Title
Exploring the Connections Between Teaching Practices and Math Identities in Middle School Teachers

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Publication Date
2021

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA

Los Angeles

Exploring the Connections Between Teaching Practices and Math Identities in Middle School Teachers

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Education

by

Kathryn Leigh Campbell

2021

ABSTRACT OF THE DISSERTATION

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Middle School Teachers

by

Kathryn Leigh Campbell

Doctor of Education

University of California, Los Angeles, 2021

Professor Megan Leof Franke, Co-Chair

Professor Kristen Lee Rohanna, Co-Chair

This study explored the connections between teaching practices and math identities in middle school teachers. In spite of the introduction of common core math standards, math instruction as a whole has had minimal changes in pedagogy on a large scale. Inequities exist in what type of student receives a strong conceptual foundation in math, and this study aimed to contribute to the explanation of why some teachers teach math the way they do. Through looking at teachers' math experiences as students as well as how they taught math, this qualitative study hoped to explore the impact their math identity had on their pedagogy. This study consisted of ten teachers from opposite ends of the traditional and conceptual teaching spectrum and found differences in math identity between the two groups. Identity is personal and nuanced, and

exploring those nuances led to an increased understanding of how their pedagogy connected to their own experiences in math, as well as their identity.

The dissertation of Kathryn Leigh Campbell is approved.

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2021

DEDICATION

This dissertation is dedicated to two people for whom this would not be possible without their support: my mother and my partner. My mother laid the educational foundation for me, and my partner has been an amazing support system. Mom, thank you for everything you have done to push, guide, and support me. Jo Ann, thank you for being you.

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CHAPTER 1: INTRODUCTION

Mathematics achievement in the United States as a whole has been stagnant over the last 15 years. Using the National Assessment of Educational Progress (NAEP) to compare states nationwide, scores in mathematics have remained constant despite an increased focus on math and shift in standards for more than half of the country (National Center for Education Statistics, 2017). Additionally, in comparison with the rest of the world using the Program for International Student Assessment (PISA), U.S. students consistently rank in the middle with little improvement (National Center for Education Statistics, 2020). This lack of growth has held for math achievement in California. According to the California Department of Education's Dataquest, there was only 6% growth in Met and Exceed scores in math over the 5 years after the adoption of the Common Core State Standards (CCSS). Furthermore, there are significant differences in the achievement of higher- and lower-socioeconomic students. Students who are economically disadvantaged consistently score 30% lower than students who are not economically disadvantaged (CAASPP). This lack of growth and equity in achievement is problematic as students enter the global workforce.

The CCSS that have been adopted by many states, California included, have attempted to embed concepts into their standards and framework through the Standards for Mathematical Practice (SMPs). This has shifted expectations of how mathematics is to be taught, with an emphasis on more conceptual understanding. Despite this shift, however, the data suggest students have not gained a deeper understanding of math, as evidenced by the California state test.

High achievement in mathematics has been linked to the types of activities and instruction students are exposed to and the way in which they are taught (Gales & Yan, 2001;

Wenglinksky, 2002). However, not all students receive the same quality or form of teaching in mathematics. The quality of conceptual teaching in mathematics education differs in higher- and lower-SES areas (Wenglinksky, 2002). Higher-SES students receive more conceptual and investigative teaching; lower-SES students receive more worksheets and memorization. These pedagogical practices have been linked to differences in achievement of higher- and lower-SES students (Wenglinksky, 2004), and how those practices are utilized depends on the decisions and perspectives of the teacher. Considering that California is 61.5% socioeconomically disadvantaged, providing students access to instruction that is linked with achievement is more important than ever (CDE, n.d., 2017 data). Given the recent shift in focus prioritizing conceptual understanding over skills, it is clear that curricula and standards alone are not the reason students' math scores are not improving. Because certain pedagogical practices promote math achievement more than others, how teachers choose to teach mathematics deserves further exploration. Furthermore, research has suggested math instruction is connected to the way in teachers were taught, themselves, along with how they view their own abilities (Bjuland et al., 2012; Hodgen & Askew, 2007; McCulloch et al., 2013). Thus, one area for deeper investigation is the math identity of teachers and the extent to which it affects perspectives and decisions regarding instructional content and pedagogy.

Background of Identity

There are multiple ways to describe a person's identity, including how they are seen by others and how they see themselves. Identity encompasses how people see themselves, how they describe themselves to others, and how they believe other people will describe them (Gee, 2000; Neumayer-Depiper, 2013; Sfard & Prusak, 2005). People can have more than one identity (Gee, 2000), and those identities are not fixed points; they change over time as experiences change

(Peressini et al., 2004). Identity is important to acknowledge and understand because it is the underlying foundation for the choices people make. Knowing how people identify themselves helps others to understand why they do what they do.

Teachers' identities are fluid and change as their experiences within schools and social groups change (Gee, 2000; Steinberger & Magen-Nagar, 2017). The stories they tell themselves and others about how and who they teach will affect their identity. As teachers experience these identity changes, their teaching practices may also change. As such, the relationship between teachers' identities and their pedagogy has yet to be explored. This study specifically examined teachers' math identities, as defined by how they view mathematics and themselves as math learners, as well as how their identities developed and how these identities affect their pedagogical practices.

Math Identity Formation

Cribbs et al. (2015) connected individuals' self-perceptions of their own interest, competence, performance, and recognition to the impact of the development of their own math identities. While Cribbs et al.'s study focused on students, identity formation can be tied to adults as well. Unlike students, teachers have had a lifetime to develop their teaching and subject matter identities, and those identities can affect their professional growth (Bjuland et al., 2012; Gresalfi & Cobb, 2011). When asked to give personal narratives, teachers related that almost all of their positive and negative memories about mathematics stemmed from the teachers they had and how those teachers had taught them (McCulloch et al., 2013). Very few teachers spoke about having an easy time in math throughout their schooling; many spoke at length about challenging teachers.

A teacher's identity is heavily influenced by previous experiences, both as a student and as a teacher (Bray, 2011; Campbell et al., 2014). Every teacher who enters the profession has experience as a student; no one is without some familiarity or expectation of what it is like in a classroom. Within mathematics, many teachers have strong memories of what learning math was like for them. Though teachers range in grade levels from kindergarten through high school, most studies around teacher identity and previous math experiences have focused on elementary and middle school teachers. For many elementary teachers, their memories of their experiences in math were not positive and affected how they believe mathematics should be taught (Davies & Adams, 2000). Many middle school math teachers stated they were motivated by their experiences as a student, either to be like the teachers they loved or to provide better experiences for their own students because they struggled with their teachers. As they gain experience as a teacher, those perspectives will shift as their experiences shift (Muijs & Reynolds, 2015). For teachers, those experiences come in two forms: content knowledge and teaching practices. Both have an impact on the direction teachers take with their own students, and both have been shown to influence student achievement (Muijs & Reynolds, 2015).

Connecting Identity to Teaching Practices

Previous studies have connected teacher perspectives, instructional practices, and achievement of their math students (Gales & Yan, 2001; Wenglinksky, 2002). An emphasis on concept over memorization, student discussion of topics, and allowing students to make mistakes have all been shown to improve student achievement and better prepare students for higher-level mathematics. When teachers believed students should be challenged and given the opportunity to struggle with mathematical concepts, they designed lessons that allowed students the time and space to do that (Muijs & Reynolds, 2015). For example, when elementary teachers were confident in their mathematics ability, they provided more challenging problems to their students, provided more student-to-student opportunities for discussion, and prompted critical thinking skills when students made an error (Bray, 2011; Campbell et al., 2014). Those lessons were directly related to positive student growth, and they were heavily influenced by the perspectives of their teachers.

The way teachers choose to present math to students affects how students view math as a subject. When secondary students were interviewed regarding their perspectives about mathematics, many reported that they believed math to be "rigid and inflexible" (Boaler et al., 2000) and that they felt they were good at math when they believed their teacher thought they were good at math (Cribbs et al., 2015). Being recognized as being good at math was as important as doing the activities; participating in discussions, peer-to-peer recognition, and positive experiences in class all increased students' interests in math as a subject. The experiences those students had in math class affected their view of it, and those experiences were designed by their teachers. Thus, it was the teacher who profoundly influenced their math identity based on what the teacher believed being good at math looked like.

While there are studies that focus on the experiences and perspectives of elementary school teachers around mathematics (Bjuland et al., 2012; McCulloch et al., 2013; Sexton, 2008), there is less information on secondary teachers, particularly those without full single subject credentials. Additionally, some studies have explored how students develop a math identity (Cribbs et al., 2015) and how teachers' experiences affected their identities as math learners (McCulloch et al., 2013), but less has been done about how those experiences affected how they teach.

Statement of the Problem

This study aimed to further investigate the connection between secondary teachers' math identity and their instructional practices, in order to explain the current stagnation in math achievement as well as offer a guide on future professional development for teachers to change how they believe math should be taught. The results of this study could have a profound impact on how professional development is administered to math teachers. The following research questions guided this study.

Research Questions

1. How have teachers' own experiences shaped how they view mathematics, if at all?
2. How do teachers describe themselves regarding their math identity?
3. How do teachers' math identities connect to their teaching practices, if at all?

Research Design

This qualitative study examined secondary middle school math teachers who teach in low-income, high–ethnic minority schools in a large suburban district in southern California. It was important to conduct this research in low-income schools, as the research has shown these students are most likely to have low math achievement and be taught with less challenging teaching practices. This study utilized interviews, journaling, and artifacts to discover whether a connection exists between teachers' math identity and the types of activities they design for their students. Teachers were invited to participate in two interviews, one that examined their teacher identity and one that examined their teaching practices. For the first round of interviews, the questions focused on exploring in more detail the math identity of teachers. Teachers had an opportunity to share their personal experiences of studying math at every level. The second interview focused on their teaching practice. Teachers had an opportunity to discuss how they teach math and why they choose to teach it the way they do, as well as bring in an artifact (such as student work or a lesson plan) that they felt represented how they want to teach. At the end of the second interview, teachers were asked to journal about how they feel their teacher identity and past experiences have affected their teaching styles.

Significance

Despite the lack of mathematics achievement in the United States at present and a general consensus that something needs to be done to improve it, recent attempts have not lessened the achievement gap or improved the country's standing in math compared with other countries. This study explored the idea that improving mathematics achievement starts with identifying teachers' perspectives on mathematics and themselves as math teachers. So much of what individuals do depends on the identities they have developed over time. Most people act according to their perspectives, and that includes teachers and their teaching practices. Gaining a better understanding of what teachers believe about teaching and learning math can encourage dialogue around effective teaching practices of mathematics. From there, professional development can be designed to help teachers grow as math learners as well as math teachers.

CHAPTER 2: LITERATURE REVIEW

Math achievement in California has seen limited growth statewide since the inception of the Common Core State Standards (CCSS). This stagnation matches the mathematics achievement in the United States despite a nationwide standards reform initiative. The CCSS were created with the intention of changing how mathematics was taught. Generated by a commission of governors partially to create a continuity among states and grade levels and partially to respond to college and the professional communities' concerns around the math ability of students exiting the K–12 sphere, this educational reform was intended to create a greater conceptual understanding by focusing on more depth of standards and less breadth. However, student conceptual understanding of mathematics has failed to improve with the reform (National Center for Education Statistics, 2017, 2020). Numerous studies have indicated that specific teaching practices and pedagogy are linked to higher student conceptual understanding (Gales & Yan, 2001; Wenglinksky, 2002), yet those teaching practices are not widespread. To understand the discrepancy between the educational reform intended to increase conceptual understanding and the lack of student improvement, this study explored how teacher identity can affect pedagogy and teaching practices.

