard (3.NF.A.1 from the domain of number and operations – fractions) from the entire set of grade level standards (26 content and 12 subordinate standards). Time did not permit the investigation of how teachers understood the remaining standards. Additionally, the researcher did not include observations of the generalists’ instruction in order to determine their understanding of the SMC.

Wiggins and McTighe (2005) stated that one who understands can apply what they have learned by using and adapting what they know to diverse settings. Thus, the researcher could have included observations of the generalists teaching lessons based upon the SMC in order to see application of the standards. This evidence could have been used to show how teachers understood or misunderstood these content standards. Additionally, the observations conducted in the study should have started earlier.

The researcher began his observations of professional development in November, 2013. However, the teachers began using the CCSSM in December, 2011. Hence, the researcher had to rely on interview and document evidence to determine what happened during district and individual professional development from December, 2012 to November, 2013. Further, during this unobserved time four key people, who were not part of this study, influenced the generalists’ professional development and in turn their understanding of the CCSSM.

The researcher was unable to include four significant subjects in the study. They included the former Euler superintendent (who retired in the fall of 2012), the interim superintendent (whose term of service ended in July, 2013), the assistant superintendent (who
resigned in July, 2013), and the reform mathematics teacher educator, Ada (who did not respond to an invitation to participate in the research).

**Conclusions**

This instrumental case study explored how three third grade generalists learned about and perceived the *Common Core State Standards* for mathematics. The research used a sense-making theoretical framework that demonstrated that teacher learning of a reform message depends on the teacher’s: experiences, beliefs, knowledge, and attitudes; social contexts; and how the reform message is represented. Data was collected with: semi-structured interviews of three generalists, one retired teacher, and three administrators; professional development observation; and document collection.

The major findings of this study and the related elements of the theoretical framework and literature review are identified in the following paragraphs.

**Developing Understanding**

The generalists’ experiences with learning reform mathematics as K-16 students and during teacher professional development have provided them with a developing understanding of the content and process standards of the CCSSM. The scholarship related to this finding held that what teachers learn from and about the CCSSM depends upon the interaction of their cognitive structures (i.e., beliefs, knowledge, attitudes), social contexts, and how the message is represented (Spillane et al., 2002). Moreover, the new information that they are trying to learn becomes a supplement to existing knowledge (Bransford et al., 2000).

Elementary teachers generally have not been prepared during teacher education programs or professional development to make sense of the abstract and complex terminology in the CCSSM (Ma, 1999; Wu, 2009). This may be a reason why school districts typically take five to 10 years to fully implement content standards (Collins, 1997; Fullan & Stiegelbauer, 1991).
Those with a stronger content and pedagogical content knowledge with reform mathematics are more likely to make sense of reform mathematics messages in ways that are congruent with policymakers’ intentions than those with less knowledge of reform mathematics (Hill et al., 2008; Spillane et al., 2006).

**Few and Basic Messages**

The Leibniz generalists received few and basic messages during district provided professional development that helped them understand the CCSSM. During their lone CCSSM-focused professional development experience (i.e., the 39-minute SMP seminar) the generalists experienced low level mathematics content. The research showed that the basic CCSSM message put forth by the Euler administration may have been a response to elementary teachers generally having little experience with reform mathematics language (Ma, 1999; Wu, 2009). Since learners build new knowledge by consolidating it with existing knowledge (Bransford et al., 2000) such a simple message could be a good place to begin teacher learning.

Administrators have been largely responsible for helping teachers understand curriculum reforms such as the CCSSM (ASCD, 2013; Spillane & Thompson, 1997). Thus, administrators must understand the reform in order for successful implementation to occur (Spillane & Zeuli, 1999). Yet, administrators typically respond to mandated curriculum reforms by adopting and implementing a textbook to serve as a proxy for the reform (Remillard, 2005). Unfortunately, most textbooks are not sufficiently aligned with the CCSSM (NCSM, 2013; Wu, 2011).

**Insufficient, Inadequate, Professional Development**

There was not enough professional development time allotted to help the Leibniz generalists understand the CCSSM. Further, Leibniz professional development was implemented through a lecture-based format. This type of traditional professional development
is insufficient for deep teacher learning (Darling-Hammond, 2010). The literature on professional development showed that teachers need to be engaged in sustained high quality professional development in order to understand this complex curricular reform.

About three fourths of American mathematics teachers have stated that their district has not provided enough professional development time for them to gain an adequate understanding of the CCSSM (Hart Research Associates, 2013). Most teachers have spent three days or less learning about the CCSS (EPERC, 2013). Moreover, this professional development has emphasized ELA over mathematics.

In order for teachers to understand and implement a reform mathematics curriculum they must engage in the content and type of learning advocated by the reform curriculum (Guskey, 2000).

Reform mathematics professional development requires that learners engage in learning that is interactive; focuses on content and how students learn that content; engage in problem solving; practice new methods of instruction; give and receive feedback on the skills they are learning; reflect upon their experience, attitudes, beliefs, and knowledge about how students learn mathematics their learning; examine student work; and confront their beliefs and teaching practices (Battista, 1994; Darling-Hammond & Richardson, 2009; Desimone, 2011; Spillane et al., 2006). This teacher learning should be ongoing, permeate the school day, and last at least 20 hours over half of a school year (Desimone, 2011).

**Foreign Terminology, Superficial Understanding**

The foreign terminology and language used in the standards blocked the generalists’ sense-making efforts. This resulted in teachers missing the more abstract aspects of the CCSSM and leaving them with a superficial understanding of the curriculum reform.
The literature on teacher interpretation of curriculum reform showed that complex reforms will be misunderstood by teachers as a result of their lack of experience with reform mathematics language (Cohen, 1990; Fullan, 2007; Hill, 2001). Curriculum scholars found that the SMC were lengthy, wordy, and vague (Carmichael et al., 2013; Wurman & Wilson, 2012) and the SMP were described as nebulous, highly abstract, and difficult to interpret (Hull et al., 2012; Wiggins, 2011). William McCallum (2013), the lead author of the CCSSM, defined the reform as difficult to read and hard to interpret in terms of the instruction and student learning actions they require.

Teachers must understand the entire document and especially how the SMP and SMC relate to each other (McTighe & Wiggins, 2012). Helping teachers understand the CCSSM will require sustained professional development with active learning, access to reform mathematics expertise, and ongoing support to teachers. Such professional development should be an ongoing process of teacher learning about the instructional intents of the CCSSM.

**Future Research**

The findings from this research showed that elementary generalists missed unfamiliar aspects of the CCSSM and gained a superficial understanding of the CCSSM. Yet, the CCSSM was not the only reform the teachers had to learn. They were also learning about the new teacher evaluation initiative and the CCSSELA.

Future research could focus on what teachers understand and misunderstand about each of the reform initiatives: the CCSSM, CCSSELA, and the teacher evaluation program. Alternatively, it could focus on either teacher understanding of the CCSSELA or the teacher evaluation initiative. The present study also identified administrator misunderstanding of the curriculum reform.
Subsequent research could explore how administrators achieve and maintain understanding of reforms, how they communicate their understanding of the reform, and how they determine the content and type of professional development that teachers receive. A study that builds on this research might explore the issue of teacher understanding through a school culture lens.

In order to build on this study potential researchers may do well using a theoretical framework based on school culture (Schein, 1985; Schoen & Teddlie, 2008). Such a framework might show the influence of school culture on administrators’ and teachers’ responses to and understanding of a reform curriculum.
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Appendix A: Glossary

The following CCSSM related terms (used throughout this manuscript) have been defined in order to provide the reader with a greater understanding of the terminology in the CCSSM. The following definitions were developed from a synthesis of descriptions contained within *Principles and Standards for School Mathematics* (NCTM, 2000), *Adding it Up* (Kilpatrick, Swafford, & Findell, 2001), and the *Common Core State Standards for Mathematics* (CCSSI, 2010).

**Coherence**: This term refers to the necessity of the curriculum being strengthened by its connections between domains or strands (e.g., algebra, geometry, measurement). In a coherent curriculum grade level standards form a cumulative progression where concepts, ideas, and skills build on and strongly relate to one another. Such a curriculum can allow learners to construct greater mathematical understanding, attitudes, dispositions, and skill.

**Communication**: This word relates to speaking, reading, writing, listening to, and showing ideas to others and making understanding visible. Communication allows students’ ideas, strategies and solutions to be revised, organized and connected, made explicit and coherent, reflected upon and improved. When students communicate their ideas they learn to make their ideas specific and persuasive. As they try to understand another’s ideas, thinking, and strategies they can gain a greater understanding of concepts as they try to see diverse points of view. They also learn to use and convey ideas in a precise manner; justify reasoning and formulate questions; and present, defend, and critique solution strategies, ideas, and solutions.

**Computational fluency** (procedural fluency): This refers to being equipped with efficient, flexible, appropriate, and accurate methods for computing (adding, subtracting, multiplying, and dividing). Such students are fluent in mental math, using paper and pencil, using an algorithm as
a general procedure, and employing technology in computing answers involving numbers (e.g.,
whole numbers, fractions and decimals) to identify solutions and estimate the results of
computations. Students should also recognize which of many methods or strategies is best based
for a given problem context. Such fluency requires balancing and connecting procedural fluency
with conceptual understanding. Last, learners should be able to determine if an exact answer or
an estimate is appropriate for a given problem.

**Conceptual understanding**: This is comprehension of mathematical concepts, operations, and
relationships. Conceptual understanding is when knowledge is consolidated into a coherent
whole. This process allows students to gain new understanding by merging new information and
using what they know to solve non-routine and challenging problems.

**Conjecture**: A type of guess aided by information. Elementary learners can gain understanding
by creating, trying, and evaluating conjectures. Teachers should encourage this by asking
questions like, What do you believe will happen? What pattern do you see? and Is your idea
always true?

