PERCEPTIONS OF SECONDARY MATHEMATICS TEACHERS CONCERNING INFLUENCES ON PEDAGOGICAL PRACTICES

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

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ABSTRACT

The purpose of this study was to explore the perceptions of Secondary Math Teachers (SMTs) concerning the influences that affect teaching practices and also investigate the possible existence of pluralistic ignorance concerning the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a *typical* SMT. While other studies have quantitatively analyzed teaching influences through the use of traditional surveys (Weiss, Pasley, Smith, Banilower, & Heck, 2003; Whittington, 2002; Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013; Smith, 2013), this study used Q methodology to analyze the subjective, qualitative aspects of SMT perceptions concerning influences on teaching practices.

Nineteen SMTs from North Dakota sorted a list of potential influences under two conditions of instruction (one pertaining to themselves and the other pertaining to their beliefs concerning the typical SMT). The data were collected and analyzed, resulting in the identification and description of three archetypes: the *Realists*, the *Pragmatists*, and the *Self-Referents*. Furthermore, there was evidence to suggest the existence of pluralistic ignorance amongst the participants based on the inconsistency between their two sorts. This was particularly evident concerning *Pragmatists* who inaccurately viewed themselves as unique.

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CHAPTER 1: INTRODUCTION

A large volume of research exists concerning the shortcomings of math education in the United States (e.g. Ginsburg, Cooke, Leinwand, Noell, & Polluck, 2005; Bishop, 1992; Battista, 1994; Battista, 1999; Romberg & Carpenter, 1986; Hiebert, 2003; Donovan & Bransford, 2005; Stigler & Hiebert, 2009; Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992). Much of this research has focused on the specific pedagogical practices of secondary math teachers (SMTs). Specifically, research has attempted to identify which teaching strategies are effective and which are ineffective (e.g. Esmonde, 2009; Slavin, Lake, & Groff, 2009; MacIsaac & Falconer, 2002; Borko et al., 1992; Edwards, Higley, Zeruth, & Murphy, 2007; Hennessey, Higley, & Chesnut, 2012; Anthony & Walshaw, 2007). Research findings have also reported on the pedagogical practices that are most prevalent in today's math classrooms (Stigler & Hiebert, 2004; Stigler & Hiebert, 1999; Wu, 1999) and teachers' beliefs about what effective teaching is and how it should be implemented (Ball, 1996; Pajares, 1992; Hart, 2002; Smith, 1996; Battista, 1994; Hennessey et al., 2012).

This research has contributed to the creation of several standards documents designed to inform and guide SMTs' teaching strategies. For example, The Interstate Teacher Assessment and Support Consortium (InTASC) has developed model core teaching standards that describe what all teachers should know and be able to do in order to promote effective student learning. Similarly, the National Council for Accreditation of Teacher Education (NCATE) has developed professional standards and content-specific guidelines for universities that prepare teacher candidates. The NCATE standards for future SMTs are largely based on the process standards, content standards, and pedagogy standards outlined by the National Council of Teachers of Mathematics (NCTM). Finally, the National Board for Professional Teaching Standards

(NBPTS) has defined Five Core Propositions of effective pedagogical practices. These propositions are then further sub-divided into content-specific standards. SMTs have the opportunity to earn an advanced teaching credential by becoming certified through the NBPTS. This certification requires SMTs to demonstrate effective pedagogical practices as defined by NBPTS standards.

While none of these organizations subscribe to one *right way* to teach mathematics, they share similar visions regarding the overall complexity of teaching and the effective ways to promote student learning. In general, they agree that effective teaching requires the ability to use multiple instructional and assessment strategies to engage a diverse student population. They promote student engagement, collaboration, problem solving, exploration, etc. For example, the NCTM (n.d.) suggests that SMTs are responsible for creating an intellectual classroom environment that promotes serious engagement amongst students. Similarly, The NBPTS (2010) suggests that SMTs must create an environment where students actively learn through investigation and exploration of patterns; discovery of mathematical structure; establishment of relationships; formulation and solving of problems; and justification and communication of results. Finally, NCATE and NCTM standards for the preparation of SMTs suggest candidates have the ability to use and critique a wide variety of curricular materials, employ various strategies in assessment (e.g. listening and understanding how students view mathematics), use a variety of instructional strategies to engage students in conceptual understanding, and demonstrate knowledge of research results in teaching and learning.