I begin by providing context surrounding the lack of math achievement by reviewing the current math scores in California and the lack of growth compared with many countries. I then investigate the connection between student achievement and specific teaching practices in order to provide context for why higher-socioeconomic students achieve at higher rates than lower-socioeconomic students. The concept of identity is then explored, both how it is formed and why it matters within the context of a secondary math classroom. I then examine how teachers form their math identities, both as students and as adults, and how these identities can change over time based on experiences. Finally, I discuss how teacher identity can connect to classroom practices and pedagogy, with the hope of ultimately influencing student achievement.

Achievement Gap

As measured by the California Assessment of Student Performance and Progress (CAASPP), California students have increased their Met or Exceed scores by only 5% since the inception of the test 5 years ago (CDE, n.d., 2019 data). While this lack of growth holds for both socioeconomically advantaged and disadvantaged students, the former consistently score more than 30% higher than the latter (CDE, n.d., 2019 data). This gap persists across all grade levels and can be reframed as an opportunity gap because these same students also experience differences in quality of instruction depending on socioeconomic status (CDE, n.d., 2018 data; Moller et al., 2013; Wenglinksky, 2002). Though their study focused primarily on elementary teachers and students, Moller et al. (2013) found that "achievement gains vary across students of different racial/ethnic and socioeconomic status" (p. 186). This lack of equity in student achievement in mathematics has persisted from the inception of the CCSS.

The shift to CCSS from previous standards was meant to improve students' conceptual understanding of mathematics by including Standards for Mathematical Practice (SMPs). The combination of these standards created a shift in the expectations of what students are able to understand and apply with mathematics, thereby deepening students' mathematical understanding. Nevertheless, across California, only some students are performing at standard. Lower-SES districts, as measured by the SBAC, have consistently scored 30% lower than higher-SES districts from the inception of the assessment (CDE, n.d., 2019 data). Additionally, the achievement gap holds true for students of color regardless of socioeconomic status. This reflects not just differences in income and ethnicity, but differences in the quality of education afforded to all students in California.

Higher achievement in mathematics has been connected to completion of the year's curriculum and the quality of instruction and rigor of math students are exposed to (Gales & Yan, 2001; Muijs & Reynolds, 2015; Wenglinksky, 2002). When students are given more open-ended and rigorous math activities at grade level, they are more likely to score higher on the SBAC. Unfortunately, the opportunity to be exposed to that level of math instruction is not afforded to every student; students in higher-SES schools are more likely to be taught conceptually than students in lower-SES areas (Moller et al., 2013; Wenglinksky, 2004). Thus, the inequity of math achievement can be tied to the inequity of levels of instruction. Considering that California is more than 60% socioeconomically disadvantaged (CDE, n.d., 2017 data) and that the change in standards was not enough to improve students' math scores, focusing on teachers' pedagogical practices becomes more important than ever. Exploring the connection between teacher identity and pedagogical practices may help to explain this lack of instructional equity.

Background of Identity

People conceptualize their own identity in numerous ways: from self-identities, such as gender and spirituality, to collective identities, such as nationality and class. The identities of people affect what they believe and how they behave. Identity is about how people view themselves, how they describe who they are to other people, and how they believe other people would describe them (Gee, 2000; Neumayer-Depiper, 2013; Sfard & Prusak, 2005). A person's identity is not fixed; it is fluid and changes as a person has new experiences, within both his/her personal and work life (Gee, 2000; Peressini et al., 2004; Steinberger & Magen-Nagar, 2017). As those identities shift, so can perspectives and behaviors.

Defining Identity

Identity has its roots in psychology and largely falls into one of two groups. Mead (1934) posited that identity was formed through interactions with a person's environment and that his/her identity could form contradictions based on new experiences, while Erikson (1968) posited that identity formed throughout a person's life and tended to be more uniform in nature (Graven & Heyd-Metzuyanim, 2019). Though the former positions identity as an action and the latter positions identity as an acquisition, both state that a person's identity is formed over time and involves how one sees oneself or how one is seen by others. This duality has been incorporated into many studies around identity in education (Gee, 2000; Graven & Heyd-Metzuyanim, 2019; Neumayer-Depiper, 2013; Peressini et al., 2004; Sfard & Prusak, 2005). It is through their interactions and experiences over time that teachers' identities are formed and then actualized.

Though many studies have explored the impact of learner and teacher identity, few have formally operationalized the concept of identity (Graven & Heyd-Metzuyanim, 2019). Two of the first to do so were Gee (2000), who found that a person can have multiple types of identities depending on the situation and experiences of the person and that those identities are fluid, and Sfard and Prusak (2005), who focused on identity as a combination of the narratives a person uses to describe themselves as well as the way they are described by others. Though they differ on their formal definition, both include elements of life experiences and interaction with others within the formation of the identity of an individual. While there is a lack of uniform definition of identity in education, these two main concepts of identity—that it is fluid and based on experiences and dependent upon or revealed through narratives—have been utilized in numerous research on multiple forms of educational identity, including mathematics (Grootenboer & Zevenbergen, 2008; McCulloch et al., 2013; Steinberger & Magen-Nagar, 2017). For the purposes of this study, identity was defined as the way people describe their previous experiences and how they believe those experiences affect how they view mathematics.

Why Identity Matters

In the past several years, there has been an influx of studies around both teacher and learner identities at both the elementary and the secondary levels (Graven & Heyd-Metzuyanim, 2019). Because identity is a defining part of who a person is, identity is now seen as a key element of teaching and learning; it directly affects how and what a person learns. Though people are complex, "identity is a unifying and connective concept that brings together elements such as life histories, affective qualities and cognitive dimensions" (Grootenboer & Zevenbergen, 2008, p. 243). When studying identity in students, researchers have found it to correlate with interest, persistence, and academic performance in mathematics (Cribbs et al., 2015). By learning about student identity, research has expanded on the knowledge of how and why students learn, as well as why they do not. When studying identity in teachers, researchers have found that personal experiences can affect which students they identify with (Davies & Adams, 2000), their opinion of mathematics as content (McCulloch et al., 2013), and their opinion about student ability (Clark et al., 2014; Gresalfi & Cobb, 2011; Muijs & Reynolds, 2015). As identity is linked to experiences and experiences are linked to perspectives, identity is the root of how and why people make the choices they do. These choices affect how they teach mathematics, which in turn affects students' achievement and development as math learners. As such, studying teacher math identity and its impact on teachers' choices within their mathematics classroom can further the exploration of why the introduction of the CCSS alone was not enough to improve student conceptual understanding.

Math Identity Formation

Every teacher has experiences of mathematics from two areas: as a student and as a teacher. The two are connected; those prior student experiences have a profound impact on teacher identity (Bray, 2011; Campbell et al., 2014). As teachers gain experiences with math, every new and prior experience they had influences how they see math. The sum of all of their experiences, as both a student and a teacher, forms their math identity.

Math Content Identity Formation

Previous studies of upper elementary and middle school teachers have explored the impact of their experiences as students on their view of mathematics (Bray, 2011; Davies & Adams, 2000), and autobiographical studies of elementary teachers have revealed teachers' memories of math as a student (Ellsworth & Buss, 2000; McCulloch et al., 2013). Most of those qualitative studies relied on journaling or interviews to allow teachers to discuss in detail what they remembered about math. When telling stories about their experiences with mathematics, teachers revealed that both strong positive and strong negative emotions about mathematics were connected to their experiences with a specific teacher. Of the five themes found by Ellsworth and Buss (2000) to influence attitudes about mathematics, only one was not controlled or affected by the teacher. When asking K–2 teachers about their relationship with math, McCulloch et al. (2013) found that their most positive memories of math were in elementary school; in middle and high school, they began to develop negative experiences and opinions of math and their math teachers. Indeed, most teachers spoke of experiencing difficulty with mathematics at many points as a student, and often those difficulties stemmed from a teacher whom they felt could not explain the concepts or with whom they lacked a connection (Lutovac & Kaasila, 2014; McCulloch et al., 2013). In fact, many primary teachers expressed fear of teaching math at higher levels because of their own experiences as students (Lutovac & Kaasila, 2014). However, the inverse relationship was also true. Many middle school teachers who had positive relationships with mathematics spoke fondly of their teachers and expressed a desire to be as supportive to students as their teachers were to them. Whether negative or positive, teachers' experiences as students affected how they viewed their job as math teachers.

Studies of college and secondary students also have revealed the integral role of the teacher in beginning to develop math identity in students. The experiences in the classroom, largely directed by the teacher, affect how students view mathematics as a subject and themselves as a math learner (Boaler et al., 2000; Cribbs et al., 2015). Being successful in math was not enough for students to think highly of the subject, or even to think of themselves as math people. When classroom activities centered around textbook work with limited discussion, students viewed math as procedural and expressed a lack of interest in math (Boaler et al., 2000). This lack of interest is critical because interest in math has a profoundly positive effect on the creation of a positive math identity (Cribbs et al., 2015). Significantly, these activities in class were designed and controlled by the teacher; the development of math identity is made through the relationships between the math, the teacher, and the student (Grootenboer & Zevenbergen, 2008; Hodgen & Askew, 2007). The discourse between the student and the teacher affected how the student viewed both the subject and themselves as a math learner (Cribbs et al., 2015). Though these studies focused on students, every teacher began their math identity as a student; thus, these are the foundations of teacher math identity.

Much of the research around teacher identity has examined the impact of personal experiences on teacher perspective (Gales & Yan, 2001; Wenglinksky, 2002), but less has been done to explicitly study both what a teacher's math identity is and how it is formed. Given the importance of the teacher in math class, a strong math identity by the teacher can affect students' success in math (Clark et al., 2014; Grootenboer & Zevenbergen, 2008). The more mathematically confident a teacher is in their subject, the more likely they are to project a sense of positive math identity to their students. This affects not only how teachers see math, but also how they choose to teach it and what activities they design.

Pedagogy Identity Formation

Pedagogy is the method by which a teacher chooses to teach and is heavily influenced by teachers' perspectives. Though teachers may enter the profession with experiences in math, the only experiences most teachers have are in their teacher education program, so their pedagogical perspectives are still developing. Traditional mathematics teaching and a more inquiry-based conceptual understanding model represent two different pedagogical approaches. A behaviorist view holds that skills are built upon other skills, and that knowledge is acquired, which coincides with a more worksheet-based approach to math. In contrast, a constructivist view that holds that the learner can create their own insights and test hypotheses matches more with the conceptual idea of teaching (Gales & Yan, 2001). This study focused on these two pedagogical beliefs.

A teacher's pedagogy can and will change as their teaching experiences change (Muijs & Reynolds, 2015; Neumayer-Depiper, 2013). When studying teachers before and after a workshop or professional development focused on a specific teaching style, researchers found that teachers either changed how they viewed the content or altered how they implemented lessons (Bjuland et al., 2012; Hsieh, 2016; Ntow & Adler, 2019; Sexton, 2008). This indicates that pedagogy is not a fixed style; it can be developed based on experiences. For many teachers, this develops through their personal experiences as classroom teachers. Before they are employed as teachers full time, their teaching identity begins to develop in their teacher education program and student teaching. Studies of preservice teachers found that they were less likely than their peers to believe that they could effectively implement pedagogy to persuade a student to do well in a content area (Edwards et al., 2007), indicating that such perspectives require teaching experience to become part of a teacher's identity. Another study with a secondary math student teacher found that the student teacher was deeply affected by students' responses to pedagogical efforts (Peressini et al., 2004). When one student teacher tried teaching math conceptually and met with resistance from the students, the student teacher concluded that the students could not handle working together and relied on worksheets for the rest of the term. The student teacher's lack of previous experience teaching conceptually led him to alter his teaching style.