**Content standard**: A statement of the attitudes, knowledge, understanding, or skill that students
will gain as a result of instruction. The standards for mathematical content (SMC) are content
standards.

**Contextualize**: Students do this by looking at the context of a problem to determine operations
and other strategies they will use to solve the problem. They must make meaning of the symbols
within the problem. Students can also contextualize by representing their solution (developed by
decontextualizing) into terms that are appropriate for the context of the problem.
Connections: Understanding requires recognizing and understanding the connections between mathematical concepts and ideas. It is also essential for learners to see how mathematical ideas build on one another and recognize and apply the mathematics they learn to realistic contexts.

Decontextualize: This is the ability to extract numbers, symbols, variables, or expressions from a problem and work with these representations in another context to develop a solution. Decontextualize can also mean representing a situation with symbols and manipulating those symbols as part of a solution strategy.

Discourse: This is a whole-class discussion where students talk about mathematics in order to reveal their understanding of mathematical concepts, strategies, solutions, and ideas. During discourse students learn to engage in mathematical reasoning and debate, respect others’ ideas, use reasoning and proof, present and clarify ideas, adjust and improve ideas, and reflect on the processes and products of their discourse. Teachers can promote discourse by asking questions that promote such discourse, creating an environment for discourse, inspiring student involvement, encouraging precise language and representations, and fostering the use of reasoning and proof.

Focus: A curriculum should be focused on the most important aspects of mathematics. Focus requires that teachers provide students within a narrow range of content so that students can engage in deeper learning experiences in order to gain a sophisticated understanding of concepts and begin to understand their relationship to each other. This type of understanding forms a foundation for more complex learning in subsequent years.

Model: This is an effort to abstract explicit mathematical cases into a general understanding of a concept. A model is a mathematical representation of the elements and connections in another version of a sophisticated phenomenon. Models are used to make sense of the phenomenon and
solve related problems. A mathematical model is a description of a process, concept, system, or problem using numbers, concepts and language. The model is used to solve a problem.

**Number sense:** This competency includes making sense of mathematical concepts and procedures. It includes being able to demonstrate many ways to solve problems, decompose numbers, explain the relationships between numbers and operations in a problem, do mental mathematics, estimate, understand a number’s meaning, explain one’s thinking, and use measurement effectively.

**Pattern:** This term refers to the arrangement or sequence of a set of numbers or objects where all of the members are related to each other by a specific rule or rules.

**Precision:** In the SMP this term refers to the use of accurate communication. Precise communication and language is largely supported by the use of correct symbols, terms, units, labeling, measurements, tools, strategies, calculations and so forth. Learners should strive for accurate communication of their ideas, solution pathways, conjectures, questions, critiques, and explanations. Student communicators should reflect on their solution strategies and solutions for accuracy and revise their arguments if necessary to ensure effective communication.

Mathematicians may also use the term precision to refer to how close measured values are to each other.

**Problem solving:** This is the ability to engage in a problem of which the method for its solution is not known. Problem solving is a means and an end for learning in mathematics education. Solving problems in a variety of ways can help learners develop an understanding of concepts and connections between mathematical concepts. The problem should be important and challenging (require higher order thinking). Further, it can require interactions, dialogue and
consensus, multiple solution pathways, monitoring and evaluation of the solution strategy and solution, solving through a variety of approaches, and connections to important ideas and skills.

**Process standard:** A statement of a behavior that a student should exhibit in order to support and enable their achievement of a content standard(s). The standards for mathematical practice (SMP) are process standards. They are also referred to as habits of mind.

**Proof:** This is a method of conveying specific types of reasoning and justification.

**Reasoning:** This refers to making sense of mathematics through the use of logic to explain and justify solutions, extending understanding from what is known to what is not known, and the ability to relate concepts to situations. Students who reason develop their ideas and solution pathways, justify their ideas, develop and present conjectures, explore problems, see patterns and structure within problems and in everyday life.

**Reform mathematics:** During this type of mathematics education teachers provide students with the following: many experiences solving non-routine, complex, and interesting problems; opportunities to read, write, discuss, and use mathematics; and experiences to create and test the validity of their ideas and identify their own findings. Students should use demonstrations, objects, arguments, drawings to prove their ideas. There is also an emphasis on reasoning and proof, communication, representation, justification and sense-making of ideas, and independent interpretation.

**Representation:** This refers to the process and product of a problem or showing a mathematical concept or relationship in one form and the form itself. Representations enable understanding of concepts and connections between ideas and concepts; they also can be used to communicate solution pathways and solutions. Representations for objects and actions can include numbers, shapes, operations, connections, figures, graphics, algebraic expressions, graphs, and matrices
that may portray a method for solving problems. Using many, diverse representations can enlarge students’ ability to think mathematically.

**Rigor**: Rigor relates to teaching mathematics for conceptual understanding, procedural (computational) fluency, and the application of skills and understanding to real world problems.

**Structure**: Students using structure examine a problem as a whole (they take a big picture or overview of the problem) or combination of parts to see what big ideas (e.g., distributive, commutative, and associative properties) and operations could be contained within it. Students looking for structure dissect and analyze the parts of the problem or the problem’s configuration in order to see the relationship between the parts. In order to understand the organization of the problem students may use what they know or what is familiar to them in order to make sense of the problem.

**Traditional mathematics**: Instruction that typically involves the teacher demonstrating the best way to solve a type of problem followed by students applying their understanding of the method they learned to a set of related problems in class and during homework. Traditional mathematics emphasizes: memorization of facts and algorithms, computational skills (addition, subtraction, multiplication, and division); rote skill practice; linear coverage of topics; textbook-driven instruction; and getting the right answer. Traditional mathematics does not stress conceptual understanding (comprehending why ideas, solution strategies and solutions are correct or incorrect).

**Unit fraction**: a (rational) number represented as a fraction with a numerator of one and a denominator that is a positive number (e.g., ⅓, ⅛, ½).
# Appendix B

Table B.1

*Leibniz School Professional Development Activities during the 2013-2014 School Year*

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/4/13</td>
<td>Full day (8 a.m. to 3 p.m.) in-service on new teacher evaluation program: goal setting and self-analysis</td>
</tr>
<tr>
<td>9/10/13</td>
<td>Mandated topics: bullying, harassment, Title VI, Section 504, IDEA, child-abuse, digital technology</td>
</tr>
<tr>
<td>9/17/13</td>
<td>Classroom management software training: data entry for attendance, grades, and curriculum maps</td>
</tr>
<tr>
<td>9/24/13</td>
<td>Teachers given time to prepare for curriculum night (Leibniz School open house for parents)</td>
</tr>
<tr>
<td>10/1/13</td>
<td>Teachers given an overview on how the principal will implement the new teacher evaluation program</td>
</tr>
<tr>
<td>10/8/13</td>
<td>Teachers met with peers from district’s sister elementary school to discuss student grading procedures</td>
</tr>
<tr>
<td>10/15/13</td>
<td>Full day in-service teachers reviewed state high stakes test data, overview of Symphony Math program</td>
</tr>
<tr>
<td>10/22/13</td>
<td>Discussion of diagnostic and benchmark assessments for ELA and mathematics</td>
</tr>
<tr>
<td>10/29/13</td>
<td>Discussion of software program for managing teacher evaluation documents, work on evaluation plans</td>
</tr>
<tr>
<td>11/5/13</td>
<td>Discussion and planning of student measurement and evaluation for report card grading</td>
</tr>
<tr>
<td>11/12/13</td>
<td>Teachers were given time to enter student data into report card software program</td>
</tr>
<tr>
<td>11/19/13</td>
<td>Teachers met with parents for conferences on student learning and achievement</td>
</tr>
<tr>
<td>11/26/13</td>
<td>Teachers met with parents for conferences on student learning and achievement</td>
</tr>
<tr>
<td>12/3/13</td>
<td>Teachers browsed the internet to identify resources to help with CCSSELA and CCSSM lesson plans</td>
</tr>
<tr>
<td>12/10/13</td>
<td>Discussion of grading procedures and writing program with peers from district’s other elementary school</td>
</tr>
<tr>
<td>12/17/13</td>
<td>Teachers browsed the internet to find CCSSELA and CCSSM resources (one hour session – snowstorm)</td>
</tr>
<tr>
<td>1/7/14</td>
<td>Discussions on Symphony Math software; instruction on how to teach open response questions</td>
</tr>
<tr>
<td>1/14/14</td>
<td>Discussion of housekeeping issues, teacher evaluation issues, state high stakes testing schedule</td>
</tr>
<tr>
<td>1/21/14</td>
<td>Teachers given time to enter data into grading software program</td>
</tr>
<tr>
<td>1/28/14</td>
<td>Teachers given time to complete their student grades for the second term</td>
</tr>
<tr>
<td>2/3/14</td>
<td>Math coach explained SMP to third grade teachers (39 minutes)</td>
</tr>
<tr>
<td>2/4/14</td>
<td>Teachers met with parents for conferences on student learning and achievement</td>
</tr>
<tr>
<td>2/11/14</td>
<td>Teachers reviewed benchmark assessment data for ELA and mathematics</td>
</tr>
<tr>
<td>2/25/14</td>
<td>Teachers listened to a 90-minute talk on social thinking for students with social/attention deficits</td>
</tr>
</tbody>
</table>
Appendix C

Invitation letter to the superintendent of the Euler Public Schools

Terry Langton, Northeastern University
Email: Telephone:

Date

Mr. Isaac
Superintendent
Euler Public Schools
567 Main Street
Euler, State

Dear Mr. Isaac:

I am a doctor of education candidate from Northeastern University. I am writing to request permission to conduct qualitative (case study research in the Euler Public Schools for a doctoral thesis. This research seeks to investigate local implementation of an education reform policy – The Common Core State Standards for mathematics (CCSSM). Such a reform, that seeks to promote student learning, cannot succeed unless teachers understand what it is asking them to do differently. Thus, the purpose of this research is to explore how elementary generalist teachers are learning about the CCSSM, and the ideas they construct relative to this reform policy.