Statement of the Research Problem

The suggestions communicated through InTASC, NCTM, NCATE, and NBPTS standards could certainly be viewed as an attempt to encourage SMTs to move away from traditional teaching methods (e.g. lecture-based, teacher-centered, focus on rote memorization and procedures, etc.) and employ more student-centered practices. Yet, traditional teaching methods, in spite of research that discounts their effectiveness, still continue to dominate the math classroom (Donovan & Bransford, 2005; Hiebert, 2003; MacIsaac & Falconer, 2002; Battista, 1999; Shulman, 2000; Wittington, 2002). In fact, when researching the various influences on teachers' instructional strategies, Weiss, Pasley, Smith, Banilower, and Heck (2003) of Horizon Research, Inc. found that not one K-12 math or science teacher cited national standards documents as influential to their teaching. It can be argued that the overuse of lecture and general lack of effective pedagogical practices by SMTs are primary culprits contributing to the mediocre mathematical achievements of today's students. Battista (1999) may have summed it up best:

> For most students, school mathematics is an endless sequence of memorizing and forgetting facts and procedures that make little sense to them….Numerous scientific studies have shown that the traditional methods of teaching mathematics are not only ineffective but also seriously stunt the growth of students' mathematical reasoning and problem solving skills….Yet traditional teaching continues, taking its toll on the nation and on individuals. (p. 426)

Other researchers have had similar views. Romberg and Carpenter (1986) argued that teachers tend to break mathematical learning into small, disconnected fragments. "This fragmentation of mathematics has divorced the subject from reality and from inquiry" (p. 851). They identified three specific problems with traditional math pedagogy: (a) teachers are primarily focused on maintaining order and control, rather than student learning, (b) teachers tend to see their jobs as covering the text, and (c) teachers fail to see that learning proceeds through construction, not absorption.

Donovan and Bransford (2005) reported that one of the main problems in the current structure of math education is the importance placed on procedures and the concept that "sense making" is too often treated as irrelevant. Stigler and Hiebert (1999) found that 96% of student seatwork is spent practicing procedures and less than 1% is spent investigating new procedures or analyzing new problems. Referring to the lack-luster achievement of U.S. math students, Hiebert (2003) said, "Presuming that traditional approaches have proven to be successful is ignoring the largest database we have" (p. 13).

The criticisms of the traditional pedagogies employed by today's SMTs seem endless. In response, researchers and practitioners have attempted to promote alternative forms of teaching. Cooperative learning (CL) structures, for example, have been recommended as a way to engage and enlighten students (Kagan, 1990; Esmonde, 2009). Furthermore, CL promotes students' mathematical understanding by providing opportunities for multiple ideas to be critiqued, reexamined, and built upon, leading to more sophisticated thinking (Francisco, 2013). In a review of multiple mathematics teaching programs for middle and high school students, Slavin et al. (2009) found that the two most effective programs were based on CL models. Similarly, problem-based learning (PBL) was designed to construct an extensive and flexible knowledge base amongst students through the emphasis of problem solving skills, self-directed learning, collaboration, and intrinsic motivation (Barrows & Kelson, 1995). PBL has been shown to produce positive effects in assessing students' abilities to understand principles that link various concepts (Gijbels, Dochy, Van den Bossche, & Segers, 1995). In general, research has shown these reformed pedagogical practices to be effective. Smith, Sheppard, Johnson, and Johnson (2005) summarized:

> Classroom-based pedagogies of engagement, such as cooperative learning and problem-based learning, can help break the traditional lecture-dominant pattern. To maximize students' achievement, especially when they are studying conceptually complex and content-dense materials, instructors should not allow them to remain passive while they are learning. (p. 97)

Certainly, SMTs all over the country exhibit a wide variety of pedagogical practices and instructional strategies. However, it is unclear what influences them to teach the way they do. There is an overwhelming amount of research available to SMTs that promotes the use of reformed teaching practices as an alternative to traditional methods. Furthermore, there exist multiple written standards from various organizations in education (e.g. InTASC, NCATE, NCTM, NBPTS) supporting this transition away from traditional practices. Yet, SMTs continue to employ what have been identified as ineffective instructional strategies despite access to evidence that more effective strategies exist.