Pedagogical beliefs can be held by individuals, but they can also be part of the culture of a school (Deng et al., 2014; Moller et al., 2013). Many student teachers started out wanting to teach math more conceptually but worried about the pressure their site would put on them to raise test scores rather than focus on pedagogical practices (Peressini et al., 2004). When a teacher's beliefs do not align with the beliefs and values of their colleagues or institution, they may become conflicted about the direction in which they should take their teaching (Lutovac & Kaasila, 2014; McCulloch et al., 2013). As identity is fluid and influenced by ongoing experiences, the organizational culture that teachers work in will inevitably affect their own identity. With the push for many districts to participate in professional learning communities (PLCs), the relationships teachers have with their colleagues have the ability to influence their teaching. In fact, many studies have found that when teachers collaborated with their peers, the teachers felt that their overall teaching improved (Bjuland et al., 2012; Gresalfi & Cobb, 2011). Thus, a collective identity can form and affect what teachers believe about their practices as well as how they will implement teaching content.

Connecting Identity to Teaching Practices

Professional Identity and Teaching Practices

Previous studies around identity have connected teacher professional identity to pedagogical practices (Bjuland et al., 2012; Hsieh, 2016; Peressini et al., 2004; Sexton, 2008). Like other identities, professional identity lacks an agreed-upon operational definition in research (Hsieh, 2016; Steinberger & Magen-Nagar, 2017). Also like other identities, teachers' professional identity is formed over time through experience and culminates in "how a teacher perceives himself or herself and his or her role in the classroom" (Hsieh, 2016, p. 94). It incorporates a teacher's sense of self, as well as how a teacher reflects on that sense of self. Though many studies focus on primary teachers, Hsieh (2016) found that the professional identity of preservice secondary teachers greatly affected their receptiveness to professional development that challenged their previous experiences, which in turn affected their instructional perspectives and practices in the classroom. Their willingness to learn was part of their professional identity.

Reflection plays an integral part in a teacher's professional identity. Two separate case studies with primary teachers found that when the teacher was provided time to reflect on the professional development, the teacher actively changed how she saw math as well as how she ran groups and selected the tasks to assign students (Bjuland et al., 2012; Hodgen & Askew, 2007). More than the professional development itself, it was the teacher's reflection exercises that influenced her teaching practices. In one instance, the teacher needed to express her dislike of math as a secondary student and was allowed to explore the different ways in which students can learn math; she initially struggled with allowing students to discuss math but in time came to value it (Hodgen & Askew, 2007). In both case studies, teachers' professional identity affected both how they saw math and their pedagogical approach to it.

While there is evidence that professional identity can influence behavior, such as teaching practices, there is less evidence that it can change perspectives. When receiving professional development, teachers changed behaviors based on their reflections of how aligned the professional development was to their incoming perspectives (Ntow & Adler, 2019; Sexton, 2008). In one study, teachers got out of the professional development by reflecting on what they wanted to learn going in (Ntow & Adler, 2019). In another study, the teachers' reflections on the dissonance of their experiences as a student compared with their experiences student teaching most influenced their teaching practices (Sexton, 2008). Either way, teachers' identity prior to the professional development determined whether they changed their practice.

Teaching Practices and Student Achievement

The manner in which students are exposed to mathematics has a direct correlation with their achievement. When students are presented with more open-ended, unique, and conceptual problems, they reach higher math achievement (Boaler et al., 2015; Kane et al., 2011; Richland et al., 2012; Wenglinksky, 2002). Though there are many ways to teach mathematics, most fall into two dominant categories: using procedures and making connections (Richland et al., 2012). When Kane et al. (2011) observed and codified effective teaching practices, three of the five were centered around student discourse with thought-provoking questions, promoting conceptual understanding, and providing immediate feedback around student misconceptions that arise through those student discussions. Not one emphasized providing routine problems for students to solve. When used in combination with making connections, using procedures contributes to high student achievement. In fact, when students applied mathematical reasoning through a procedure, they made far fewer errors than those who attempted to apply a procedure blindly (Richland et al., 2012). However, when used in isolation, using procedures causes students to lack conceptual understanding of the concept behind the procedure and results in students believing that math is a set of rules to be memorized rather than applied and used (Boaler et al., 2000, 2015; Richland et al., 2012). Memorization and routine procedural computation are not grade specific; they take place throughout K–12 mathematics education and result in students' inability to explain the reasoning behind the procedure. This widespread pedagogy contributes to lack of achievement on end-of-year tests, as well as lack of conceptual understanding as students leave the K–12 system and enter into higher education.

The Current Study

The current study was guided by the literature on identity and the National Council of Teachers of Mathematics (NCTM) book *Principles to Actions*, which lays out a framework for the benefits of teaching math conceptually. I was guided by the literature around identity formation, from professional to pedagogical, as it relates to teacher experiences and behavior. One unifying part of identity is that critical reflection and communication are key components of learning both how people identify themselves and how their identity formed. Identity forms over time and changes based on a person's experiences, and each person's identity is unique.

A second framework that guided this study was the impact of teacher perspectives and behaviors in *Principles to Actions*. NCTM lays out the differences in teacher perspectives of those who teach math conceptually versus those who teach math more procedurally. Productive beliefs, or constructivist beliefs, lead to a more conceptual method of teaching, while unproductive practices lead to more traditional and procedural teaching methods. Using these as a guide for teacher interviews allowed this study to explore the teachers' pedagogies. Taken together, these two frameworks help to inform how identity can lead to perspectives, and perspectives can lead to pedagogy, thereby informing how identity can directly or indirectly influence pedagogy.

Math Identity and Teaching Practices: The Gap

Though studies have shown that teaching practices have different effects on student learning (Bray, 2011), less has been studied about how teacher beliefs about this subject matter influence those teaching practices, particularly in secondary classrooms. Knowing that some forms of identity can directly affect teaching practices and that teaching practices directly affect student achievement in mathematics, it is worth examining how math identity in teachers influences their decisions about how to teach it. From a research standpoint, there is little empirical evidence connecting a secondary teacher's math identity to pedagogical practices. From a practical standpoint, there has been little improvement in math achievement in K–12 schools in California, and there is a significant gap between lower- and higher-SES achievement. Research has shown that concept-based teaching does more to raise achievement than procedural; research has also shown that professional development can affect teacher behavior in the classroom. Given that math education has come increasingly into focus, this study aimed to determine where to focus professional development in the future. If math identity does, in fact, affect teaching practices, then we can begin to alter how we provide math professional development.

CHAPTER 3: METHODOLOGY

The quality of conceptual teaching in mathematics education differs between higher- and lower-SES areas (Wenglinksky, 2002). Higher-SES students tend to receive more conceptual and investigative teaching, while lower-SES students tend to receive more procedure-oriented teaching. These pedagogical practices have been linked to differences in the achievement of higher- and lower-SES students (Wenglinksky, 2004), and how those practices are utilized depends on the decisions and perspectives of the teacher. Knowing that certain pedagogical practices promote math achievement more than others, how teachers choose to teach mathematics deserves further exploration.

This study investigated how teachers' perspectives about mathematics as a subject influence their lesson design and classroom activities. Given that teaching conceptually is fundamentally different from teaching through memorization of facts, identity may play a role in the choice between teaching conceptually and teaching through facts.

Research Questions

1. How have teachers' own experiences shaped how they view mathematics, if at all?
2. How do teachers describe themselves regarding their math identity?
3. How do teachers' math identities connect to their teaching practices, if at all?

Research Design

I conducted a phenomenological, qualitative study aimed at understanding the phenomenon of math teachers' identity (Merriam & Tisdell, 2016). Because the focus of this study was the development of teachers' math identity and how it affects their perspectives about math, it needed to be qualitative, to allow teachers to describe their previous experiences in math and how those influenced their current perspectives. The best way to do that is to ask them and give them the space to talk about it through interviews and journaling. As such, a qualitative study was most appropriate (Merriam & Tisdell, 2016). Quantitative studies and surveys tend to be more deductive in nature and would not provide the space for teachers to inductively share their experiences, teaching identity, and teaching practices.

I sought to gather stories from teachers about their experiences and perspectives related to mathematics, so this study consisted of two interviews, an artifact collection, and a single journal prompt. Adapted from Seidman (2013), the process followed his phenomenology-based interviewing, which uses open-ended questions that build upon the responses of the interviewees to allow them to delve into the experience the interviewer wants explored. The first interview examined the teacher's own experiences with mathematics, both as a student and as an adult. The second interview focused on the teacher's teaching practices and gave the teacher time to explain the artifact he/she brought. The artifact was meant to represent a successful lesson showing how he/she teaches math and could have been student work or lesson plans. All three stages were necessary to answer the research questions. Personal experiences take time to explore, so an hour-long interview devoted just to the teachers' math experiences ensured that enough time was given to them to share things that helped shape their view of mathematics. The second interview allowed time to be devoted to the teachers' current math practices and how they see themselves as current practitioners of mathematics, as well as how they like to teach math. The artifact collection and journaling allowed for triangulation of the teachers' thoughts on their teaching practices.

Methods

Site Selection

Scores between higher- and lower-SES districts differ significantly, so I chose a district that is fairly typical for my surrounding area in California: low SES and high minority. Math scores in California are low, particularly for low-SES students, in part because they have less access to conceptual pedagogy than students in higher-SES districts (Wenglinksky, 2004). For this reason I chose a large suburban district in southern California, which from here I will call Southern California Unified School District (SCUSD). This district is a Title I district and more than 95% of the student population are students of color.

Additionally, I selected a district that has seen little overall growth in math scores since the inception of the California Assessment of Performance and Progress (CAASPP). Like the state, SCUSD has seen little overall math growth at the middle school levels. This makes it a typical district in California, which was ideal for my study of math teaching practices, especially because research has shown that students in lower-SES schools do not receive the same quality of instruction as their peers in higher-SES schools. Finally, I selected SCUSD because of its size and diversity of math classes at the middle school level. With multiple middle schools, I had a larger pool of teachers to interview and conduct focus groups with, which improved my chances of capturing diverse teacher identities and experiences in math.

Sample Selection

In order to best answer my research questions, I needed a diverse teacher sample of teachers with both single-subject and multiple-subject backgrounds who teach middle school math, grades 6 through 8. Middle school was the ideal sample because, while they are considered secondary teachers, the teachers have diverse credentials, thus allowing me to interview all types of credential holders about their math identities and teaching practices. SCUSD also has multiple-subject and single-subject teachers at every middle school, increasing the likelihood that I would be able to interview teachers from each teaching style. Because I was looking for teacher identity and teaching practices, it was ideal for the sample to consist of teachers who had at least 2 years of teaching experience. I used my own experience, the experiences of my secondary math team, and my secondary math coordinator to select teachers based on their pedagogy. As all of us had been in teachers' classrooms over the past 3 years, I used what I knew about how teachers teach to select teachers of diverse teaching practices. Once I selected the teachers, I conferred with my coordinator to get a second opinion. The diverse teaching practices from which I selected represent teachers from two groups: those who teach more on the procedural side, and thus teach more traditionally, and those who teach more on the conceptual side of the productive belief spectrum, thereby teaching less traditionally. Selecting five teachers from each teaching practice provided me with a sample of 10.