I am requesting permission to gain access to staff members from October, 2013 through February, 2014 in order to conduct the following data collection activities two one-hour interviews with three Leibniz School elementary generalist teachers (a total of six interviews), a single one-hour interview with three administrators, collection of such artifacts as curriculum materials (e.g., commercially developed textbooks, unit plans), copies of grade level mathematics curriculum maps, collection of handouts from professional development sessions, and observations of the classroom teachers participating in professional development experiences and grade level meetings. These observations will also include the administrators when they are involved in professional development with the three teachers.

If you grant me access to the participants mentioned above I also respectfully request permission to send them the attached recruitment letters.

I do not expect that participation in this study will pose any risks to Euler staff members or students. The identities of those who choose to participate in this study as well as those of the school and district will be kept confidential and referred to by pseudonyms throughout data collection and analysis and in the written report. The interviews will be (audio) recorded and transcribed by me; the audio files and other files containing identities (except the signed informed consent forms for each participant) will be destroyed following transcription and data analysis.
There is no compensation offered in exchange for participation; I will make every effort to minimize the use of staff time. However, the written report of this research, which will be provided to you, can offer insight into how these educators shape this education reform policy during the implementation process.

If you have any questions or concerns about this research you can contact me at or ; or the principal investigator Dr. Kelly Conn, at . If you have any questions about participants’ rights relative to this research you may contact Nan Clark Regina, the director of Human Subject Research Protection at Northeastern University at or; you may contact Ms. Regina anonymously.

Your assistance in helping me gain access to willing participants would be greatly appreciated. I would need a letter of permission from you (see below) for the Northeastern University IRB before I could begin my recruitment. Thank you for your consideration of this research.

Sincerely,

Terry Langton


I have read this letter. I understand the content of this letter. I give consent to Terry Langton to conduct the research described in this letter within the Euler Public Schools.

______________________________________________
Signature of the Superintendent of the Euler Public Schools       Date

__________________________________________________
Printed name of person above

Please send a copy of this letter to Terry Langton and keep a copy for your records.

*Figure C.1. Recruitment letter to the Euler Superintendent*
Recruitment Letter to the K-8 Director of Teaching and Learning

Terry Langton, Northeastern University
Email: Telephone:

Date

Sophia
K-8 Director of Teaching and Learning
Euler Public Schools
567 Main Street
Euler, State

Dear Sophia:

I am a doctor of education candidate from Northeastern University and a teacher at the Leibniz Elementary School. I am writing to request your participation in research I plan to conduct for a doctoral thesis. The purpose of this qualitative case study research is to explore how elementary generalist teachers are making sense of the Common Core State Standards for mathematics (CCSSM), and the ideas they have constructed relative to this reform policy.

You have been identified as a potential participant because you are having some influence on teacher understanding of the CCSSM through district level professional development. If you choose to participate your involvement will include observation of your engagement in professional development only when you participate with the teacher participants of this study from October, 2013 through February, 2014, collection of documents related to mathematics (e.g., curriculum maps, professional development handouts), and one interview that will last approximately one hour at a location and time of your choosing.

During this interview you will be asked to describe your beliefs and experience with mathematics, how you learned about the CCSSM, and what you perceive the CCSSM to be asking teachers to do. This interview will be (audio) recorded and transcribed verbatim by me. You will be provided with a copy of the transcript of your interview. I will also ask you to review and validate the accuracy of my transcription of your interview and the findings and conclusions that I draw from the data analysis of the transcript. You may request deletion of any of your responses.

I do not expect that your participation in this study will pose any risks to you. Your participation in this research will be completely voluntary. You may refuse to respond to any question and withdraw at any time.

Your identity, others who choose to participate in this study, and those of the school and district will be kept confidential. You will always be referred to by a pseudonym in the written report. All files containing your identity will be destroyed upon completion of the study (except the signed informed consent form). In addition to me only two people will know your identity: the
Euler Public Schools superintendent and Dr. Kelly Conn of Northeastern University, the principal investigator.

There will be no compensation offered in exchange for your participation. However, I will provide you with an executive summary of the study. I will also make every effort to minimize the use of your time. It is my hope that this study will provide policymakers, instructional leaders, teacher educators, and teachers with insight into how educators shape policy during implementation.

If you would like to participate or have any questions or concerns you can contact me at or . You may also contact the principal researcher for this project - Dr. Kelly Conn, at . If you have any questions about your rights relative to this research you may contact Nan Clark Regina, the director of Human Subject Research Protection at Northeastern University at or ; you may contact Ms. Regina anonymously.

Thank you for considering participation in this research project.

Sincerely,

Terry Langton

*Figure C.2. Recruitment letter to the Euler Director of teaching and learning*
Recruitment Letter to the Leibniz School Principal

Terry Langton, Northeastern University
Email: Telephone:

Date

Elena
Principal
Leibniz Elementary School
1313 Leibniz Street
Euler, State

Dear Elena:

I am a doctor of education candidate from Northeastern University. I am writing to request your participation in research I plan to conduct for a doctoral thesis. The purpose of this case study research is to explore how elementary generalist teachers are making sense of the Common Core State Standards for mathematics (CCSSM) and the ideas they have constructed relative to this reform policy. I am also asking your assistance in identifying three potential teacher participants who have been engaged in learning about the CCSSM. These teacher participants must be Pre-kindergarten through fourth grade teachers who teach all subject areas.

You have been identified as a potential participant because you are involved in teacher understanding of the CCSSM through district level professional development. If you choose to participate your involvement will include observation of your engagement in professional development only when you participate with the teacher participants of this study from October, 2013 through February, 2014, collection of documents related to mathematics (e.g., curriculum maps, professional development handouts), and one interview that will last approximately one hour at a location and time of your choosing.

During this interview you will be asked to describe your beliefs and experience with mathematics, how you learned about the CCSSM, and what you perceive the CCSSM to be asking teachers to do. This interview will be (audio) recorded and transcribed verbatim by me. You will be provided with a copy of the transcript of your interview. I will also ask you to review and validate the accuracy of my transcription of your interview and the findings and conclusion that I draw from the data analysis of the transcript. You may request deletion of any of your responses.

I do not expect that your participation in this study will pose any risks to you. Your participation in this research will be completely voluntary. You may refuse to respond to any question and withdraw at any time.

Your identity, others who choose to participate in this study, and those of the school and district will be kept confidential. You will always be referred to by a pseudonym in the written report; all files containing your identity will be destroyed upon completion of the study (except the
signed informed consent form). In addition to me only two people will know your identity: the Euler Public Schools superintendent and Dr. Kelly Conn of Northeastern University, the principal investigator.

There will be no compensation offered in exchange for your participation. However, I will provide you with an executive summary of the study. I will also make every effort to minimize the use of your time. It is my hope that this study will provide policymakers, instructional leaders, teacher educators, and teachers with insight into how educators shape policy during implementation.

If you would like to identify three potential teacher participants and/or accept involvement as a participant or have any questions or concerns you can contact me at or . You may also contact the principal researcher for this project - Dr. Kelly Conn, at . If you have any questions about your rights relative to this research you may contact Nan Clark Regina, the director of Human Subject Research Protection at Northeastern University at or; you may contact Ms. Regina anonymously.

Thank you for considering participation in this research project.

Sincerely,

Terry Langton

Figure C.3. Recruitment letter to the Leibniz Principal
Recruitment Letter to the Elementary Mathematics Coach

Terry Langton, Northeastern University

Date

Maria
Mathematics Coach
Euler Public Schools
Leibniz Elementary School
1313 Leibniz Street
Euler, State

Dear Maria:

I am a doctor of education candidate from Northeastern University. I am writing to request your participation in research I plan to conduct for a doctoral thesis. The purpose of this case study research is to explore how elementary generalist teachers are making sense of the Common Core State Standards for mathematics (CCSSM) and the ideas they have constructed relative to this reform policy.

You have been identified as a potential participant because you are involved in teacher understanding of the CCSSM through district level professional development. If you choose to participate your involvement will include observation of your engagement in professional development only when you participate with the teacher participants of this study from October, 2013 through February, 2014, collection of documents related to mathematics (e.g., curriculum maps, professional development handouts), and one one-hour interview at a location and time of your choosing.

During this interview you will be asked to describe your beliefs and experience with mathematics, how you learned about the CCSSM, and what you perceive the CCSSM to be asking teachers to do. This interview will be (audio) recorded and transcribed verbatim by me. You will be provided with a copy of the transcript of your interview. I will also ask you to review and validate the accuracy of my transcription of your interview and the findings and conclusion that I draw from the data analysis of the transcript. You may request deletion of any of your responses.

I do not expect that your participation in this study will pose any risks to you. Your participation in this research will be completely voluntary. You may refuse to respond to any question and withdraw at any time. Your identity, others who choose to participate in this study, and those of the school and district will be kept confidential. You will always be referred to by a pseudonym in the written report; all files containing your identity will be destroyed upon completion of the study (except the signed informed consent form). In addition to me only two people will know your identity: the Euler Public Schools superintendent and Dr. Kelly Conn of Northeastern University, the principal investigator.
There will be no compensation offered in exchange for your participation. However, I will provide you with an executive summary of the study. I will also make every effort to minimize the use of your time. It is my hope that this study will provide policymakers, instructional leaders, teacher educators, and teachers with insight into how educators shape policy during implementation.

If you would like to participate or have any questions or concerns you can contact Terry Langton at or . You may also contact the principal researcher for this project - Dr. Kelly Conn, at . If you have any questions about your rights relative to this research you may contact Nan Clark Regina, the director of Human Subject Research Protection at Northeastern University at or ; you may contact Ms. Regina anonymously.