Purpose of the Study

The purpose of this study is to better understand what influences SMTs' pedagogical practices and to examine potential themes that may emerge amongst SMTs concerning their perceptions of these influences. It has been shown that traditional methods still remain dominant in the math classroom, yet questions remain as to why this trend continues. One theory suggests a cultural influence. Bullock and Russell (2010) reported the following:

> The cultural routines and patterns associated with schools, teaching, and learning are firmly embedded in our culture from a very young age and thus highly resistant to

change. Simply put, every adult knows what teaching and learning should look like because he or she has spent thousands of hours as a student in school. (p. 93)

Similarly, Stigler and Hiebert (2009) argued that even when considering all of the reform efforts in math education, teaching is a cultural phenomenon, hence over the past 100 years very little has changed in the classroom. It is difficult for SMTs to change the way they teach because most have never been given adequate opportunity to learn how to change their instructional practices (i.e. in general, teachers are exposed to alternative forms of teaching via one or two days of in-service training during a school year, which is far from adequate (Hiebert, 2003)).

The implications of the cultural effects on instructional strategies of SMTs are extensive and reach well beyond the scope of this study. However, it is an important theory to consider in the context of pedagogical influences. In fact, Hiebert (2003) showed no hesitation in providing a general summary of the consistent and predictable way mathematics is taught in the U.S. His general description was comprised of an observation of a math classroom by a researcher in 1978. The class session begins with a review of answers to the previous day's homework problems, moves to a brief explanation of the new material, and ends with the assigning of a new set of problems that are to be completed individually during student seat-work while the teacher circulates the classroom answering questions. Most notably, this routine repeats itself every day. Hiebert argued that most readers of this summary would recognize this classroom environment as quite similar to their own experiences. Furthermore, he suggested that this 1978 description of a math classroom is, in general, compatible with current math classroom environments, thus providing support for the theory of cultural influence (i.e. very little has changed over time).

Even considering Hiebert's (2003) generalization of math instruction, it can still be argued that SMTs employ a variety of teaching methods (e.g. CL, PBL) that have been shown to be effective. However, it is not always evident exactly why SMTs choose to teach the way they do. Horizon Research, Inc. (e.g. Weiss et al. 2003; Whittington, 2002; Banilower, Smith, Weiss, Malzahn, Campbell, & Weis, 2013; Smith, 2013) has done extensive, wide-scale research on the beliefs, influences, and instructional practices of SMTs. (Much of this research will be addressed in upcoming sections of this dissertation). However, this research has typically been conducted via surveys, thus providing mostly quantitative data. The current study built upon this body of knowledge by examining the subjective, qualitative aspects of SMT perceptions concerning their pedagogical practices.

Research questions. This study addressed the following two questions.

1. What archetypes of SMTs exist amongst the perceptions of SMTs concerning the influences that affect teaching practices?
2. What differences (if any) exist amongst the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT?

These two questions were addressed through the use of Q methodology, a research method designed in 1935 by British psychologist and physicist, William Stephenson. The study identifies patterns of beliefs SMTs hold concerning the influences on pedagogical practices. Q methodology was chosen because it provides an organized technique to uncover qualitative data within the participants' opinions, as well as, a way to quantify this data using factor analysis procedures (Edwards, 2007). Q-sample items of various potential pedagogical influences, along with open-ended responses from participants, were used to identify SMT perceptions and potential emergent factors amongst the participants. Results of this study contribute to the existing body of knowledge on SMT beliefs and perceptions concerning pedagogical practices.