Data Collection Methods

I utilized three methods of data collection: interviews, journaling, and artifact collection. The interviews answered my research questions by exploring teachers' previous experiences with math as students as well as their view of math currently. The interviews consisted of middle school math teachers from SCUSD and took place after school through Zoom, and each teacher was interviewed twice. Each protocol was piloted with teachers on assignment and math teachers who did not participate in my study. The interviews were recorded on two electronic devices, one of which was a handheld recording device and the other was the Zoom recording feature. Each lasted approximately 30 minutes to 1 hour, and each teacher received a small, electronic gift card at the end of each interview.

During the first interview, I asked them about any strong memories they had of mathematics, first as an elementary student and then as a secondary student. Once we explored those memories, I asked them if they remembered a specific turning point in mathematics where they changed how they felt about the subject. We also discussed their college math courses and whether they had any plans to pursue higher mathematics as well as what made them decide to become math teachers, or even if they intended to become math teachers. I wanted to allow them to tell their stories to create an identity profile that I could then apply in the second interview about their teaching practices.

The second interview focused on their own teaching practices by asking the teachers to walk me through a math problem or problem set they had done with students recently. They discussed the type of math problem, how it was introduced, what happened when/if students struggled with the problem or concept, and whether it was a typical math day for them. I wanted to walk through one specific lesson in order to delve into an example of their teaching practice. Table 1 contains NCTM's productive and unproductive thinking about mathematics, on which I based my analysis of where the teachers' lessons fell on the spectrum of conceptual teaching practices. The artifacts that the teachers selected were also analyzed using these principles. The final journal prompt concluded the second interview, and it asked them to write about what they think a student who is good at math looks like, including what skills they have and how they respond to math problems.

Table 1

NCTM's Productive and Unproductive Thinking About Mathematics

Productive beliefs about mathematics	Continuum	Unproductive beliefs about mathematics
Importance of concepts, problem solving, reasoning		Memorization of patterns and practicing procedures
Lots of strategies are evidenced in students' work and practice		Formulas are king
Exploring math is a good way to learn		Exploring happens only after students know the basics (time permitting)
Teacher uses tasks and discourse		Teacher tells students what to do
Students make sense of math for themselves		Students memorize and practice
Teacher makes sure students are challenged and can persevere		Teacher guides students step by step; frustration and confusion should be avoided

During the second interview, each teacher was invited to bring an artifact, in the form of a lesson plan or example of student work, preferably from the current school year but it could be from previous years, that the teachers felt represented a teaching practice that they utilize often or that they feel is very successful. The artifact was of the teacher's choosing so that it would be a true representation of their beliefs. The artifact was incorporated into the interview and gave the teacher an opportunity to talk about what it meant to them as well as how they felt it represented them as a teacher. It allowed for more representation of their teaching practice than just one observation and interview.

Journaling was also utilized at the end of the second interview. As teaching practices are often deeply personal choices made by the teacher, journaling gives the teacher uninterrupted time to express how they feel their past experiences are connected to their current practice. For about 10 to 15 minutes, the teachers journaled their responses to one question about what they believe a student who is good at math looks like. The teacher was asked to write at the end of the interview, and the journal was emailed before they left or just after the interview.

Data Analysis Methods

I triangulated my data in order to verify my results using self-reported data from the interviews and analysis of the artifacts and observations. I transcribed the interviews with otter.ai and then checked them for accuracy. I first coded them deductively using a priori codes established from the research. I coded the second interview first, using NCTM as a reference for conceptual and traditional teaching. For each teacher and teaching style, I looked for evidence during the lesson of exploring math, reasoning in math, using multiple strategies, students explaining math, novel problems, memorization or formulas, peer-to-peer work, and teacher guided step-by-step sections. The presence or absence of these denoted if the teacher taught more conceptually or traditionally. I also coded the first interview with codes from the research. Those codes fell under these major categories: fear or anxiety around math, opinion about access to higher math, belief in math "giftedness," and impact of a teacher on their math ability. A second cycle of coding allowed for more inductive themes to emerge within the broader codes established in the first cycle. I stored the data by removing identifying information and coded the teachers by number. I coded the journals using the same categories as the interview, but I noted whether the teacher made the statement in the interview itself or through the journal.

I collected and analyzed the artifacts for routine math structure or a more inquiry-based approach to math. The codes were primarily predetermined by the research prior to receiving them from teachers. Each coding theme had indicators, such as rigor of the problems, openendedness, need to explain answers or solve problems, evidence of the standards of mathematical practice, and problem novelty.

Positionality

Though I am a secondary math coach, it was important for me to position myself as a researcher first; this allowed the teachers to see that this research was separate from my job and in no way would be communicated to their principal or the district office. As a member of the bargaining unit, I am a teacher, not an evaluator. Though I have friendly relationships with all of the teachers with whom I work, we do not meet outside of work, so there is little concern for favoritism among teachers or school sites. I am their equal in every sense of the word, but I focused on my position as a researcher for the purposes of this study. At the two sites I support, the teachers know that I do not report back to their administrator regarding our conversations. Regardless, I made sure that my position was very clear, and in both my recruitment meeting and the interview protocol I made sure they knew their participation was voluntary, all conversations would be confidential, and no names or school names would be used in my study. Upon the completion of each interview, I provided small thank-you gifts for those who participated.

I will share my findings with my district office as agreed upon for permission to conduct my study. As a math coach, I will share my results with my coordinator in an effort to adapt our professional development to best meet the needs of our teachers and students. My coordinator will then decide whether to share the results with our director.

Ethical Issues

As I am not an evaluator, there was little risk for coercion or exploitation; teachers were reminded of this prior to participation in the study. However, in order to ensure there are no ethical issues, all of my interviewees and interview responses will be kept confidential, as will the collected artifacts. Aliases were included in the research study, and during coding each teacher was simply given a number that was used for analysis purposes. Each interview was stored in three places: my recorder, my desktop, and a backup hard drive. I am the only one with access to those locations. I am the ultimate owner of the data, and that was shared with SCUSD as an institution, each site, and each teacher.

Credibility and Trustworthiness

The two largest credibility threats to my study were reactivity and bias, both teachers' and my own. I was concerned about reactivity in two capacities; the teachers might have told me what they thought I wanted to hear. My interview protocols had two primary sections: their own math identity and their teaching practices. During their own math identity, to reduce the reactivity I emphasized that each teacher has their own math experiences and that every teacher gets to speak their own truth. Their answers regarding their current teaching practices were likely to be more subject to reactivity than their past experiences. To address this concern, I triangulated the data with observations, journals, and artifacts collected from the teachers. Allowing teachers to choose their own artifacts from their classroom, selecting something significant to them, allowed me to compare the artifact with the interviews.

An additional concern was bias, both from the teachers and from myself. Many teachers have strong opinions about their teaching practices and how they affect student learning, based on their years of teaching experience. I had to keep my own bias out of my questions and avoid leading teachers to answer in a way that supports my theory. Because I sought to determine what teachers believe, I needed to ensure that my interview protocol was as neutral as possible while still addressing my research questions. In order to ensure that happened, I practiced my interview protocol with teachers prior to the study with the express intent of looking for bias. I also ran my protocol through my chair and additional faculty to ensure that I would be evaluating what the teachers truly believe, rather than what I wanted to find.

Study Limitations

The intent of this study was not to claim that the results are representative of middle school teachers across the nation; in fact, the results may be indicative only of districts with similar populations. However, the results reveal how teachers' previous experiences with math may inform their current teaching practices. Given that much of the research occurred around teacher beliefs, this study could add to the literature related to teacher math identity and how it affects pedagogy. Further research will be needed to make broad claims.

Conclusion

This study used qualitative methods to learn how past experiences in math may influence current teaching practices in middle school math teachers in a low-income district. In math instruction, teachers have failed to make the massive shift in teaching practices required to match the current standards. By exploring the possible connection between teacher math identity and pedagogy, this study aimed to understand why teachers make the choices they do regarding how they teach mathematics.

CHAPTER 4: FINDINGS

This study explored the possible connection between middle school teachers' math identities and their teaching practices. Interviews regarding the teachers' math experiences, identities, and teaching practices; artifact collection; and journal prompts were used to explore that connection. Ten teachers participated in the study and were divided into two groups: those who taught more conceptually and those who taught more traditionally. Each teacher's identity was then pulled from their experiences and perspectives, and patterns began to emerge within each group of teachers. This chapter addresses the following research questions:

1. How have teachers' own experiences shaped how they view mathematics, if at all?
2. How do teachers describe themselves regarding their math identity?
3. How do teachers' math identities connect to their teaching practices, if at all?

Patterns began to emerge from the data. Traditional teachers self-identified less often as bad at math, less often reported fearing math as a student or having math anxiety, more often differentiated between people who were good at math and people who were not, and more often attributed their success in math to their own abilities. More conceptual teachers self-identified more often as bad at math at some point, viewed all math as accessible to everyone, and more often credited a teacher for helping them succeed in math. However, identity is deeply personal and unique to each person. Though each group of teachers had common aspects to their math identities, a list of features is not enough to get a true picture of identity or of how it relates to teaching practices. As such, this chapter examines the similarities within each group of teachers and describes teachers who were outliers within their group to provide a richer understanding of how math identity affects teaching practice. I unpack first how the teachers themselves described their teaching practice and then how they described themselves in relation to the teaching and learning of mathematics.

More Traditional Teachers

Five of the teachers were selected to participate in this study because they were observed to be more traditional teachers following the criteria from NCTM's book *Principles to Actions*. On the spectrum of teaching practices, these teachers were seen as teachers who tended to prioritize practicing procedures, formulas, memorization, guided practice, and step-by-step directions given by them to the students.

Teaching Practice

Teachers walked me through a lesson, in detail, where they described what they taught and how. It was through the analysis of these interviews that greater detail emerged about how they teach and the impact they want it to have on student mathematical understanding. There were four trends in the ways the more traditional teachers described their practice: (a) Teaching was primarily whole group with the teacher doing most of the talking, (b) the teacher offered multiple guided step-by-step examples with routine problems, (c) the focus of the lesson was on solving problems and getting the answer without reasoning about what those answers mean, and (d) students were expected to ask questions when they did not understand the math. Each of these steps followed a similar progression for most of the more traditional teachers.

The first key pattern that emerged was that the majority of the lesson was conducted whole group, with all five teachers doing the bulk of the talking and instructing and the students following along or working independently. Malcolm opened the core of the lesson by talking about making sure the students knew the rules: "I was delivering the rules, and they're basically, you know, the rules for adding and subtracting integers . . . the initial approach was to explain the rules, so they can kind of pretty much understand the process.” The teacher was the one who was talking about math, while the students listened and took notes so that they could then solve some problems on their own. Timothy spoke of how important it was to explain things to students so they understand. When students were taking notes with him, he explained everything to help them understand: “They’re copying because what I do, everything I write, they write. . . . And I explain what I’m writing. . . . I’m also doing all this by explanation.” He valued the explanation as much as the notes and felt his instruction was vital to their understanding.

The second pattern was closely tied to the first: During that whole group instruction, four of the five teachers provided several examples for students that detailed the steps to solve a traditional math problem. The students were to copy those problems into their notes, and then use those examples during their independent work time. When describing how she helps students solve problems, Stephanie talked about how she always has them refer back to their notes: “Most of the time, you know, we’ve got our notebooks. . . . Where does it say in the notes? Where do we start? What is step one, what is step two, and we just take it back.” Malcolm had a similar method of following a step-by-step process of instruction: “I’m systems oriented, or if you will, step by step. Here’s step one, here’s step two, here’s three.”