Thank you for considering participation in this research project.

Sincerely,

Terry Langton

*Figure C.4. Recruitment letter to the math coach.*
Recruitment Letter to an Elementary Generalist Teacher

Terry Langton, Northeastern University
Email: Telephone:

Date

Classroom (generalist) Teacher
Leibniz Elementary School
1313 Leibniz Street
Euler, State

Dear Dr., Mrs., Ms., Mr. _________________________:

I am a doctor of education candidate from Northeastern University and a teacher at the Leibniz Elementary School. I am writing to request your participation in research I plan to conduct for a doctoral thesis. The purpose of this case study research is to explore how elementary generalist teachers are making sense of the Common Core State Standards for mathematics (CCSSM) and the ideas they have constructed from and about this reform policy.

You are being asked to participate because you are an elementary generalist who has been learning about the CCSSM. If you agree to participate your involvement would include observation of your participation in mathematics professional development within the Euler Public Schools and two one-hour interviews that would take place between October, 2013 and February, 2014 at locations and times of your choosing. During these interviews you will be asked to describe your beliefs and experience with mathematics, how you learned about the CCSSM, and what you perceive the CCSSM to be asking teachers to do. This interview will be (audio) recorded and transcribed verbatim by me. You may refuse to respond to any question and withdraw at any time. Further, you will be provided with a copy of the transcript of your interview. I will also ask you to review and validate the accuracy of my transcription of your interview and the findings and conclusion that I draw from the data analysis of the transcript. You may request deletion of any of your responses. Your participation in this research is completely voluntary. I do not expect that your participation in this study will pose any risks to you.

Your identity and others who choose to participate in this study and those of the school and district will be kept confidential. In addition to me only three people will know your identity: the Euler Public Schools superintendent, Dr. Kelly Conn my Northeastern University supervisor and principal investigator for this study, and the Leibniz principal. You will be referred to by a pseudonym in the written report; all files containing identities (except signed informed consent forms) will be destroyed upon completion of the study.

There is no compensation offered in exchange for your participation. However, I will provide you with an executive summary of the study. I will also make every effort to minimize the use of your time.
If you would like to participate or have any questions or concerns you can contact me at or . You may also contact the principal researcher - Dr. Kelly Conn, at . If you have any questions about your rights relative to this research you may contact Nan Clark Regina, the director of Human Subject Research Protection at Northeastern University at or you may contact Ms. Regina anonymously.

Thank you for considering participation in this research project.

Sincerely,

Terry Langton

*Figure C.5. Recruitment letter to an elementary generalist teacher*
Appendix D

Informed Consent Form for Elementary Generalist Teachers

Northeastern University: College of Professional Studies, 50 Nightingale Hall, 360 Huntington Avenue, Boston, MA 02115-5000
Human Subject Research Protection, 960 Renaissance Park, Boston, MA 02115-5000

Principal Investigator: Dr. Kelly Conn –
Student Researcher: Terry Langton; Email: Telephone:

Title: Sense-making of the Common Core State Standards for Mathematics: A Case Study of Elementary Generalist Teachers

You are invited to participate in a research study that will take place from October, 2013 through February, 2014. This form is offered to you so you can decide if you would like to participate. The researcher will also tell you about the study. You may ask him any questions that you have. When you are ready, you may tell the researcher if you want to participate or not. Your participation in this research is completely voluntary. You do not have to participate if you do not want to. If you want to participate the researcher will ask you to sign this statement. You will get a copy to keep. We are asking you to participate because you are a teacher who has been learning about Common Core math.

The purpose of this study is to explore how elementary teachers understand the Common Core State Standards for math. This task is my doctoral thesis research project for Northeastern University. If you decide to be part of this study you will be asked to participate in two one-hour interviews at locations and times of your choosing. During the interviews you will be asked about:

- your experiences with mathematics
- how you learned about the Common Core math standards
- what you think these standards are asking you to do

Participation will also include the researcher observing you during professional development. Last, the researcher will collect documents related to Common Core mathematics.

I do not expect that your participation in this study will present risk or discomfort to you. If you do experience discomfort the researcher will tell you where you can go for help.
Informed Consent Form for Elementary Generalist Teachers

Northeastern University: College of Professional Studies, 50 Nightingale Hall, 360 Huntington Avenue, Boston, MA 02115-5000
Human Subject Research Protection, 960 Renaissance Park, Boston, MA 02115-5000;

There will be no cost or payment for your participation. However, there will be many benefits of this research. The responses you give can add to the literature on how reform policies are implemented. The information you give may also help improve professional development. The results of this research could help find the parts of the Common Core math standards that are misunderstood.

Your part in this study will be confidential. Only the researcher and his Northeastern University faculty advisor will know your identity. You will be referred to by a pseudonym throughout the research process. Your identity will not be connected to your statements on any document. The identity of the district and school will also be referred to with pseudonyms.

You can refuse to answer any question during interviews. The interviews will be recorded and transcribed word for word by the researcher. Some of the statements you make may be included in a published report. The published report will not use information that can identify you as a part of this project. You do not have to answer any question if you feel uncomfortable. You may listen to the recording and review the transcript of your interview. You may request that statements you make to the researcher be withdrawn. You also have the right to see the final report so that you may identify things that are not fair or correct.

Digital files that state your identity such as the record of the interview and this consent form will be kept in secure locations. Paper files will be kept in a locked cabinet in a locked door within the researcher’s office. The files that contain your identity will be destroyed at the end of the study. Northeastern University staff may ask the researcher to see information about you. They may do this to make sure you are protected.

Even if you begin the study, you may quit at any time. If you do not participate or if you decide to quit, you will not lose any rights or benefits that you would otherwise have.

If you have questions or problems with the research you may contact Terry Langton. Terry’s email address is and his telephone number is . You may also contact the principal researcher – Dr. Kelly Conn. Dr. Conn’s email address is .

If you have any questions about your rights as a person involved in this study you may contact Nan Clark Regina. Ms. Regina is the director of Human Subject Research Protection at Northeastern University. Ms. Regina’s telephone number is ; her email address is . You may contact Ms. Regina without saying your name.
Informed Consent Form for Elementary Generalist Teachers

Northeastern University: College of Professional Studies, 50 Nightingale Hall, 360 Huntington Avenue, Boston, MA 02115-5000
Human Subject Research Protection, 960 Renaissance Park, Boston, MA 02115-5000

Thank you,

Terry Langton

I have read this form. I understand the content of this form. I agree to participate in this research.

__________________________________________________
Signature of person agreeing to take part Date

__________________________________________________
Printed name of person above

__________________________________________________
Signature of person who explained the study to the participant Date
Above and obtained consent

__________________________________________________
Printed name of person above

Page 3 of 3

Figure D.1. Informed consent form for teachers
Informed Consent Form for School Administrators

Northeastern University: College of Professional Studies, 50 Nightingale Hall, 360 Huntington Avenue, Boston, MA 02115
Human Subject Research Protection, 960 Renaissance Park, Boston, MA 02115-5000;

Principal Investigator: Dr. Kelly Conn – Student Researcher: Terry Langton; Email: Telephone:

Title: Sense-making of the Common Core State Standards for Mathematics: A Case Study of Elementary Generalist Teachers

You are invited to participate in a research study that will take place between October, 2013 and February, 2014. This form is offered to you so you can decide if you would like to participate. The researcher will also tell you about the study. You may ask him any questions that you have. When you are ready, you may tell the researcher if you want to participate or not. Your participation in this research is completely voluntary. You do not have to participate if you do not want to. If you want to participate the researcher will ask you to sign this statement. You will get a copy to keep. We are asking you to participate because you are an administrator who has been learning about the Common Core State Standards for mathematics.

The purpose of this study is to explore how elementary teachers understand the Common Core State Standards for math. This task is my doctoral thesis research project for Northeastern University. If you decide to be part of this study you will be asked to participate in a single one-hour interview at a location and time of your choosing. During the interview you will be asked about:

- your experiences with mathematics
- how you learned about the Common Core math standards
- what you think these standards are asking teachers to do

Participation will also include the researcher observing you during professional development. Last, the researcher will collect documents related to Common Core mathematics.

I do not expect that your participation in this study will present risk or discomfort to you. If you do experience discomfort the researcher will tell you where you can go for help.

There will be no cost or payment for your participation. However, there will be many benefits of this research. The responses you give can add to the literature on how reform policies are implemented. The information you give may also help improve professional development. The results of this research could help find the parts of the Common Core math standards that are misunderstood.

Page 1 of 3
Informed Consent Form for School Administrators

Northeastern University: College of Professional Studies, 50 Nightingale Hall, 360 Huntington Avenue, Boston, MA 02115

Human Subject Research Protection, 960 Renaissance Park, Boston, MA 02115-5000;

Your part in this study will be confidential. Only the researcher and his Northeastern University faculty advisor will know your identity. You will be referred to by a pseudonym throughout the research process. Your identity will not be connected to your statements on any document. The identity of the district and school will also be referred to with pseudonyms.

You can refuse to answer any question during the interview. The interview will be recorded and transcribed word for word by the researcher. Some of the statements you make may be included in a published report. The published report will not use information that can identify you as a part of this project. You do not have to answer any question if you feel uncomfortable. You may listen to the recording and review the transcript of your interview. You may request that statements you make to the researcher be withdrawn. You also have the right to see the final report so that you may identify things that are not fair or correct.

Digital files that state your identity such as the record of the interview and this consent form will be kept in secure locations. Paper files will be kept in a locked cabinet in a locked door within the researcher’s office. The files that contain your identity will be destroyed at the end of the study. Northeastern University staff may ask the researcher to see information about you. They may do this to make sure you are protected.

Even if you begin the study, you may quit at any time. If you do not participate or if you decide to quit, you will not lose any rights or benefits that you would otherwise have.