Conceptual Framework

The following section defines and builds the conceptual framework on which this study was based. Ravitch and Riggan (2012) define a conceptual framework as "a way of linking all of the elements of the research process: researcher disposition, interest, and positionality; literature; and theory and methods" (p. 6). They identify three primary elements that comprise a conceptual framework: personal interests, topical research (i.e. extant empirical literature), and theoretical frameworks (i.e. extant formal theories that can explain how and why things exist within the research area). The following sub-sections describe these three components of the conceptual framework for this study.

Personal interest. [*Note the intentional shift to first person narrative for this sub-section in order to adequately describe the researcher's personal interest in the study, as suggested by Ravitch and Riggan (2012)*]. At the time of this writing I was in my tenth year of teaching math. The first four of these years were spent teaching high school math at a small, rural school in North Dakota. The rest have been spent as a math education instructor at a small four year university. My main responsibility at this university is to prepare, mentor, and supervise the math education majors (i.e. those students pursuing a career as a SMT). My goal is to work with the school of education to produce the best SMT candidates possible. It is this facet of my career that motivates me to pursue research in the area of math education.

Most of what I had come to believe about math education (i.e. what it meant to be a math teacher) early in my career was a result of personal experience and observation. My entire K-12 experience as a student took place in a single school building in a small, rural North Dakota town. In fact, I had the same math teacher every year from 7th grade to 12th grade. Therefore, I had a very limited, narrow view of what a math teacher was. I simply assumed that all math teachers were exactly like mine. When I went to college I took numerous math courses from various instructors, yet I did not recognize a great deal of variation in their instruction. In hindsight, it is quite possible that there were significant differences in their teaching strategies, yet if these differences did indeed exist, it was not evident to me at the time. In short, I viewed the teaching of math as the dissemination of mathematical content from the teacher to the student. This was mostly accomplished via lecture, student note-taking, and student homework practice that focused on computation and skill development.

Because of my current position as a math education instructor, I often reflect on my own preparation in becoming a SMT. The perception of what it meant to be a math teacher as described above was the main driving force behind the pedagogical strategies I took with me to my student teaching experience (prior to earning my undergraduate degree in math education). I recall my cooperating teacher exhibiting nearly identical pedagogical practices to those I had previously experienced. In other words, he was very much the same as my high school teacher. I don't recall any "ah ha" moments during my student teaching experience that lead me to believe anything *new* about teaching math that I did not already know. Not surprisingly, I spent my entire student teaching experience modeling the same traditional practices employed by my former high school teacher and my new cooperating teaching. As previously mentioned, Stigler and Hiebert (2009) argued that teaching math is a cultural phenomenon (i.e. very little has changed over time in the classroom). Similarly, Bullock and Russell (2010) reported that the cultural routines and patterns learned as a student carry over into a teacher's pedagogical practices. These observations were certainly befitting of my early experiences as a SMT.

During my student teaching experience a typical lesson would look quite similar to the description provided earlier by Hiebert (2003). It would be comprised of lectured material from the textbook, including notation and modeling of problems on the chalkboard. Meanwhile, the students sat in their desks passively receiving the content, sometimes taking notes and/or asking questions. Students would be assigned daily homework exercises (normally those provided by the textbook). Then, at the end of the chapter, the students would take a summative test on the previously covered material. This would *end* that particular chapter of content and I would simply start the process over again for the next chapter.

These are the typical traditional pedagogical practices that I still witness from SMTs today, even though much of the current research in math education tends to discount the effectiveness of this approach. Since my current position involves making multiple supervisory visits to the various classrooms of my student teachers, I have the opportunity to witness the pedagogical practices of multiple SMTs (i.e. both the student teachers and their veteran cooperating teachers). These experiences have driven me to become more interested in math education, specifically the ways in which it can be improved.

Every time I make a supervisory visit to one of my student teachers, I reflect on my own student teaching experience and the relationship I had with my supervisor at the time. In my current position, after observing each lesson I will sit down with my advisee and we will have a conversation about various facets of that day's lesson (e.g. what things went well, what things did not go well, potential areas for improvement, how he/she can implement the various strategies taught in the university preparatory courses, concerns of the student teacher, etc.). My goal is to get my student teachers to think more about active student learning and the ways in which they can establish an effective learning environment in their classrooms.