The third pattern was that after the students were able to solve the problem, they moved on to the next problem without reasoning about their answer. The focus was on solving traditional problems and moving to the next. To this end, four of the five teachers prioritized repetition as the best way to improve students’ math abilities. When it came to practicing problems, Timothy said,

> I explain to my students that professional athletes do not perform only at the games. They practice constantly to gain their skills. A mathlete must be the same way. . . . The successful student must practice the early basic skill to forge a more lasting memory.

Malcolm had a similar outlook on practice problems but placed a lot of value on making sure that the students' answers were correct:

> I would proceed to go ahead and go over the answers, and I require them to take notes on each of the problems. And then if they do not submit the correct answers, I insist that you must make sure that all of your answers are correct, because I'm giving you the correct answer to all for these.

He wanted to make sure that the students knew which answers they got correct and which they missed, even making sure they corrected their mistaken answers. However, as they corrected each answer they did not reason about why that was the correct answer, only that it fit with the procedure.

The final pattern was that they were happy to help the students with any mathematical misunderstandings, but all five felt it was the responsibility of the student to ask questions and let the teacher know they need help. In the journal response, Timothy spoke frequently of how much he valued students who ask questions in class:

> I may be good at explaining concepts, but I am not good enough to reach everyone the first time. I invite students to interrupt my lesson the moment that I do or say something they do not understand. They need to leave their pride and insecurities outside.

When asked to describe what they want from students, David said they wanted a student "that is naturally inquisitive" and "is to able to question." When talking about student misunderstandings in math lesson, Stephanie said, "If I'm lucky, they tell me 'I don't . . . I don't understand.'" All of the teachers welcomed questions and expressed a true desire to clear up misunderstandings, but they also indicated that it fell to the student to inform them of when those misunderstandings occurred.

Math Identities

To explore teacher math identities, each teacher described their experiences with math as students. There were three patterns that emerged related to the more traditional teachers' math identities: (a) They tended not to have experiences with anxiety around math, (b) they viewed their own math abilities as an innate part of themselves that they were born with, and (c) they viewed higher math levels as reserved for only some people (not everyone has the passion to be successful in higher math classes).

These teachers were less likely to have fear or anxiety around math, with only one teacher expressing having experienced any anxiety around math at all throughout their life. When asked about his own math ability and experiences, Miguel said, "Nothing has ever made me frustrated about it. I just do it." David spoke about his ease with understanding math "because I enjoyed it, and I could do most of it. That [math] was not a big deal." When thinking back to his own history with math, Malcolm said, "Math has never been anything that I've been—that's been perceived by me as difficult." All of these four teachers indicated their lack of anxiety by expressing the ease with which they were able to do well in math as students.

The teachers were also very likely to separate people into those who are good at math and those who are bad at math, with all five expressing the perspective that some people are natural at math and some are not. Additionally, when it came to their own math ability, they viewed it as part of themselves, a skill they were born with, and not something they attributed to their teachers. The perspective that people can be either good or bad at math, and that their own ability is something they were born with, indicated they felt that math ability is more innate than it is learned. Three stated they were good at math and succeeded because of themselves and their ability, which further indicated their perspective that math is an inborn ability and not necessarily something that is flexible. Miguel said, “I just do it. It’s like washing the dishes.” He also attributed that lack of struggle to his own innate ability to see math as a puzzle that just needs to be solved. No one taught him to do that, he said; he was just always able to do it. When describing his history with math, Malcolm said, “It was a skill I had, that I was best at, you know, math.” By describing his math ability as an ability he has always had, he is indicating he believes he was born with that skill. Even the one teacher who expressed fear of math said it “wasn’t in my genes to be good in it . . . it’s not my strength,” thus reinforcing the idea that math capabilities are innate and not learned.

Related to their perspective that math is often an innate skill that some possess, the teachers who taught traditionally also reported that higher levels of math were not possible for everyone. Timothy talked about wanting to make sure he could help “all those that are capable for higher-level math,” clearly distinguishing between students who can do higher-level math and those who cannot. David said that higher math classes were more for students who were going to college, and not really necessary for everyone. He also said that everyone knew about “the pecking order, these are the bright kids.” When it came to themselves, only one said they struggled with math in school, but three spoke of lacking a passion for higher mathematics. They had the innate ability, but not the passion to pursue math at higher levels. Malcolm said, “I don’t really get off, some teachers do I mean, I’m not a person that really loves that real high, high-level math.” Miguel stated, “You know, I took [college math], I did well, and I was done.” Timothy was particularly proud that he could do the math but that he did not pursue it further.

When told that he was a good math teacher, he replied, "Because I'm a teacher, not a mathematician. . . . When you can find a mathematician that is a teacher, you've got a crown jewel." He firmly believed that people who pursue higher mathematics should not teach in the K–12 system.

Connecting Math Identity to Teaching Practices

As indicated by the earlier section, there were teaching practices that were unique to traditional teachers. They focused more on providing notes, offered step-by-step instructions, and wanted students to take the initiative to ask questions. There were also unique math identity patterns that were found only among traditional teachers. They tended to describe their math ability as an innate skill rather than a learned one, were less likely to remember struggling in math, and were more likely to believe that higher levels of math are not for everyone.

More Conceptual Teachers

Prior to the interviews, five teachers were selected to participate in this study because they were observed to be more conceptual teachers following the criteria from NCTM's book *Principles to Actions*. On the spectrum of teaching practices, these teachers tended to emphasize the importance of concepts, problem solving, and reasoning; prefer students use multiple strategies and explore the math; use tasks and discourse; challenge students; and want the students to make sense of the math rather than the teacher explaining the math.

Teaching Practices

Teachers who taught more conceptually also showed patterns in their teaching practices. Five trends emerged: (a) The teachers more often presented novel problems during their lessons, (b) they more often provided time for students to explore the problem or math concept being taught, (c) they more frequently expected students to explain their work and reason about their solutions regardless of whether the answer was correct, (d) they more often relied heavily on peer-to-peer interactions and group work, and (e) they were more likely to stop students to see if they had any questions or misunderstandings rather than wait on the students to ask them.

When talking about their lessons or providing artifacts, three of the five conceptual teachers provided novel problems, or problems that go beyond the standard algorithm or traditional math problem. After a quick review for warm-up, Jim led the students into a task where they had to make a choice about which option was the better deal. Jim said the task was "setting the kids up for real-world situations" and liked that it made the students think in different ways. Similarly, Jorge likes to open with real-world scenarios to engage the kids in the math. He said he asks himself, "What can I spark today that can relate to what I'm going to teach? . . . In this case, it was a fun situation about how you can describe graphs." He used that opening to launch into his lesson, which was also task based. Danielle likes to incorporate open-ended problems that have multiple solutions as the warm-up. For the lesson she described, she had students come up with the problem and solution to identifying types of angles. She said the best part was that "they know the answer, they know the problem, and then they get to kind of create their own in the middle." It required the students to think differently than a traditional problem would have.

After presenting the students with a problem, novel or traditional, each of the five conceptual teachers provided time for the students to explore their math. They expressed a desire to make sure the students knew what the problem was asking, the math involved, and what the answer meant. After presenting students with their task, Jim talked about the importance of making sure everyone was on the same page. He had the students read the task and then "walked them through the thinking portion. Just think out loud. What do you see? What do you recognize? What do you think it could be?" He wanted the students to describe to the whole group what the scenario was about. Jorge talked about how much he values student feedback after he presents a task: "I think that's the most important, when they feel comfortable telling you how they feel." Prior to leaving the students on their own to work on the task, he wants students to let him know if they actually understand and to use technology to allow them to do it anonymously if they are not comfortable yet. Leslie likes to have the students get on a virtual whiteboard after she introduces a topic so she can see immediately if her students understand what they are going to do. After introducing a small part of the lesson, she said, she values that opportunity to check in to see if they understood: "It was really cool to do kind of an intervention based on their responses and if they get it or not." She was able to check in and see if all of her students were ready for the next step.

After students were given time to explore the math and come up with a possible solution, the teachers did not view the math as being finished. All five teachers expressed a need for the students to explain not only their steps, but their answer. They each wanted to not only understand what the students were thinking, but also make sure the students understood what they were doing with the math and what it meant. Maria checked in with students, even if the answer was correct, because "there's those students, too, that can get the right answer but they can't explain why. I think it's just as important to be able to explain the steps." She expressed a need for her students to not only know what they did, but be able to explain it. Leslie talked about the need for students to be able to explain things themselves, rather than just get the answer: "I think they feel more like a sense of self-worth and just more confident, and they figure out their mistakes, by opposed to me pointing it out." She valued the process of student explanation because she felt it helped the student solidify their learning. Jim had a similar process of allowing students to explain the math, right or wrong. When a group had given him a wrong answer, rather than say whether it was correct, he said, "Well let's come back and revisit this at the end. So, we came back and revisited it, it gave the kids a chance to process and think. . . . [They] said it does work, and they were able to explain why." In each case, the students' ability to explain their answer, and how they got there, was more important to the teacher than the answer itself.

Though the timing of peer-to-peer interactions varied among the teachers, all five prioritized the students working in small or large groups at some point during the lesson. This was the only aspect of their lesson design where they actively said COVID affected their practices; three said they used small groups far more during live instruction than with distance learning, but each of them found ways to get students to talk about their learning to other students during their lesson. Maria's lesson centered on students working in groups in order to become experts in one problem. She spoke about how much she valued that student group time because "you see competence in kids that ordinarily, they don't volunteer. . . . So I don't know, when I walk around the room and I'm hearing them talk and I'm seeing—hearing new voices." She said that group work provides space to achieve her goal, which is for more students to feel comfortable talking about math. Jorge wanted his students to work in groups and help each other as they worked on problems or tasks. For him, the students did better when they were allowed to collaborate with their peers: "You're going to learn better anyways, working with somebody you like." He does not view math as a solitary subject; he wants his students working in groups. Leslie talked about using students to help each other before she will step in because, she felt, students can sometimes understand things better from other students: "Sometimes when they say it in their own way, they get it more. So, I just have them explain it to each other: the student-to-student dialogue."

Math Identities

There were four distinct patterns of math identity among conceptual teachers: (a) They reported being afraid or anxious about math at some point; (b) they self-identified as being "bad at math" at a specific point in their K–12 schooling; (c) they credited a teacher with helping them understand math better, thereby helping them like math more; and (d) though they felt that some people are natural at math and some are not, they felt that everyone could achieve in math at high levels.

Conceptual teachers more often reported feeling fear, anxiety, or lack of confidence around math at some point in their trajectory. Four of the five teachers specifically referred to lacking confidence in math, two referenced having a clear fear of math, and one stated that she still had anxiety over new math concepts to this day. Leslie would often shut down when she saw word problems as a child, and she stated, "I was like, cognitively, I was able to perform problems, but it was a confidence thing. I just always would say 'I can't do it' without even looking at it." That gut feeling of panic when she saw word problems has remained with her, in spite of teaching math for years. When asked about his experiences in middle school, Jim stated, "There was a lack of confidence." He credits that lack with stopping him from being successful. When talking about her worst year in math, Danielle stated, "So that was the main thing that I felt at the beginning of the class, like I wasn't prepared. I wasn't confident in myself like that." That feeling stayed with her and affected how she viewed that subject, trigonometry, for the rest of her life.

Four of the five conceptual teachers self-identified as being "bad at math" at some point and could pinpoint the exact math, grade level, and teacher they were with when they felt that way. For Jim, that moment was "high school geometry. Just coming to the realization that I was bad at—in my mind at that point, I was bad at math, especially geometry." For Danielle, being bad at math had an impact on how she viewed math overall: "I definitely feel like it changed my relationship a little bit with math, just because I felt like I wasn't good enough." Leslie traced her current math anxiety to the exact moment she first felt it in elementary school:

> Still, there's a little part of me that was, whenever we were given a new concept to learn I always felt a little apprehensive just because I was afraid that if I didn't get it, I would feel like how I felt when I first moved here.