If you have questions or problems with the research you may contact Terry Langton. Terry’s email address is ——— and his telephone number is ———. You may also contact the principal researcher – Dr. Kelly Conn. Dr. Conn’s email address is ———.

If you have any questions about your rights as a person involved in this study you may contact Nan Clark Regina. Ms. Regina is the director of Human Subject Research Protection at Northeastern University. Ms. Regina’s telephone number is ———; her email address is ———. You may contact Ms. Regina without saying your name.
Informed Consent Form for School Administrators

Northeastern University: College of Professional Studies, 50 Nightingale Hall, 360 Huntington Avenue, Boston, MA 02115
Human Subject Research Protection, 960 Renaissance Park, Boston, MA 02115-5000;

Thank you,

Terry Langton

I have read this form. I understand the content of this form. I agree to participate in this research.

__________________________________________________
Signature of person agreeing to take part

__________________________________________________
Date

__________________________________________________
Printed name of person above

__________________________________________________
Signature of person who explained the study to the participant
Above and obtained consent

__________________________________________________
Date

__________________________________________________
Printed name of person above

Page 3 of 3

Figure D.2. Informed consent form for administrators.
Appendix E
First Teacher Interview: Relationship to Mathematics

Interviewee: [Name]
Title: [Title]
Date: [Date]
Start time: [Start time]
End time: [End time]
Location: [Location]
Characteristics of space: [Characteristics]

Interviewer: [Name]

Purpose: to acquire data on teachers’ relationship to mathematics and mathematics education.

Related research sub-question: 1. What were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM?

Question: What is your role within this school district?
Probes:
1. What is your role in relation to mathematics education? How many years have you been: a teacher; an elementary generalist; a mathematics teacher; teacher at this school; mathematics teacher at this school; teacher at other schools; mathematics teacher at other schools; teacher at this grade level; mathematics teacher at this grade; teacher at other grade levels; mathematics teacher at other grade levels.

Question: Tell me about your experiences with mathematics?
Probes:
1. Tell me about your experiences as a K-12 mathematics student? What mathematics courses did you take in high school? What do you remember most about high school mathematics?
2. What were your experiences with mathematics as an undergraduate student? (what was your major, minor, what mathematics courses did you take; what was the teaching and learning like, how did you feel about the courses)
3. Describe your teacher preparation? (university, baccalaureate program, traditional, non-traditional)? What was your preparation for becoming a mathematics teacher?
4. What have been your experiences with mathematics as a graduate student? (courses, content, type of teaching and learning)
5. Describe your overall experiences with mathematics professional development (PD) prior to 2011 (PD)? (major method of delivery of the PD, content of the PD, type of instruction promoted, learning experiences you engaged in)

Question: Tell me about your experiences as a mathematics teacher?
Probes:
1. Describe your philosophy toward (your overall approach to) mathematics education in your classroom? (content, type of instruction, nature of student learning, assessment)?
2. How much time do you spend teaching mathematics? (daily and weekly minutes)
3. Tell me about the role curriculum materials play in teaching mathematics?
What is role of mathematics education in relation to the school curriculum? (level of importance, value)

Thank you for your time and for sharing your experiences.

Figure E.1. First interview questions for a teacher.
Second Teacher Interview: Mathematics Learning as a Professional

Interviewee: Title:
Date: Start time: End time:
Location: Characteristics of space:
Interviewer:
Purpose: to acquire data on what and how teachers have learned about the CCSSM.

Related research sub-questions:
1. What were teachers’ major experiences, beliefs, attitudes, and knowledge and overall orientation to mathematics and mathematics education prior to the CCSSM?
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?
3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?
4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

Question: How do you keep informed with what is going on in education?
Probe:
  1. What has been the recent focus of your professional development (PD)

Question: How have you gone about learning about what is going on in mathematics education?
Probes:
  1. What has been the recent focus of your professional development in mathematics?
  2. When and how did you first become aware of the CCSSM? How much time have you spent engaging in learning about the CCSSM?
  3. From whom or from what groups have you learned about the CCSSM?
  4. What was the content of this CCSSM professional development (what was the overall message, guiding philosophy, standards for mathematical content, standards for mathematical practice, assessment, what grade levels were focused upon)
  5. Through what medium was the content delivered? (verbal/lecture, text-based, visually through graphics or video) What was the method of instruction?
  6. What types of tasks did you and the teachers participate in? (reading standards, crosswalk activity, unpacking standards, discussion of what Standards for Mathematics Content (SMC) and or Standards for Mathematical Practices (SMP) look like during a lesson, relating SMC to SMP, teaching English Language learners and Special education students) How were teachers grouped?
  7. What was the level of cognitive demand required for engaging in the tasks?
  8. How did you and the other participants engage in learning about the CCSSM? (passive reception/active construction of ideas)

Question: How have you and your grade level colleagues been engaging in learning about the CCSSM?
Probes:
1. How have you personally engaged in learning about the CCSSM (professional associations, workshops, courses, what has the learning been like – direct instruction, inquiry-based learning, social constructivism)? What aspects of the CCSSM have you focused upon?

2. How have you engaged in learning about the CCSSM within the Euler Public Schools? What aspects of the CCSSM have you focused upon?

3. What has been the nature of teacher discussions? (probes: what aspects of the CCSSM were discussed or dealt with, challenging each other’s ideas, reflect on practice, ask others to make thinking visible) How would you describe the groups’ attitude toward mathematics?

4. How did the group try to understand the CCSSM?

5. What is the school and grade level culture or history related to mathematics education?

**Question: Tell me what you have learned about the MCFM?**

**Probes:**

1. If a new teacher who had no understanding of the CCSSM joined your grade level team as a mathematics teacher how would you describe the CCSSM to her or him? (overall message of CCSSM, content, type of instruction, role of the learner, is there a relationship between your grade level standards and the standards at other levels, between the SMP and SMC? )

2. What is the CCSSM asking you to do differently than the state 2000/2004 mathematics framework did? (content, instruction, role of the learner)

3. What are the Standards for Mathematical Content (SMC)? (how are they different from the 2000/2004 standards, what is the major emphasis of the SMC in grade 3)

4. Several SMC use the word understand. What does it mean for a mathematics student to understand?

5. What are the standards of mathematical practice? (how do they relate to teachers and students)

6. How would you unpack this standard: SMC 3.NF.A.1. What could it look like in the classroom from a teaching viewpoint and from a student’s perspective? What skills do students need to possess in order to achieve this standard?

7. What aspects of the MCFM are hard to understand? Why are they difficult to understand?

**Probe 6 from Teacher interview 2: How would you unpack this standard (3.NF.A.1 below)?**

3.NF.A.1 Understand a fraction \( \frac{1}{b} \) as the quantity formed by 1 part when a whole is partitioned into \( b \) equal parts; understand a fraction \( \frac{a}{b} \) as the quantity formed by \( a \) parts of size \( \frac{1}{b} \)

Probes:

What key previous standards are related to this standard?

What to look for in the participant’s response (Pre-requisite standard: 2.G.3)

What skills do students need to have in order to achieve this standard?

What to look for in the participant’s response:
The student should have acquired the following knowledge and skill – The ability to:
- Divide a shape into parts of equal size
- Describe the parts using language of fractions
- Recognize that parts collectively represent the whole

The student should know the following:
- A fraction symbol represents a quantity that involves parts of a whole; the number of equal parts tell how many make a whole; fractions can be used to show how something can be shared equally
- Multiple parts of a whole can be counted and represented by a fraction symbol
- A fraction symbol such as 1/b is one part of a whole and that whole is divided into b equal portions
- A fraction a/b is the amount formed by a portions of amount 1/b
- The numerator of a fraction is the upper number and it identifies the number of portions of a given size that are counted; this is the count of equal parts; ¾ means there are 3 one-fourths
- The denominator of a fraction is the lower number that identifies the amount of equal portions the whole is divided into

Probes (continued):
Identify a student learning experience (i.e., a task) that would represent this standard?
What standards of mathematical practice are related to this task?

Unpacking a standard question. This page relates to probe 6 from the third teacher interview from Figure C3. This question was adapted from Barlow, A. T., & Harmon, S. (2012). CCSSM: Teaching in grades 3 and 4: How is each Common Core State Standard for mathematics different from each old objective? Teaching Children Mathematics, 18(8), 498-507, the State’s version of the CCSSM, and Arizona Department of Education. (2010). Mathematics: Arizona academic content standards: Grade 3. Phoenix, AZ: Author.

Thank you for your time and candid responses.

Figure E.2. Second interview questions for a teacher.
Administrator Interview: Demographics, Orientation to Mathematics, how they learned about and understand the Common Core State Standards for Mathematics (CCSSM)

Interviewee:  
Title:  
Date:  
Start time:  
End time:  
Location:  
Characteristics of space: 

Interviewer:  
Purpose: to acquire data on administrators’ beliefs and experiences with mathematics, how they learned about the CCSSM, what they perceive the CCSSM to be asking teachers to do, and the content and type of messages they sent to teachers.

Related research sub-questions:  
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?  
3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?  
4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?  

Question: What is your title and what are your responsibilities in this district?  
Probe: 
1. What are your responsibilities in relation to mathematics education? How many years have you been: a teacher at grade level(s), subject(s), district(s), schools, an administrator (titles, districts).  

Question: Tell me about your experiences with mathematics as a student and educator.  
Probes:  
1. Tell me about your experiences as a K-12 mathematics student? (elementary, middle and high school, attitudes toward math, beliefs, what was the instruction like; what were the learning experiences like) What mathematics courses did you take in high school?  
2. What were your experiences with mathematics as an undergraduate student (major, minor, courses taken, what was the teaching and learning like, attitudes, beliefs)?  
3. Describe your preparation for your career in education? (university, baccalaureate program, traditional, non-traditional)? What was your preparation for becoming a mathematics teacher?  
4. What have been your experiences with mathematics as a graduate student? (courses, content, type of instruction and student learning experiences)  
5. In relation to your personal life how do you feel about mathematics? (overall attitude toward mathematics, changes in feelings over time)  
6. Define your philosophy toward mathematics education? (content, role of teacher and student)  
7. What is the role of mathematics education in relation to the school curriculum?  
8. Describe the school’s history or culture relative to mathematics education? (type of instruction, role of student)  
9. How have you gone about learning about what is going on in mathematics education?  