This is quite different than the experiences I had with my supervisor when I was a student teacher. I recall once reading the handwritten notes she had made on my evaluation form after a particular visit to my classroom. She noted that my voice quality was superb and commented on the quality of the notation/diagrams that I had displayed on the chalkboard. She also noted that I tended to teach primarily to the right hand side of the classroom and that I should work to improve this (i.e. give equal attention to the students sitting on the left side of the room). There was no mention of classroom management strategies, attempts to establish a quality learning environment, use of differentiated instruction, promotion of student engagement, use of formative assessment strategies, etc. Instead, she simply provided an evaluation of my lecturing skills, and that evaluation was mostly positive. This led me to believe that teaching was lecturing (i.e. I believed that I was doing a great job and I had very few things to improve on). Again, this situation aligned well with Stigler and Hiebert's (2009) notion that teaching was a cultural phenomenon. If both my cooperating teacher and university supervisor believed in the traditional model of lecture-driven pedagogy, then it would only make sense that I would follow this path.

It was not until my second or third year of full-time teaching that I finally experienced something other than the traditional lecture style of teaching math. I attended one of the North Dakota Council of Teachers of Mathematics (NDCTM) conferences for the first time. The conference involved hands-on workshops where veteran teachers shared their various lessons and pedagogical approaches. I remember being amazed at the variety of teaching practices that other math teachers in the state were using. Why had I not been exposed to any of this before? I came away from that conference with so many new ideas and philosophies about teaching math that it was almost overwhelming.

Furthermore, around this same time, the superintendent at my school required all faculty members to attend a one day workshop on establishing an effective learning environment for students. This workshop included the partial viewing of Dr. Harry Wong's DVD series, titled *The First Days of School*. I recall Wong's observation that teachers tend to be overly tired at the end of the school day, whereas students seem to have an abundance of energy as they leave the building. His assessment was that this was due to an educational environment in which the teachers were doing all of the work and the students were passively watching it happen. This made me think critically about my own classroom environment. Sure enough, Wong's general assessment of the teacher-student relationship quite accurately described my classroom. Watching Wong's video, along with attending my first NDCTM conference, gave me a completely different view of what it meant to be a math teacher. This was a turning point in my career. From that point, I began to think less about my own presentations and lectures and more about active student-centered learning.

My teaching practices were further reformed upon completing my master's degree in math education. Again, I learned more about various instructional strategies (other than traditional lecture) that could be incorporated in the math classroom. I composed two formal research papers required for the completion of the degree. One of these was on the 4MAT teaching model, which focuses on student engagement and emphasizes the existence of various learning styles amongst students. The other was a comparison of math education in the United States versus that of Japan, a world power country whose math students continually outperform U.S. students in international assessments. The composition of these papers, along with my annual experiences at subsequent NDCTM conferences, served as the springboard for my interest in improving math education. This passion for math education was a continual theme throughout my doctoral courses, capstone experience, and comprehensive exams. It continues to drive my research interests today, leading into this dissertation study. Subsequently, I envision that it will continue to drive both my research and practitioner interests in the future. This study simply serves as a starting point in examining SMT's perceptions of why they choose to teach the way they do. Certainly, the results of this study will create more research questions for future examination.

As I conduct this study, I find myself reflecting on the various influences that have shaped my personal pedagogical approach. Certainly, some influences have been stronger than others during my personal development as a math teacher. Much of what I believe to be true about effective math education comes from personal experiences, beliefs, values, and biases. I suspect that my experiences are not unique (i.e. most other SMTs have probably experienced similar progressions). Yet, it is important to recognize that my experiences, beliefs, values, and biases, alone, do not constitute a conceptual framework. "Belief alone is not evidence. Interest alone is not an argument for why a study matters. Hunches about how the world works do not constitute a theoretical framework" (Ravitch & Riggan, 2012, p. 11). The next section will examine some of the topical research that has contributed to the overall conceptual framework for this study.

Topical research. Several areas of research have been prominent in building the conceptual framework for this study. This section contains a summary of some of the research that that has contributed to reform efforts in math education by way of both curriculum issues and pedagogy issues. Chapter 2 will provide a more comprehensive literature review specific to this research project and the Q methodology that was used.