That moment, when she first felt anxiety and that she was bad at math, stayed with her. Though the teachers felt they were bad at math at one or multiple points, they also spoke of times when that identity changed and they no longer felt like they were bad at math. They viewed being good or bad at math as temporary and fluid, and not part of a fixed identity.

One's math identity is not developed in isolation; other people play a role in that development. Each of the five conceptual teachers credited one of their teachers with helping them become good at math, making them believe they were bad at math, or both. When Jorge finally had a teacher who believed in his ability to think and not copy, he said, it changed how he viewed education: "He wouldn't tell me how to do it; he would say, 'You're smart enough, you need to figure it out, start working on that.' . . . I was the most thankful, like, thank you dude." For Jorge, that was his first positive experience with math in school. After a particularly difficult year with math that left her wanting to never take a math class again, Danielle had a teacher who made her believe in herself again. She said, "[He would say] 'I'm here to help you.' . . . And these sorts of things really helped support and change my mind back, you know, to, 'I am successful at this.'" Within a year, she went from hating math and wanting to quit to believing that she was good at math again. She credited that teacher with helping her love math again. For Maria, it was when her teacher would not let her quit just because she was afraid of the math: "[She] was like, 'Yes, you can do it,' like we're going to do this. But she never gave up on me, and um, yeah, and then I remember it started getting easier." This is further evidence that the more conceptual teachers believe that math ability is not something students are born with, but rather something that is developed as they experience math throughout school. Additionally, they linked being good at math to getting help in math; math was not learned in isolation.

That perspective translated directly into another identity pattern among the conceptual teachers: Though some people are naturally good at math, higher math is accessible to everyone, and everyone can learn math at high levels. Jim felt that when it came to math, "some people are going to be fast with this, and some people take a little bit longer." When Maria has students who tell her they do not like math, she responds, "That means you hate thinking, like math is thinking." To her everyone can think, so everyone can do math. Leslie said that the more math someone had, the more likely they would grow comfortable with it: "I think the more exposure you have to certain material, of course, it's going to build your confidence, and you're going to feel more relaxed when you see it again." She said she has valued taking additional math classes because it has grown her own confidence in the subject. In this view, math ability is not fixed, and people or students who are struggling now can be helped and can learn math.

Connecting Math Identities to Teaching Practices

Conceptual teachers showed teaching practices that were unique to this group. They tended to offer more novel problems, valued students' explanation of their thinking over their solutions, questioned the students about their process, and provided peer-peer collaboration time within their lesson. They also tended to have very strong math identities that were connected to negative experiences in school with the math or a teacher, often both. All of them felt very strongly about a few of the teachers they had had in school, in both a positive and a negative way, and felt that those teachers had had a strong impact on their view of math. They did not view themselves as being good or bad at math in a static way; it was fluid and changed depending on their experiences. They also viewed math as being accessible to everyone, regardless of how quickly someone can understand mathematical concepts.

Going Deeper

Many patterns may emerge when exploring identity, but those patterns do not, and cannot, define a person or wholly explain a person's behavior. Identity is complex and is built up through personal experiences. In order to get a true picture of how unique math identities are formed over time, as well as how they are connected to pedagogy, a deeper look at a few teachers who differed from the others in their teaching style groups may be helpful. Each of the following teachers had a difference that made them unique, and I explore those differences here to better understand their math identity and how it related to their teaching.

Jorge

Jorge was the most direct, and explicit, in describing his teaching style and why he does what he does in class. He teaches the way he does because he abhorred how he was taught and treated in grade school. He was also the only conceptual teacher to never struggle with math; he loved math from a young age and was always exceptional at it. He even helped his older siblings: "I was doing my brother's and my brother is 2 years older than me, my sister is 3 years older than me. . . . I know I was doing a lot of their math." There was never a point in his K–12 experiences when he struggled or did not like math, which was very unlike his fellow conceptual teachers in this study. His struggles in school started because he was so good in math: “So, I remember like, my behaviors really did get worse in math classes, because I knew everything. You know, just sit there, mess up, mess around.” The problems were too easy, too traditional, and he became bored. He reported that rather than address the issue and meet his needs, his teachers started holding him back instead of putting him in advanced classes that would challenge him. It bothered him, knowing he was deliberately placed in classes beneath his ability level. He was afraid that was going to continue until he had a teacher, Mr. A, who told him he was smart, and he could figure things out. Mr. A fought to get him out of remedial math classes and into a higher-level class. The non-remedial class and that teacher were different. “You have to work out the scenario, so it was always problem solving, right? So, I was busy in this problem.” He started working in groups, his teacher did not judge him, and he had to think. He described it as a light bulb going on. He started tutoring his friends, and his outlook on helping people in math carried through to college.

This profoundly influenced his view of how math should be taught and how students should be treated. He never wants students to feel the way that he felt or be treated the way that he was in math. When he opens lessons, he thinks, “What can I spark today that can relate to what I’m going to teach?” He wants to get students “engaged and hooked on what we’re about to talk about.” His class is scenario based, math is given context, and student dialogue and group work are relied upon, and he does all of that because of his own experiences in math.

Leslie

While several conceptual teachers expressed fear or lack of confidence, only one teacher discussed her math anxiety, which remains to this day. Leslie was the only conceptual teacher to express any anxiety over math. Though not as direct as Jorge in how her math identity connected to her teaching practice, it was still apparent that her math identity had a profound impact on her teaching practice. Leslie spoke a lot about confidence, both in describing herself and math, and in identifying what she wanted for her students as a teacher. She described herself as being good at math in elementary school, in part because “I just felt more comfortable, and I just did well. My confidence was a lot higher.” She moved at the end of elementary school, and that changed for her. She had a very hard transition and lost her confidence: “I’m not really sure why I had trouble understanding what they were asking.” This had a deep impact on her and led to her having anxiety about math, and for several years she felt like she could not do the math. That changed when a teacher started helping her at home. “She really instilled that confidence in me” by sitting with her and providing her with the space and time she needed to learn math. Once she had that confidence back, “it was just like a switch, just like went off, and then I was doing really well.” She ended up joining a math club in high school and taking AP Calculus with a teacher who, though strict, made sure to engage every student and was “deliberately kind” when he saw a student needed it. Through all of that, her anxiety around math continued: “I always felt a little apprehensive just because I was afraid that if I didn’t get it, I [would] feel like how I felt when I first moved.” Despite her achievement in math as a student, her math anxiety did not leave her.

That anxiety ended up giving her empathy for her students, and she reported intentionally teaching in a way to reduce anxiety in math for them. She spoke of the value of instilling “a sense of self-worth and confidence” in her students as they do the math. Her desire to instill that confidence in her students is why she spoke of the value of having students figure out how to do the math rather than her telling them; wanting to instill confidence in her students directly affected her teaching practices. She also spoke about how, regardless of the lesson, she wants to incorporate diagrams or manipulatives so the students can have access to the math if numbers or words confuse them, which was reminiscent of her early struggle with word problems. Leslie's continued anxiety around math, and the positive experiences she had with math teachers as a student, changed not only how she saw math, but how she taught it.

Stephanie

Stephanie was the only traditional teacher who self-identified as bad at math and still feels that there is math she is unable to do. She was also the only traditional teacher who used peer-to-peer dialogue and groupwork in her lesson. Stephanie did not have many strong memories of math in school from elementary school, and what she did remember about middle school math was being in band: "Typically, students that were in band were better in math . . . and so I paid a little bit more attention to it, because I know one affected the other." Her desire to be good in math was tied to her love of being in band. She felt that as long as one helped the other, it was valuable. Stephanie liked math when it was practical and deeply disliked math when it was not. Her dislike stemmed, in part, from feeling overwhelmed by certain classes as well as a deeply held belief that she could not learn all math: "I couldn't pick up things like other people, and it was a really big handicap. So, I just—I just couldn't get it." That turning point was very specific for her; once she had no practical use for math, she saw no point in trying to get past the overwhelming feeling she got when she looked at it. "Algebra I like. I like the practicality of it. It's very, very useful in real life. . . . I don't want to fill my brain with information I don't need." She disliked all math beyond Algebra I so much that she never took a math class again. She felt there was no need. Her experiences with her last math teacher were also not positive; she referred to him as "robotic" and said that "he never saw anybody in class. So, he never looked around the minute you walked in and that door shut." He never asked them questions or tried to help. However, rather than describe her teacher as a possible reason she did not like that class, she felt that "it's not in my genes to be good in it, you know, it's not my strength."

Though she did not pursue a career in teaching math, her appreciation of practical math fit well with teaching middle school math. She liked what she was currently teaching: "As long as I don't get too much higher, I'm okay." In her lesson, she was very traditional except for in one area; she wanted her students to work in groups. She created a game where students could review for a test, where "it's the same problems that I would have given, except it was in a different format." She was tired of her class feeling "like a séance, you know, can you hear me?" No one would ever respond or participate in her traditional lessons, so she changed the format to hear them speak. Part of that ties back to her memories of school. She was very social, and most of her memories center on her friends; the one teacher she remembered refused to make eye contact or engage the students in any way. She said, "It was terrible. It was terrible." She tried to make a lesson for her students that was engaging, where they felt seen, and that was not a terrible experience for them.

Conclusion

In this study, clear math identity and pedagogy patterns emerged among traditional and conceptual teachers. Traditional teachers were more likely to view math as an innate skill, more likely to view higher-level mathematics as being for only an elite few, and less likely to have suffered from past math anxiety. Conceptual teachers were more likely to view math ability as something that can be learned or gained over time, more likely to view higher levels of mathematics as achievable for all students, and more likely to have experienced math anxiety at some point in their lives. Additionally, traditional and conceptual teachers spoke about their own math experiences in different ways. Traditional teachers had fewer negative experiences in math than conceptual teachers, but traditional teachers also had fewer positive memories of their teachers than conceptual teachers. Taken on their own, these findings indicate that there is a relationship among math experiences, math identity, and teacher practices. However, these patterns were not shared by every traditional and conceptual teacher, and therefore they alone do not provide a full explanation about how math identity is connected to teaching practices. Going deeper into individual teachers' experiences and identities revealed richer connections to their teaching practices.

CHAPTER 5: DISCUSSION

This study explored the possible relationship between teachers' math identities and their teaching practices. Five conceptual and five traditional teachers voluntarily participated in this study. I collected data through interviews, journal prompts, and artifact collection to answer the following questions:

1. How have teachers' own experiences shaped how they view mathematics, if at all?
2. How do teachers describe themselves regarding their math identity?
3. How do teachers' math identities connect to their teaching practices, if at all?

Reflecting on my own experiences as a math coach, I expected there to be differences in math identity between conceptual and traditional teachers. Based on informal conversations I have had with teachers over the years, I have noticed that conceptual and traditional teachers tend to talk about math differently. I expected those differences to be related in some way to their own understanding of math and their confidence about their ability to explore math. Based on the literature, I expected to find differences in their own experiences in math class as a student, and that those experiences would begin to frame their math identity (Bray, 2011; Davies & Adams, 2000; Ellsworth & Buss, 2000; McCulloch et al., 2013). Looking at each set of teachers as a conceptual or traditional group, patterns clearly emerged. Conceptual teachers were more likely to view math ability as something that can be learned and is accessible to all, while traditional teachers were more likely to view math ability as a skillset that some were born with and some were not, thereby limiting access to higher math to only a few. Conceptual teachers also tended to have had negative experiences with math that led them to lack confidence in their own math ability, while traditional teachers tended to have struggled less with math as a student and tended to view math as something they were always good at. In exploring these patterns, exceptions emerged within each group. Not every conceptual teacher struggled with math at some point, and not every traditional teacher viewed math as easy. It was through looking at teachers individually that an understanding of the depth of the connection between identity and teaching practices emerged.