Question: What has been going on with mathematics education recently in this district?  
Probes:  
1. What is this CCSSM? What is it asking teachers to do? (SMC, SMP, overarching ideology)  
2. How have you or how has the school and district gone about providing professional development for the CCSSM in the Leibniz School  

Thank you for your time and sharing your experiences.

Figure E.3. Administrator interview questions
Appendix F

Observation of Professional Development (PD) Instrument

**Related research sub-questions:**
2. What has been the content and type of the CCSSM messages presented to teachers during professional development?
3. How and with whom have teachers engaged in sense-making of the CCSSM during professional development?
4. What ideas have teachers constructed relative to the CCSSM and what aspects of the CCSSM have teachers found most difficult to comprehend?

**Field Notes**

**Purpose of meeting:**

Date: ________ Start time: ________ End time: ________ Location:____________________

Instructor or professional development leader:________________________________________

Staff present: List staff names by numbered chairs on the diagram below. For example: seat 1 – grade 3 teacher Mrs. Pluto, seat 2 – Grade 3 teacher Mr. Saturn.

Members not present:________________________________________________________________

Relationship of meeting to other PD:________________________________________________

**Physical setting**

Positioning of teachers and presenter(s) in the Leibniz School Library (possible meeting room for in-service sessions)
**Physical setting**
Positioning of teachers and presenter(s) in Classroom (possible meeting room for in-service sessions)

What is the content and type of CCSSM messages being presented to teachers?

What Common Core math content is being represented? ________________________________

How is the content being represented to teachers? ________________________________

How is Common Core math content being represented: Oral Visuals Text

Type of instruction: Teacher directed Participant centered Hybrid

**How and with whom are teachers engaging in sense-making of the content?**

With whom are teachers engaging in sense-making of the content? ____________________

How are teachers engaging in sense-making of the content? _________________________
What Ideas are Teachers Constructing from the Professional Development?

What understandings about the CCSSM are teachers identifying? ________________________________

______________________________

Quote, paraphrase and summarize dialogue (not who is speaking to whom), note silence and nonverbal actions.

What CCSSM ideas seem difficult for teachers to comprehend?

______________________________

Researcher’s behavior

What is the researcher’s role? Participant Observer Participant/Obsess

How is what you are doing influencing participants’ actions? ________________________________

What did you say or do? ________________________________

What are your thoughts about what is going on? ________________________________

______________________________

Figure F.1. Observation of professional development (PD) instrument.
Appendix G

Document Content Analysis Form

**Related research sub-questions:**

3. What has been the content and type of the CCSSM messages presented to teachers during professional development?

**Questions to consider:**

How is the Common Core mathematics standards document being represented to teachers? What ideas are teachers constructing relative to the Common Core math standards?

**Document Title:**


**Author(s):**

Date created: Date obtained:

**Publisher:**

**URL:**

**History of its development and use:**

**Purpose for being created:**

**Context in which it was developed:**

**Sources of information used to develop it:**

**References cited:**

**Relationship of document to Common Core math standards:**

**Major message of the document:**

**Alignment to the Common Core math standards:**

**Audience:**

**Language:** (e.g., clear, specific, concrete, and easy to understand or dense, ambiguous and abstract)

**Concrete or abstract representation:**

**Notes:**

---

**What is the content and type of CCSSM messages being presented to teachers?**

**What is the content the message relative to the Common Core math standards?**

1. Ideas on rigor, focus, and coherence:
2. Ideas on the Standards for mathematical content:
3. Ideas on the Standards for mathematical practice
4. Ideas on the connections between the SMC and SMP

**Potential Sources of Data for teacher learning about the Common Core math standards**

1. District created documents - curriculum framework, unit plan, lesson plan, curriculum map, student task, assessment, test (could be co-constructed by administration and teachers)
2. Administrator messages about the Common Core math standards - letters to teachers and parents, district website or webpage, professional development artifacts provided to teachers (e.g., PowerPoint file, handout poster board, chart paper with bullet points, graphics)
3. External messages to teachers – professional association books and articles, textbook, textbook related workbook, external professional development artifacts

**Learning directly from the Common Core math standards**

Primary sources: Common Core website and webpages.

**What teacher ideas have been constructed within the document?**

Documents to look for: Lesson plan, unit plan, teacher web page, letter to parents, curriculum map, action research, bullet points on chart paper from professional development session, student task, test, lesson study artifacts, action research.

**What administrator ideas have been constructed within the document?**

Documents to look for: Letter or message to teachers regarding mathematics, professional development handout or PowerPoint file.

---

*Figure G.1. Document content analysis form*
Appendix H

Table H.1

*Demographic Information Collected from Euler and the State*

<table>
<thead>
<tr>
<th>Webpage</th>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euler enrollment data: 2014</td>
<td>State Department of Education website</td>
<td>Total Euler student population &amp; student population by race/ethnicity</td>
</tr>
<tr>
<td>Euler selected populations (2013-2014)</td>
<td>State Department of Education website</td>
<td>Euler totals of English language learners, students with disabilities, &amp; Low income students</td>
</tr>
<tr>
<td>Euler 2013 cohort graduation rates: 4-year graduation rate (2013)</td>
<td>State Department of Education website</td>
<td>Graduation rates</td>
</tr>
<tr>
<td>Leibniz elementary: Enrollment data: 2014</td>
<td>State Department of Education website</td>
<td>Total Leibniz student population &amp; student population by race/ethnicity</td>
</tr>
<tr>
<td>Leibniz elementary: Selected populations (2013-2014)</td>
<td>State Department of Education website</td>
<td>Euler totals of English language learners, students with disabilities, &amp; Low income students</td>
</tr>
<tr>
<td>Town of Euler, State</td>
<td>Town of Euler website</td>
<td>Population</td>
</tr>
</tbody>
</table>
Table H.2

**Documents Collected from Euler School District**

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 State high stakes standardized test action plan: Called for increase in mathematics instruction to four days per week of 90 minutes per day</td>
<td>Administrative team</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>2011-2012 Euler professional development plan: Promote technology use; create data teams; develop HOT through curriculum mapper; increase co-teaching among regular and SPED teachers; develop smarter IEP goals; refine RTI implementation; create interdisciplinary courses; develop curriculum mapping software and include CC; understand bullying; develop school emergency protocols</td>
<td>Administrative team</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>2012-2013 Euler professional development plan: Create, distribute CC implementation plan (did not happen), identify instructional shifts, use data to improve instruction; implement teacher evaluation; develop tests to measure student learning growth; understand teacher performance rubrics; use technology to promote student learning</td>
<td>Administrative team</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>Vision 2020 Survey results: Teachers are using several math programs and unique resources not aligned with CCSSM; math is not the only subject generalists teach; teachers seem to be expected to do more than they can in math; 46% of teachers feel they can understand and can implement the SMP K-12; Elementary teachers need resources aligned to the CCSSM</td>
<td>Vision 2020 mathematics program adoption committee</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
</tbody>
</table>
Table H.3

Documents Collected from Leibniz School

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-2014 Leibniz School improvement plan: Goals include: using data to</td>
<td>Leibniz School Council</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>plan instruction and increase student achievement; train teachers on</td>
<td></td>
<td></td>
</tr>
<tr>
<td>new teacher evaluation system; reinforce technology; create an</td>
<td></td>
<td></td>
</tr>
<tr>
<td>emotionally and physically safe environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012-2013 Leibniz School Improvement plan: Implement CC: use in-service</td>
<td>Leibniz School Council</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>time to study the CC; use curriculum mapper to all subjects (spend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>time on learning and implementing CC); reinforce technology skills;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>create an emotionally and physically safe environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011-2012 Leibniz School Improvement plan: Improve reading skills;</td>
<td>Leibniz School Council</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>improve writing by implementing CCSSELA; improve math skills (</td>
<td></td>
<td></td>
</tr>
<tr>
<td>computation, problem solving, and HOTS) through computer software and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTI; reinforce technology; create home school connection; create</td>
<td></td>
<td></td>
</tr>
<tr>
<td>emotionally and physically safe environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom teachers schedules Grade one does 45 minute of mathematics</td>
<td>Leibniz principal</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>per day; Grade 2 does 79 minutes per day; Grade 3 does 60 minutes; Grade</td>
<td></td>
<td></td>
</tr>
<tr>
<td>four does 58 minutes per day.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table H.4

Summary of Data Collection for Teachers and Administrators

<table>
<thead>
<tr>
<th>Data Collection</th>
<th>Elementary generalists</th>
<th>Euler School Principal</th>
<th>K-8 Director of Teaching and Learning</th>
<th>Elementary Mathematics Specialists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviews</td>
<td>Two of 60 minutes each</td>
<td>One 60 minute</td>
<td>One 60 minute</td>
<td>One 60 minute</td>
</tr>
<tr>
<td>Observations</td>
<td>Participation in 15 two-hour professional development sessions</td>
<td>Only the professional development sessions that involve this administrator engaging with the three teachers</td>
<td>Only the professional development sessions that involve this administrator engaging with the three teachers</td>
<td>Only the professional development sessions that involve this administrator engaging with the three teachers</td>
</tr>
<tr>
<td>Documents</td>
<td>Mathematics lesson &amp; unit plans, student textbook, teacher’s edition of textbook</td>
<td>School level curriculum and curriculum maps, letters and messages to teachers regarding mathematics, professional development handouts and PowerPoint files</td>
<td>District level curriculum and curriculum maps, letters and messages to teachers regarding mathematics, professional development handouts and PowerPoint files</td>
<td>Mathematics lesson &amp; unit plans, model lessons, professional development handouts and PowerPoint files</td>
</tr>
</tbody>
</table>
Table H.5