Of course, research studies have been continually conducted in an effort to learn more about the shortcomings of math education and improve its effectiveness. Many point to the 1950s (when the Soviet Union launched Sputnik) as a wake-up call to Americans concerning math and science education. At that time, it was becoming increasingly evident that other countries were starting to surpass the United States in several innovative areas. A reaction to this was a reform attempt known as the New Math, introduced in the 1960s. The idea behind this movement was to emphasize modular arithmetic, algebraic inequalities, matrices, symbolic logic, Boolean algebra, and abstract algebra at a young age (Kline, 1973). The argument for this approach was that introducing these topics to students at a young age would allow them to eventually be able to handle the rigorous mathematics required of advanced engineers. Ultimately, the New Math was widely viewed as a failed attempt. Said Kline, "Abstraction is not the first stage but the last stage in a mathematical development" (p. 98).

The 1989 release of *Curriculum and Evaluation Standards for School Mathematics* by the NCTM prompted what became known as the "math wars." This was a debate between advocates of traditional math instruction (i.e. the belief that students need to develop computational skills before being able to learn or appreciate mathematical concepts) and advocates of reformed math instruction (i.e. a focus on deep conceptual understanding, which will inevitably lead to procedural fluency and conceptual understanding). Most modern math education research supports the reform model (Hiebert, 2003; Schoenfeld, 2002; Bransford, Brown, & Cocking, 1999; Grouws & Cebulla, 2000; Rakes, Valentine, McGatha, & Ronau, 2010). According to Schoenfeld (2002):

> On tests of basic skills, there are generally no significant differences between students who learn from traditional or reform curricula. On tests of conceptual understanding and problem solving, students who learn from reform curricula consistently outperform students who learn from traditional curricula by a wide margin. (p. 11)

Hiebert (2003) argued, "Instructional programs that emphasize conceptual development, with the goal of understanding, can facilitate significant mathematics learning without sacrificing skill proficiency" (p. 16). Bransford et al. (1999) suggested that learning needs to take place via understanding as opposed to merely memorizing a set of facts or following a fixed set of procedures. Similarly, according to Grouws and Cebulla (2000), "Students who develop conceptual understanding early perform best on procedural knowledge later" (p. 15).

Math students who show computational fluency without conceptual understanding exhibit what Shulman (2000) identified as *illusory understanding*. Shulman noted this to be the oldest, most common road block to student achievement. Illusory understanding refers to the appearance of learning, or the problem of people who appear to know something that they really do not. For example, a student may successfully complete a multi-step algebra problem, yet the performance is due to the execution of memorized procedures, as opposed to conceptual understanding. Shulman argued that dialog and argumentation in the classroom are essential for students to deeply grasp mathematical concepts. Yet, sadly, lecture is still the dominant form of pedagogy used. He believes teachers are reluctant to move away from lecture because this causes a loss of control in the classroom (i.e. if a teacher does nothing but lecture he does not have to worry about any surprises occurring, since he is dictating the entire class). Shulman believes the cure to this type of learning (or lack thereof) is through student reflection and interaction.

Another area of reform interest surfaced through the analysis of international assessments. Specifically, researchers and practitioners became interested in the mathematical performance of U.S. students on standardized tests versus their counterparts in other countries. The Trends in International Mathematical and Science Study (TIMSS) and the Program for

International Student Assessment (PISA) were two of the major assessments studied. Analysis of the data from these studies indicated that U.S. students were not performing as well as quite a few other countries, specifically Asian countries.

The 2003 PISA results showed that American 15-year-olds ranked 9th of the countries participating, whereas Japanese students ranked 3rd (Ginsburg et al., 2005). Results of the TIMSS in 1995, 1999, 2003, 2007, and 2011 showed similar trends for 4th and 8th graders (i.e. American students were not performing as well as other developed, world power nations). These results have contributed to a whirlwind of reform efforts and policy changes over the past 20 years.