Summary of Findings

There appeared to be two major differences between conceptual and traditional teachers' math backgrounds: diversity of experiences in math and a belief in teacher impact. The first major theme that emerged was that conceptual teachers in this study tended to have both strong positive and strong negative experiences with math and in the math classroom. They were able to share minute details of times when they knew that they were bad at math and classes that made them miserable, as well as moments where they knew they understood the math well and classroom experiences that they loved. Not only were conceptual teachers able to recall specific moments, but they were able to remember many such moments. Their memories did not seem to be defined by a single strong moment, but rather multiple small moments they experienced in the math classroom that had had a profound impact on how they saw math. Traditional teachers lacked this diversity and strength of math experiences. Their memories of math tended to be static and not memorable; they had vague recollections of being good at math, but they lacked the ability to recall the details of those experiences that conceptual teachers were able to talk about. For most traditional teachers, there were no strong moments that had defined their math ability.

The second major theme that emerged in this study was that conceptual teachers tended to place a high value on the importance of a teacher in helping them truly understand math at high levels. Previous research showed that using personal narratives revealed that most teachers related their positive and negative experiences back to the teachers they had and how they were taught (McCulloch et al., 2013). In this study, that proved to be particularly true for conceptual teachers, as they spoke often of their experience with math through the lens of how they felt about their teacher. In fact, at some point, every conceptual teacher spoke of either how they felt about math, or how they felt about themselves in math, in combination with how they felt about their teacher. Some conceptual teachers had negative experiences in math that they attributed to the math itself, but not one spoke of positive experiences with math without relating it to the extra support or love a math teacher gave them. To them, the experiences of being good at math, as well as being recognized for being good at math, were not separated from their teacher. In contrast, traditional teachers did not have strong memories of their teachers. What few memories they did have of math as a student were about their own abilities, such as being good at multiplication or always having the correct answer, but not one traditional teacher was able to recall moments where their teacher helped them develop a greater understanding of mathematics.

Importance of Math Experiences for Teaching Practices

Conceptual Experiences as Students

Principles to Actions (2014) served as the framework for teaching practices within this study. The authors described conceptual teaching practices as ones in which the teacher facilitates student learning through the use of tasks, problem solving, discourse, and evidence of student thinking. In essence, conceptual teaching is that in which the teacher designs lessons around creating mathematical experiences for students; students are reasoning through both problems and answers, talking and listening to each other, and problem solving when solutions are not readily available. At its core, conceptual teaching is interactive; students interact with math, their peers, their teacher, and their own thought process. The teachers in this study who teach conceptually not only provide those experiences in their own classes; they also had those experiences themselves as students. This was a key difference between conceptual and traditional teachers: Conceptual teachers experienced interactive, conceptual teaching at some point in their K–12 career, and it had an impact on how they viewed themselves as a math learner. Interestingly, conceptual teachers did not have only conceptual experiences in the classroom, but when they did, they tended to remember them positively. They strongly associated interactive, social learning with their mathematical understanding. It was the traditional, learn-on-your-own teaching practices that had negatively influenced their view of their math ability. In the end, both the positive and the negative experiences ended up defining their math identities. It was almost as if the negative experiences made the positive experiences more impactful—as if they needed those struggles in math to appreciate how good they could eventually become at understanding math. They used the struggles and turning points within their own background to infuse their classrooms with opportunities to check in with students, as well as allow students space to think for themselves and with each other. This matches previous research that showed that strong experiences in math affected how some teachers thought math should be taught (Bray, 2011; Davies & Adams, 2000). In line with the research, when describing both experiences, conceptual teachers referenced both as influencing how they teach. The negative experiences showed them what they did not want to do in their own classroom, and the positive experiences showed them what they did. It was the combination of both experiences that led to their current, conceptual math practice.

Traditional teachers in this study generally lacked any impactful memories of conceptual teaching as students. This does not mean that they never had a conceptual teacher, but it does imply that if they did, it did not affect them enough to be remembered. Their strongest memories of their own success in math as students revolved around them learning on their own, independently from their teacher and peers. It was those moments that they remembered, and those moments where they identified themselves as strong math learners. The process of learning was not how they remembered being good at math; they remembered knowing the math. When remembering traditional teaching practices such as repetitive practice or an ability to follow steps to solving a problem, traditional teachers remembered them fondly and credited them with helping them understand the math. To them, the ability to follow the rules meant they understood how to solve the problem, and through that, the math itself. They internalized these experiences as the events that led to them being good at math.

Impact of the Teacher

Conceptual teachers had stronger memories of not only how they had learned math, but who had taught them. While many had negative experiences with teachers and felt that this hindered their math growth, every conceptual teacher in this study spoke fondly of a specific teacher or teachers who had helped them grow in math. In fact, they credited a math teacher with their success in math overall. This led conceptual teachers to internalize the value of the teacher in building and developing a student's mathematical understanding. This is paralleled in how they structured their classes; they felt it was their responsibility to stop by and check on students to see if they could help them. When conceptual teachers spoke of their classroom practices, they placed an emphasis on their ability to structure the class, whether it was groups or independent think time, to enhance students' opportunities to understand the math. They believed that their students could learn in the right settings, regardless of incoming ability level.

Traditional teachers in this study internalized the impact of the teacher differently than conceptual teachers. Traditional teachers lacked those experiences and remembered relying almost exclusively on themselves to do well in math. It was not the teacher who guided their learning; they often could not remember any details about the ones they had had. Because they relied so much on themselves and their own ability to do well in math, they internalized the idea that deep understanding of math comes from within, not without. Math ability exists within their own students just as it did for them when they were learning. They were good at math because they were always good at math, not because a teacher facilitated their learning, and therefore they put more responsibility on their students to drive their own learning. They were recreating for their own students the experiences that had been successful for them.

Relationship Between Identity and Teaching Practices

One of the key struggles with the implementation of the CCSS was the lack of integration of the SMPs within math classes. Successfully teaching these eight mathematical practices is in line with conceptual teaching, and this study revealed two potential explanations for why conceptual teachers are more likely than traditional teachers to embed them in their teaching practices. There were two teaching practices listed in *Principles to Actions* (2014) that conceptual teachers in this study regularly implemented: pose purposeful questions and elicit and use evidence of student thinking. These teaching strategies were present in conceptual teachers' classrooms but not traditional teachers', which is likely linked to their own math identity. Each group viewed the teaching practice of questioning through the lens of their own perspectives. Conceptual teachers felt that they, as the teacher, could help students deepen their mathematical understanding. As such, they posed questions to students not only to see that they could get the correct answer, but also to understand what the student was thinking about the process of solving. Based on their own experiences, they knew that having a teacher stop and check in could be the difference the student needed to understand the problem, so conceptual teachers went out of their way to pose questions to students. Conversely, traditional teachers felt that it was the responsibility of the student to internalize their own misunderstanding, then approach the teacher with a question. They viewed learning math as a more independent, internal endeavor; therefore, the questions should come from the students, not themselves.

Likewise, asking students to explain their answers was tied to each group's math identity. Conceptual teachers repeatedly asked for students to reason through their answers, whether it was explaining their process to their teacher or their peers. This is rooted in their past experiences as math being social, as well as their own struggles with understanding math concepts. They said they do not want students to mask conceptual misunderstandings through accidental correct answers and often spoke of wanting students to understand the how and the why, which makes sense in light of their own experiences. They knew what it was to look at a problem and not understand why the process worked, and they wanted to ensure their own students could understand the process as well as the solution.

In contrast, traditional teachers almost never asked for students to explain their answers. In their classrooms, the ability to get the correct answer meant that students were able to follow the procedural steps. This correlates with their own experiences. They spoke often of getting the correct answer and then moving on to the next problem. Deeper understanding was only for future mathematicians and those with an innate curiosity about math, but it was not necessary for the everyday student. These teaching practices were directly connected to their identity, which informs how districts, schools, and coaches can approach changing them.

Teacher Outliers

Exploring teachers who were outliers in their group also revealed distinct connections to their experiences, identity, and teaching practice. As the only conceptual teacher who never doubted his math ability, Jorge directly tied his teaching practices to both his negative experiences with traditional math teachers in school, as well as his appreciation for the one conceptual teacher he experienced. He had always loved math, but he disliked the strictness and negative way his teachers viewed his own ability. This led directly to his determination to only teach math conceptually, and to allow his students to explore math. Leslie, who had completely different experiences with math than Jorge, also taught conceptually. She had deep math anxiety in upper elementary and middle school, but that changed due to help from a teacher. She then went on to have wonderful math experiences, but she still has deep anxiety when exposed to new mathematical concepts. Due to this anxiety, she teaches conceptually to allow her students to never feel that anxiety that she felt. Opposite experiences led to a similar math identity and drive to ensure students enjoyed math and were not afraid of it. Stephanie also had had negative experiences with math, but she internalized them completely differently. Her lack of positive experiences with math led her to believe that she was not good at math, even to this day. When she spoke of students enjoying math, it was in the types of activities and games that students can do with traditional problems rather than having them explore the math itself. Each teacher had an identity that directly affected their teaching in a way the group patterns could not fully explain.

Implications

When combining the general trends with the specific outlier groups, it becomes clear that while teachers who teach conceptually or traditionally share some patterns in their teaching practice, math identity alone is not enough to explain how someone will teach. The outliers within each group demonstrated that identity is personal and nuanced, and that how teachers internalize their math experiences affects their identities as much as the experience itself. Each teacher in this study had specific experiences that had led to their math identity, and though teachers within the groups had similar experiences, they were each unique. As such, the results of this study indicate that math identity is only part of explaining teaching practices, that people internalize their math experiences in different and personalized ways, and that the teacher plays an integral role in the development of positive math identities in students. Taken together, the approach to changing some teachers' pedagogy may need to be as personalized and nuanced as their math identity.

When asked about their math experiences, the teachers in this study very much related their current teaching practices to their experiences and math identity. When looking only at math experiences, there are patterns among conceptual teachers: strong positive and negative memories, a teacher who believed they could achieve and went out of their way to help them, and a turning point where they struggled but then became more confident about math. Similar experiences led to similar teaching styles. However, when asked to go deeper into their math experiences, each conceptual teacher's experiences were actually unique. Their strong memories ranged from elementary to high school, the teacher who helped them did so in dramatically different ways, and their turning points happened for very different reasons. While they each taught conceptually, why they did so was unique to each person. Each conceptual teacher internalized their experiences differently and reached different conclusions about why they prefer conceptual teaching for their own students. The same is true for the traditional teachers. Their reasons why they teach more traditionally ranged from students needing structure to a deep belief that following rules is the most straightforward way to learn math. The results in this study imply that why the teachers chose their teaching styles, based on those experiences, matters as much as the experiences themselves.

These different experiences and their math identities seem to be deeply rooted in the impact a teacher had, or did not have, on them as students. Conceptual teachers spoke passionately about a teacher who helped them achieve in math, and traditional teachers did not. That seemed to carry over into their own teaching; conceptual teachers took it upon themselves to check in with their students about their mathematical understanding, and traditional teachers felt it was the students' responsibility to reach out when they needed help. This seems to imply that the presence of a teacher has the ability to have a lasting impact on the development of both math identity and how teachers view their own role in the math classroom.