Documents Collected from Carl and Related Themes

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terms 1 and 2 math benchmark assessments for grade 3</td>
<td>Euler elementary math committee</td>
<td>Developing understanding</td>
</tr>
</tbody>
</table>
## Table H.6

**Documents Collected from Emmy (elementary generalist) and Related Themes**

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Core Georgia Performance Standards</td>
<td>Georgia Department of Education; georgiastandards.org CCGPS frameworks teacher edition: Mathematics: Third grade: Grade level overview</td>
<td>Developing understanding</td>
</tr>
</tbody>
</table>
Table H.7

*Documents Collected from Charlotte (elementary generalist) and Related Themes*

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Core Georgia Performance Standards</td>
<td>Georgia Department of Education; georgiastandards.org CCGPS frameworks teacher edition: Mathematics: Third grade: Grade level overview</td>
<td>Developing understanding</td>
</tr>
</tbody>
</table>
### Table H.8

*Documents Collected from Ada’s (mathematics consultant) Websites*

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Newsletter, 2012</td>
<td>Ada’s personal webpage</td>
<td>Developing understanding; Few and basic messages</td>
</tr>
<tr>
<td>Ada’s webpage (for professional development)</td>
<td>Ada’s personal webpage</td>
<td>Developing understanding; Few and basic messages</td>
</tr>
<tr>
<td>Ada’s university webpage</td>
<td>Ada’s university webpage</td>
<td>Developing understanding; Few and basic messages</td>
</tr>
<tr>
<td>PowerPoint file Professional Development course on understanding and applying the SMP</td>
<td>Ada’s personal webpage</td>
<td>Developing understanding; Few and basic messages</td>
</tr>
<tr>
<td>Journal article showing the importance of students explaining their understanding and teacher questioning</td>
<td>Reinhart, S. C. (2000). Never say anything a kid can say. <em>Mathematics teaching in the middle school, 5</em>(8), 478-481.</td>
<td>Developing understanding; Few and basic messages</td>
</tr>
</tbody>
</table>

*Note.* The documents collected from Ada’s website related to Interactive problem solving from sub-question three and Few SMP messages from sub-question two for each elementary generalist.
### Table I.1

**Index of all Files Resulting from Data Collection and Data Analysis**

<table>
<thead>
<tr>
<th>File numbers</th>
<th>Data Source</th>
<th>Description</th>
<th>Storage Location(s)</th>
<th>Relationship to other data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-9</td>
<td>MP3 files of each interview</td>
<td>Recordings of each of six teacher interviews; 3 administrator interviews</td>
<td>Folder in laptop; flash drive</td>
<td>Data for interview data analysis</td>
</tr>
<tr>
<td>10-18</td>
<td>Word files of transcripts</td>
<td>Verbatim transcriptions of interviews with each participant</td>
<td>Folder in laptop; flash drive</td>
<td>Transcript of corresponding MP3 files 1-9</td>
</tr>
<tr>
<td>19-27</td>
<td>Paper-based transcripts</td>
<td>Printed versions of digital (Word) transcripts; will contain highlighted segments, codes, minor themes, and notes</td>
<td>Binder in locked file cabinet in locked school office</td>
<td>Printed copies of 10-18</td>
</tr>
<tr>
<td>28</td>
<td>Word file of data analysis</td>
<td>Contains codes, minor themes, notes &amp; major themes for 3 cases and 3 admin.</td>
<td>Folder in laptop; flash drive</td>
<td>Data analysis from 19-27</td>
</tr>
<tr>
<td>29-35</td>
<td>Signed informed consent forms</td>
<td>Paper copies signed by each participant</td>
<td>Binder in locked file cabinet in locked school office</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Paper-based notes</td>
<td>Data, codes, minor themes, notes, &amp; major themes from observations of professional development</td>
<td>Binder in locked file cabinet in locked school office</td>
<td>Original notes</td>
</tr>
<tr>
<td>37</td>
<td>Documents</td>
<td>Documents collected from teachers</td>
<td>Locked file cabinet in locked school office</td>
<td>Data analysis of 36</td>
</tr>
<tr>
<td>38</td>
<td>Word file</td>
<td>Codes, minor themes, notes, &amp; major themes from teacher produced documents</td>
<td>Folder on laptop; flash drive</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Documents</td>
<td>Documents collected from administrators</td>
<td>Locked file cabinet in locked school office</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Word file</td>
<td>Codes, notes, minor &amp; major themes from administrator produced documents</td>
<td>Folder on laptop; flash drive</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Word file</td>
<td>Synthesis of data analysis of interviews, observations, and documents; this will merge with DTP to become final report</td>
<td>Folder on laptop; flash drive</td>
<td>Data analysis of 28, 36, 38, 39, 40, &amp; 41</td>
</tr>
</tbody>
</table>
Appendix J

**CCSSM Case Study Interview Transcript Sample**

Interviewee: Administrator  
Interviewer: Terry Langton  
Date: 12/4/13 Start time: 3:55 Finish time: 4:45  
Location of interview: Reading room – private room  
Distinguishing features of location: outside facing view – interview not interrupted  
Abstract: Administrator’s mathematics background and CCSSM professional development

<table>
<thead>
<tr>
<th>Line #</th>
<th>Interview Transcript</th>
<th>Codes</th>
<th>Memos</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Researcher: What are your responsibilities in this district?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Administrator 2: My title is director of teaching and learning K-8 and I do a little bit of everything I have been in the position since September. I started out by just getting to know principals, getting to know what is going on in the east coast town, and then some of the department of ed. requirements came into play with district determined measures looking at what we have in place for that, putting together our pilot plan for that, working with principals around that, and then talking about PARCC assessments. We</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure J.1. Interview transcription*
Appendix K

Table K.1

Documents Collected from the State Department of Education

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comparison of state math curriculum framework to CCSSM</td>
<td>State Department of Education (Website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>1996 State Mathematics Curriculum Framework</td>
<td>State Department of Education (Website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>2000 Mathematics Curriculum Framework</td>
<td>State Department of Education (Website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>2004 Mathematics Curriculum Framework</td>
<td>State Department of Education (Website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>2011 Mathematics Curriculum Framework (incorporating the CCSSM)</td>
<td>State Department of Education (Website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>Third grade lesson plans showing how SMC relate to SMP, plans also show how students respond to CCSSM aligned tasks</td>
<td>State Department of Education: STEM department: Mathematics learning community</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>Characteristics of a standards-based mathematics classroom</td>
<td>State Department of Education: STEM department (website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>Exploring fractions in the CCSSM from first to sixth grade (PowerPoint)</td>
<td>State Department of Education: STEM department (website)</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>Unit plans (15) with students learning experiences that integrate the SMC and SMP for number sense: addition, subtraction, multiplication, division, and fractions</td>
<td>State Department of Education: STEM department: Mathematics learning community</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>PowerPoint presentations with exploration activities to help teachers learn about the focus, coherence, clarity, and rigor of the CCSSM</td>
<td>State department of education list of website: Insidemathematics.org, mathshell.org, azed.gov, ohio.gov, illustrativemathematics.org, NC state department of ed, Hunt Institute</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
<tr>
<td>Sample student learning experiences aligned with the CCSSM, videos of lessons, assessments, student work</td>
<td>State department of education list of website: Insidemathematics.org, mathshell.org, azed.gov, ohio.gov, illustrativemathematics.org, NC state department of ed, Hunt Institute</td>
<td>Few and basic messages; inadequate, insufficient learning</td>
</tr>
</tbody>
</table>
Appendix L

Table L.1

*Race/Ethnicity of Leibniz, Euler, and The State’s Students*

<table>
<thead>
<tr>
<th></th>
<th>Leibniz Elementary School</th>
<th>Euler School District</th>
<th>The State</th>
</tr>
</thead>
<tbody>
<tr>
<td>African-American</td>
<td>2.5%</td>
<td>.9%</td>
<td>8.7%</td>
</tr>
<tr>
<td>Asian</td>
<td>2.0%</td>
<td>1.6%</td>
<td>6.1%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.5%</td>
<td>1.2%</td>
<td>17%</td>
</tr>
<tr>
<td>Native American</td>
<td>0</td>
<td>0</td>
<td>0.2%</td>
</tr>
<tr>
<td>White</td>
<td>94.1%</td>
<td>96.1%</td>
<td>65%</td>
</tr>
<tr>
<td>Native Hawaiian, Pacific islander</td>
<td>0</td>
<td>0</td>
<td>0.1%</td>
</tr>
<tr>
<td>Multi-race non-Hispanic</td>
<td>0</td>
<td>0.2%</td>
<td>2.9%</td>
</tr>
</tbody>
</table>

*Source:* State Department of Education
Appendix M

Table M.1

*Time Allotted for Mathematics and ELA Instruction at the Leibniz School*

<table>
<thead>
<tr>
<th>Grade Level</th>
<th>Minutes of Mathematics Instruction per Day</th>
<th>Minutes of ELA Instruction per Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>45</td>
<td>131</td>
</tr>
<tr>
<td>Second</td>
<td>70</td>
<td>109</td>
</tr>
<tr>
<td>Third</td>
<td>60</td>
<td>105</td>
</tr>
<tr>
<td>Fourth</td>
<td>58</td>
<td>96</td>
</tr>
</tbody>
</table>

*Note. Source: Leibniz master schedule (from principal)*
Appendix N

Table N.1

*Leibniz and State Grade 3 High-stakes Test Scores for Reading and Mathematics: 2008-2013*