For example, when comparing the curriculums of the top five scoring nations in the 2003 PISA to the curriculum of the U.S., Steven Leinwand, principal research scientist at the American Institutes for Research said, “While all five of these countries have a coherent K-12 national mathematics curriculum, the United States stumbles along with the 50 state frameworks based more on whim and past practice than research” (Hardy, 2005, p. 7). Leinwand continued to say that while these other countries have rigorous national assessments aligned to their curriculums, “the United States has a hodgepodge of state-mandated assessments, few of which can be considered rigorous and even fewer of which are aligned with commonly used textbooks” (p. 7).

Stigler and Hiebert (2004) specifically looked at the differences between Japanese and American math classrooms by analyzing video-taped lessons from the 1995 and 1999 TIMSS studies. They coded each mathematical problem presented to the students as either a *performing procedures* problem or a *making connections* problem. Although teachers in both countries presented a similar proportion of the two types of problems, they found that the implementation of the problems varied quite drastically. When Japanese students were presented with making connections problems they worked individually or in groups for long periods of time to come up with solutions. American students, however, had a much different experience. Upon being presented with making connections problems, their teachers quickly changed the problems into performing procedures problems by prescribing steps, supplying necessary formulas, or in some cases even supplying the answer.

Robitaille and Travers (1992) also studied the differences between Japanese and American math classrooms. They found that American students spend more class time participating in off-task, inappropriate behavior than Japanese students. Also, Japanese teachers focus more on student mistakes (and using them as learning opportunities), whereas American teachers tend to only celebrate successes. Finally, American textbooks tend to be much longer than Japanese books. There is a great deal of repetition in American textbooks. Said Robitaille and Travers:

> Over 70% of concepts were repeated at least once in American books after their initial introduction. Almost 25% were repeated twice and 10% were repeated three times. By contrast, in Japan, 38% of the topics were reviewed once and only 6% were repeated more than once. (p. 707)

Furthermore, Japanese textbooks are more complex. They focus more on the conceptual development of skills, whereas American books tend to represent information with detailed step-by-step procedures.

Other reform efforts have come in the form of standards and policy changes. The NCTM, for example, developed process standards above and beyond the existing standards of specific math content. These process standards include problem solving, reasoning and proof, communication, connections, and representation (NCTM, n.d.). Furthermore, in 2003 the NCTM teamed with NCATE to create program standards for math teacher preparation programs.

The most recent reform effort by way of K-12 math standards is the implementation of the Common Core State Standards (CCSS) for mathematics. These standards, based largely on NCTM's process standards, "are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers" (CCSS Initiative, n.d., para. 1). At the time of this writing, 48 states (and 3 territories) had already adopted the CCSS. The standards state that all levels of math students should focus on the following mathematical practices:

- Make sense of problems and persevere in solving them
- Reason abstractly and quantitatively
- Construct viable arguments and critique the reasoning of others
- Model with mathematics
- Use appropriate tools strategically
- Attend to precision
- Look for and make use of structure,
- Look for and express regularity in repeated reasoning

There is an overwhelming amount of research behind these standards, yet it is obvious that part of the vision is to steer away from the teaching of prescribed procedures and rote memorization. The CCSS, once fully implemented, will also include a new set of standardized assessments. This represents new direction in the attempt to unify the U.S. toward common mathematics education goals. As previously mentioned, Leinwand criticized the 50 individual state frameworks and the poorly aligned assessments for math education standards (Hardy, 2005). Certainly, the implementation of the CCSS addresses this issue.

As opposed to focusing on curriculum reforms (e.g. standards, textbooks, etc.), Shulman emphasized the pedagogical approaches employed by teachers. In the early 1980s he advocated a set of signature pedagogies for teachers. His efforts, along with a team of educators, helped create the National Board for Professional Teaching Standards (NBPTS) in 1987. To become a certified member of this board, teachers must exhibit proficiency in several pedagogical areas.