Recommendations for Practice

Recommendation 1: Incorporate Math Identity Into Pedagogy PD

Math identity should be incorporated into professional development on pedagogy. To address the connection between math identity and teaching practices, we must first introduce teachers to the concept of math identity. Teachers need to understand that math identity exists, explore how math identity is formed in students, and determine what it looks like in adults. A common language needs to be developed around math identity prior to exploring it so that meaningful dialogue can occur during the training. Setting the stage for understanding what identity is, how it is formed, and how it relates to math identity will lay the framework for understanding how it is connected to teaching practices. The first step would be to allow teachers time to explore their experiences. This will give them a deeper understanding of their own math identity and how it relates to how they teach.

Understanding themselves and their identity is a start, but, as this study showed, not everyone has the same identity and experiences. Talking with others who have different experiences will expand their understanding of how math identity forms, as well as the diverse experiences that people have that lead to those identities. The professional development could then connect that to teaching students, who all come from different classrooms, and acknowledge the different experiences that have led to the development of their personal math identities.

Once they can identify how their own experiences led to their identities, teachers should then explore how the way they think about math might affect how they teach. Every single one of the conceptual teachers in this study reflected on an experience with a teacher that had changed how they felt about math and themselves for the better. Many of them spoke about how they wanted to teach like that person, or how they wanted to make their students feel the way their teacher had made them feel. While they were able to identify moments that influenced their teaching, not every teacher has those experiences. Understanding their own teaching style and why they teach it, as well as talking to other teachers about theirs, will give teachers a broader understanding of why people teach the way they do.

Recommendation 2: Explore How Students Develop Identity

Teachers should explore how identity is developed in students. Conceptual teachers were affected by both their negative and their positive math experiences. By connecting the negative experiences to ways they do not want to teach, they became more empathetic with their current students and wanted to provide them more positive experiences. It is possible that by developing a stronger understanding of how student math identity is formed, non-conceptual teachers could shift how they view their teaching practices. Numerous studies have allowed students to describe the impact their teacher has had on their mathematical understanding (Boaler et al., 2000; Cribbs et al., 2015). This study has shown that adults have a variety of mathematical backgrounds. Through understanding how students learn, and more importantly how students think and feel about how they learn, teachers can expand their awareness of mathematical learning beyond their own experiences.

Understanding how student math identity forms is particularly important for non-conceptual teachers. While conceptual teachers are able to rely on diverse experiences to inform their teaching practice, many teachers have had more monotonous experiences that have led them to develop perspectives that do not match their students'. In this study, traditional teachers believed that they were good at math because it came easy to them and they did not struggle; however, previous research has shown that being successful in math is not enough for students to view themselves as math people (Boaler et al., 2000). Traditional teachers also lacked strong relationships with their own teachers, and previous research has shown that how the teacher and student interact with each other about math affects the students' views not only of math but of themselves as math learners (Cribbs et al., 2015). If teachers are forced to rely on only their own experiences as students, they could miss out on the diversity of student experiences, and therefore limit their teaching practices to being successful with only students who are like them.

Recommendation 3: Change Teachers' Styles by Changing Their Experiences

To improve teachers' pedagogical styles, districts and sites should give them opportunities for new teaching experiences. Understanding how their own math identity is connected to their teaching styles creates awareness of their choices and impact, but teachers cannot go back in time and have new math experiences as students. Instead of trying to change their math identity through PD, they can change their identity through changing their pedagogy first, which will give them new math experiences as a teacher, which in turn can influence their view of mathematics and how it is learned. Pedagogy can change as teaching experiences change (Muijs & Reynolds, 2015; Neumayer-Depiper, 2013). As teachers incorporate more conceptual teaching practices into their classrooms, they can become more conceptual and less traditional teachers. Previous research has shown that conceptual teaching is linked to higher math scores and stronger mathematical understanding (Boaler et al., 2016; Kane et al., 2011; Richland et al., 2012; Wenglinksky, 2002). Districts and sites should focus on supporting teachers in incorporating more conceptual teaching practices systematically over time, so teachers gradually shift in their practice, which can shift their math identity.

Limitations

There were a few limitations within this study. The first was the sample size; only 10 teachers were interviewed, and there were only five within each group. The small sample size restricts the ability to generalize from the data. The second limitation was that only middle school teachers were interviewed. While they were intentionally chosen, it created a mix of single-subject and multiple-subject teachers, so generalizations cannot be made regarding the type of credential held with teachers' math identities.

Time constraints meant only one interview on teaching practices was possible. This study would benefit from classroom observations or additional interviews focused on teaching practices and multiple lessons. Attempts were made to triangulate data with an artifact from the teachers' classrooms in the form of student work or a lesson plan, as well as a journal prompt about an ideal math student. However, one interview on teaching practices is still a limitation because the teachers were permitted to select all evidence to provide to the researcher. That potentially could have affected the results if they chose lessons they did not do frequently or if the teacher wanted to be seen a certain way.

The final limitation was potential implicit and confirmation bias on the part of the researcher. I have a strong preference for conceptual-based pedagogy and needed to take extra care that I was not biasing the results by seeing what I wanted to see in the teachers' identity. Teachers were selected based on my own observations of their teaching. Steps were taken to reduce the amount of bias around the sample selection by triangulating their teaching style through the interview, lesson artifact, and journal problem. Each piece of data confirmed that they were either conceptual or traditional teachers.

Despite these limitations, the patterns were clear and the findings were supported by evidence from the data collected.

Directions for Future Research

This study focused on the connection between math identity and pedagogy in middle school math teachers. Expanding that sample to elementary and high school teachers would provide additional evidence around the connection of those teachers' identities and their teaching practices. Previous studies of elementary school teachers have explored teacher math identity and experiences in math, but they have not attempted to connect that identity to pedagogy. Future research of both elementary and high school teachers could study the impact of that identity on their teaching practices.

As this was an exploratory study with a small sample size, no effort was made here to differentiate between the identities of traditional and conceptual teachers in regard to years of teaching, gender, ethnicity, and age of the teacher. If future studies with a larger sample size are able to determine differences in math identity among subgroups, they could provide evidence that different types of students have different experiences in math, and therefore construct different math identities. As identity is often formed from deeply personal experiences, it is possible that those potential differences could expand our understanding of the development of identity. In contrast, if no differences are found, it would also provide data on the consistency of math identity development.

Though research has shown that identity is fluid and changes with experiences, it remains to be seen if professional development can provide teachers with the math experiences needed to change their math identity overall. Future studies could explore how teacher math identity is changed and under what circumstances. Programs could be explored that have utilized professional development that has been successful in changing how teachers see math. Future studies could also follow current systematic attempts to change teaching practices and determine the success, or not, of those programs in creating that change.

As this study found that different teaching styles are connected to different identities, the assumption is made that changing math identity will be correlated with a change in teaching practices. Future studies could explore the veracity of that assumption. Longitudinal studies could be conducted around professional development among the two teaching groups: conceptual and traditional. If professional development successfully changes teacher math identity, studies can be conducted to determine if that is enough to alter how they teach.

Final Remarks

In many districts across the state, math instruction has not changed, despite new standards and a new assessment that focuses on students making deeper math connections. The argument against changing how math is taught is often that math is math and it has not changed, so why should our teaching? But it must also be noted that the traditional way of teaching math produced many adults who dislike math to the point that they will avoid it whenever possible. Professional development currently exists around the standards for mathematical practice, yet many teachers are not incorporating them into their teaching in spite of their being assessed on the CAASPP. Most teachers sincerely want their students to do well in their class, so why the resistance to teaching math differently than it has been done in the past? This study implies that teaching practices can be tied to math identity, so some of that resistance could be rooted in their own math experiences and identity. To change how they teach math, we must first allow them to explore their own math identity and the math identity of others. Because research has shown that identity is fluid and changes as one's experiences change, if we want to change teaching practices, we must first address the identity that has led to those practices.

When it comes to student learning, no one has a more influential role than the teacher who is with the students every day. The teacher controls how the content is presented, the way the students interact with the content, and the overall tone of the class. As a math teacher, I saw firsthand how the way I structured my lessons could change how the students saw math and their own math ability, admittedly for both the good and the bad. As a math coach, I saw a wide variety of lessons and wondered what made the two teachers in rooms next to each other take such a different approach to teaching math. Informal conversations with teachers only led to more curiosity around how they view math as a subject. Helping teachers improve student understanding was a passion of mine at this point, but it became clear that understanding why they utilized the teaching practices they did was a necessary first step.

This study showed that math identity and practices are connected. We cannot go back and change the negative math experiences our teachers had as students, but this study shows we should not want to. Those negative experiences transformed some teachers into extraordinarily empathetic teachers who chose to provide opposite experiences for their students. This study showed the most profound memory that conceptual teachers had of math was of the one, or several if they were fortunate, teacher who worked with them to make them feel good about themselves as math learners. We should want to provide all learners, both adults and children, with those experiences.

APPENDIX

First Interview

Opening:

Thank you for agreeing to be interviewed; I greatly appreciate your time. Your answers will be confidential, and I will change the names of and anyone you mention. I will be using a recorder for accuracy and to transcribe this interview. If at any time you would like me to turn off the recorder, please let me know. This interview will focus on your experiences in math as a student. Do you have any questions before we begin?

1. How did you end up becoming a math teacher?
2. Thinking back to yourself as an elementary student, do you have any strong memories of math from kinder through 5^{th} grade?
    a. Walk me through that memory; what details do you remember most about it?
    b. What do you think it is about that memory that made it stand out to you?
    c. Do you remember anything else that stands out?
    d. If you don't have any strong memories, what is your overall sense of your memories in math?
3. Do you have any other strong memories of math in elementary school?
4. Thinking back to yourself as a secondary student, do you have any strong memories of math in middle or high school?
    a. Walk me through that memory; what details do you remember most about it?
    b. What do you think it is about that memory that made it stand out to you?
    c. Do you remember anything else that stands out?
5. Do you remember any other strong memories of math in secondary school?

6. Do you recall any turning points that changed the way you felt or thought about math? For example, was there an event or person that made you go from liking math to disliking it, or from disliking it to liking it, or even from thinking it's hard thinking it's easy or vice versa?
    a. Can you remember any specifics about what caused you to have that change?
    b. What do you think it was about that moment that caused that change for you?
    c. What do you think of now when you look back at that turning point?
7. Is there anything about math in college that stands out for you?
8. How did your family react to you being a math teacher? Were they supportive, did they understand, etc.?

Second Interview

Thank you for agreeing to be interviewed; I greatly appreciate your time. Your answers will be confidential, and I will change the names of and anyone you mention. I will be using a recorder for accuracy and to transcribe this interview. If at any time you would like me to turn off the recorder, please let me know. This interview will focus on your experiences in math as a teacher. Do you have any questions before we begin?

1. How long have you been a math teacher?
    a. Have you ever taught anything besides math?
2. Think back to a lesson you taught today in math. What was a math problem or problem set that you went over with students today?
3. Was this a typical math day for you?

    a. If it was, what made it typical?

4. If it wasn't, what made it atypical? What would a typical day look like? Talk me through how you got them started on the lesson. How did you introduce what students would be doing today?
    a. Can you tell me more?
5. What did you do after you introduced the problem or lesson?

   Prompts if needed:
    a. Did you go into a specific problem?
        i. If so, what were you doing?
        ii. What were your students doing?
    b. Did you move onto another problem like it? Similar? More advanced?
6. Did students struggle with the problem, or even part of solving it?
    a. Can you tell me more?

Journal Prompt – to be given at end of second interview

"If you were going to describe a student who was good at math, how would you describe them? What skillsets do they have that make them good at math?

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