<table>
<thead>
<tr>
<th>Spring of Year</th>
<th>Percent of students scoring advanced/proficient Leibniz Math</th>
<th>Percent of students scoring advanced/proficient State Math</th>
<th>Percent of students scoring advanced/proficient Leibniz Reading</th>
<th>Percent of students scoring advanced/proficient State Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>66</td>
<td>66</td>
<td>72</td>
<td>57</td>
</tr>
<tr>
<td>2012</td>
<td>72</td>
<td>61</td>
<td>85</td>
<td>61</td>
</tr>
<tr>
<td>2011</td>
<td>77</td>
<td>66</td>
<td>77</td>
<td>61</td>
</tr>
<tr>
<td>2010</td>
<td>74</td>
<td>65</td>
<td>76</td>
<td>63</td>
</tr>
<tr>
<td>2009</td>
<td>73</td>
<td>60</td>
<td>78</td>
<td>57</td>
</tr>
<tr>
<td>2008</td>
<td>73</td>
<td>61</td>
<td>75</td>
<td>56</td>
</tr>
</tbody>
</table>

Table N.2

*Leibniz and State Grade 4 High-stakes Test Scores for ELA and Mathematics: 2008-2013*

<table>
<thead>
<tr>
<th>Spring of Year</th>
<th>Percent of students scoring advanced/proficient Leibniz Math</th>
<th>Percent of students scoring advanced/proficient State Math</th>
<th>Percent of students scoring advanced/proficient Leibniz ELA</th>
<th>Percent of students scoring advanced/proficient State ELA</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>70</td>
<td>52</td>
<td>77</td>
<td>53</td>
</tr>
<tr>
<td>2012</td>
<td>60</td>
<td>51</td>
<td>73</td>
<td>57</td>
</tr>
<tr>
<td>2011</td>
<td>52</td>
<td>47</td>
<td>68</td>
<td>53</td>
</tr>
<tr>
<td>2010</td>
<td>61</td>
<td>48</td>
<td>72</td>
<td>54</td>
</tr>
<tr>
<td>2009</td>
<td>59</td>
<td>48</td>
<td>59</td>
<td>53</td>
</tr>
<tr>
<td>2008</td>
<td>48</td>
<td>49</td>
<td>48</td>
<td>49</td>
</tr>
</tbody>
</table>

## Appendix O

### Table O.1

**Ongoing Professional Development Initiatives at the Leibniz School**

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Source</th>
<th>Major Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implementing Elementary writing program</td>
<td>Empowering writers program (Empoweringwriters.com)</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>2. Implementing teacher evaluation system</td>
<td>Agreement between Euler school district and Euler teachers’ union</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>3. Ongoing implementation of standards-based report card</td>
<td>Standards-based report card committee</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>4. Implementing handwriting program</td>
<td>Handwriting without tears (Hwtears.com)</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>5. Ongoing implementation of curriculum mapping program</td>
<td>Web-based curriculum record keeping (Curriculum21.com)</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>6. Diagnostic assessment of mathematics learning and remediation</td>
<td>Symphonylearning.com, xtramath.org</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>7. Ongoing student achievement data collection: diagnostic and benchmark assessments in ELA and mathematics</td>
<td>Dynamic Indicators of basic early literacy skills (uoregon.edu), Developmental reading assessment, second edition + (pearsonschool.com), district created math tests</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>8. Ongoing implementation of student information system software</td>
<td>Folletsoftware.com (Aspen); attendance, grades, test scores, curriculum.</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>9. Ongoing implementation of CCSSM and CCSSELA; Finding resources to teach the CCSSM and CCSSELA</td>
<td>Corestandards.org; various websites discovered by teachers</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
<tr>
<td>10. Ongoing maintenance of teacher web pages</td>
<td>Leibniz school web page</td>
<td>Few and basic messages; Inadequate, insufficient learning</td>
</tr>
</tbody>
</table>
### Appendix P

#### Table P.1

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PowerPoint File of SMP seminar</td>
<td>Developed by the math coach</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Graphic Organizer of the SMP Showing the heading of each SMP Paper cubes (2) for guiding student problem solving with the SMP</td>
<td>Donna Boucher P-5 math coach, Morton Ranch Elementary School, Katy, Texas – mathcoachscorner.blogspot.com</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Paper cubes (2) for guiding student problem solving with the SMP</td>
<td>Oregon Council of Teachers of Mathematics – octm.org/files/3513/5439/3138/mathpracubes.pdf</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Blank cube template</td>
<td>Mommy nature.com</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Standards for mathematical practice interpretations for K-4</td>
<td>Elementary Math wikispaces.net, Charlotte-Mecklenburg Schools, Charlotte, North Carolina – cms.k12.nc.us</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Graphic organizer showing SMP in student friendly language</td>
<td>Rhode Island Department of Education, Providence, Rhode Island – ride.ri.gov</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Cover sheet with graphic of SMP</td>
<td>Euler math coach; Bakersfield City School District, California: bcsd.com</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Checklist of student behaviors relative to SMP</td>
<td>Alabama Learning Exchange, Montgomery, Alabama – alex.state.al.us</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>List of questions teachers can ask students for each SMP</td>
<td>Regional Office of Education #11, Charleston, Illinois - roe11.k12.il.us</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Common Core mathematics vocabulary terms K-5</td>
<td>East Moline School District, East Moline, Illinois – emsd37.org</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
</tbody>
</table>

*Note.* The district and school professional development calendars only provided the math coach with one opportunity to provide instruction on the SMP to the generalists. She made the most of it by providing them with many resources. However, the generalists needed more.
Table Q.1

Documents Collected that Relate to the Math Coach (Maria)

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memos reminding 1-4 teachers that students will do Symphony math during library class (9/19, 1/1)</td>
<td>Principal and math coach</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>October 15, 2013 professional development agenda (10/11)</td>
<td>Math Coach</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Memo containing list of websites offering CCSSM aligned lesson ideas (10/16)</td>
<td>Americaachieves.org, Betterlesson.com, Educore.ascd.org, Learnzillion.com, ldc.org, gatesfoundation.org (math design collaborative), teachingchannel.org, Tncore.org</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Memo to teachers stating that they all did not all receive training in Symphony math program (10/20)</td>
<td>Administrators</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Memo showing how the mathematics performance of Euler District compares to districts of similar SES status (10/24)</td>
<td>State Department of Education</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Article on new mathematics vocabulary distributed to mathematics teachers (11/4)</td>
<td>Faulkner, V. (2013). Why the Common Core changes math instruction. <em>Phi Delta Kappan</em>, 95(2), 59-63</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Letter inviting 1-12 students to participate in Math Kangaroo competition (11/30)</td>
<td>Mathkangaroo.com</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Memo to teachers with web resources on questions to ask students during mathematical discourse (12/16)</td>
<td>Univ. of Wisc. At Milwaukee, montemath.com, Louisville (OH) City Schools</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Memo reminding teachers to conduct math benchmark assessments (12/10, 1/1)</td>
<td>K-8 Director of teaching and learning and Math Coach</td>
<td>Few and basic messages; Developing understanding</td>
</tr>
<tr>
<td>Memo to teachers on Common Core aligned lessons from NEA: Common Core Toolkit (1/21)</td>
<td>National Education Association <a href="http://www.nea.org/home/ccss-toolkit.htm">http://www.nea.org/home/ccss-toolkit.htm</a></td>
<td>Few and basic messages; Developing understanding</td>
</tr>
</tbody>
</table>
Appendix R

Table R.1

*Documents Collected from K-8 Director of Teaching and Learning (Sophia) and Related Themes*

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memo on mathematics courses offered by university: operations, algebraic thinking, problem solving (10/10)</td>
<td>City university mathematics education department</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>Memo on Vision 2020 survey: find out what mathematics resources are being used, questions about CCSSM implementation (11/7)</td>
<td>Vision 2020 mathematics committee</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>Reminder memo to complete Vision 2020 survey (11/18)</td>
<td>Vision 2020 mathematics committee</td>
<td>Few and basic messages</td>
</tr>
</tbody>
</table>
Table S.1

*Documents Relating to the Leibniz Principal (Elena) and Related Themes*

<table>
<thead>
<tr>
<th>Document</th>
<th>Source</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memo to teachers: review high stakes test scores, explanation of</td>
<td>Principal, K-8 director of teaching and learning, math coach</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>Symphony math, review new math vocabulary (10/11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memo to teachers: math benchmark scores are to be turned in (11/1)</td>
<td>Principal, K-8 director of teaching and learning</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>Memo to teachers: reminder to turn in math benchmark scores (11/12)</td>
<td>Principal, K-8 director of teaching and learning</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>Memo to teachers: principal and math coach want a family math night</td>
<td>Principal and math coach</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>to occur in January or February (11/12) Carl, Emmy, and Charlotte</td>
<td></td>
<td></td>
</tr>
<tr>
<td>volunteered to participate in family math night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memo to teachers: reminder to teachers from K-8 Director of</td>
<td>Principal, K-8 director of teaching and learning</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>teaching and learning for teachers to complete pre and post benchmark</td>
<td></td>
<td></td>
</tr>
<tr>
<td>math testing (11/20)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Memo to teachers: Mathematics state testing schedule for 2013-2014 (1/14</td>
<td>Principal</td>
<td>Few and basic messages</td>
</tr>
<tr>
<td>Teacher planning of mathematics state high-stakes standardized testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>from May 14 – May 19, 2014</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix T

Table T.1

**Math Programs Used at the Leibniz School**

<table>
<thead>
<tr>
<th>School Year</th>
<th>Math Program</th>
<th>Publisher &amp; Copyright date</th>
<th>Aligned to</th>
<th>Teacher's guide</th>
<th>Student workbook</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-2014</td>
<td>On Core Mathematics</td>
<td>Harcourt 2012</td>
<td>State</td>
<td>Yes</td>
<td>Yes</td>
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