Others have also focused on pedagogical practices. Recognizing the trend that most teachers teach the way they were taught (a concept that will be further analyzed in Chapter 2), MacIsaac and Falconer (2002), working on behalf of the Arizona Collaborative for Excellence in the Preparation of Teachers (ACEPT), defined *reformed teaching* to be teaching "via the kinds of constructivist, inquiry-based methods advocated by professional organizations and researchers so that these future teachers would be taught as they were expected to teach" (p. 479). To measure reformed teaching they developed the Reformed Teaching Observation Protocol (RTOP), an instrument used to score classroom lessons. A high RTOP score indicates high levels of reformed teaching, whereas a low RTOP score is indicative of a purely lecture driven lesson. Upon using this protocol to measure teaching practices, they found that high RTOP scores strongly correlated with student conceptual gains in math and science classrooms.

Similar observation protocols have also been designed. Using the RTOP as a guide, The Oregon Collaborative for Excellence in the Preparation of Teachers (OCEPT) developed the OCEPT Classroom Observation Protocol (O-TOP) to generate a profile of what was happening across instructional settings rather than to assign a score to a particular lesson (Wainwright, Flick & Morrell, 2003). Similarly, The Teaching Dimensions Observation Protocol (TDOP) was designed to chart the ways in which a teacher uses various teaching methods, cognitive engagement, and instructional technology (Oleson & Hora, 2012). All of these observation protocols are designed to help measure teaching practices (most often at the university level, but applicable to a high school setting, as well) in the classroom so that research can be conducted in an effort to correlate these teaching practices with student achievement.

Theoretical framework. According to Ravitch and Riggan (2012), a key component of a conceptual framework is how a researcher thinks about the area of research and the theories that shape this thinking. Multiple theories concerning math education have emerged over time. Exposure to these various theories comes in several forms, most frequently through extant research literature. All of these theories played a role in the overall conceptual framework for this study.

Shulman (1986) described the evolution of what it meant to be a knowledgeable teacher from the 1870s to the 1980s. In the 1870s it was expected that a teacher be solely knowledgeable in the subject matter being taught. Very little, if any, emphasis was put on the teacher's pedagogical ability. Over time, however, there was a shift in emphasis. Shulman reported that by the 1980s the importance placed on pedagogical knowledge had grown substantially, yet the emphasis on content knowledge was "conspicuously absent" (p. 6). He and his colleagues criticized current educational research as being too focused on pedagogical skills, while deemphasizing the inclusion of content-based knowledge. Shulman referred to this as the "missing paradigm" (p. 6) problem in education. Specifically, the missing paradigm referred to "a blind spot" (p. 6) with respect to content that characterized most of the research concerning teaching, most of the teacher evaluation programs, and teacher certification criteria.

In an attempt to fill this missing paradigm, Shulman (1986) suggested defining a new facet of knowledge for teachers called pedagogical content knowledge (PCK). PCK refers to content-specific subject matter that goes beyond what a non-teaching professional in the content field would be expected to know. That is, PCK is specifically for teachers. Shulman described PCK as "the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others" (p. 9). Furthermore, Shulman noted that PCK includes an understanding of what makes the learning of specific topics easy or difficult. This includes a teacher's ability to recognize the pre-conceptions students bring with them to the classroom and knowledge of the strategies that will most effectively amend any misconceptions they might have.

As previously mentioned, organizations such as the NCTM, NCATE, InTASC, and NBPTS do not subscribe to one right way to teach mathematics. Shulman echoed this stance. However, he did argue that a teacher with sound PCK will have the ability to implement various instructional strategies. The acquisition of PCK can come in multiple forms. Whittington (2002) and Smith (2013), working on behalf of Horizon Research, Inc., provided thorough analyses of multiple aspects of SMTs' preparation, development, and current practices. Concerning the acquisition of PCK, a primary source for many SMTs might be a college course specific to the methods of teaching mathematics. Whittington estimated that 77% of SMTs have completed such a course. Similarly, Smith reported that 90% of SMTs had taken at least one college course specifically addressing math education and 72% had taken a course emphasizing mathematics content for high school teachers. Cummings (2010) reported, however, that the SMTs in her study acquired most of their PCK outside of college. One potential source of this would be professional development (PD) opportunities that address math pedagogy. Smith (2013) reported that 89% of SMTs had participated in at least some PD over the past three years, with 33% having spent more than 35 hours in PD over that time. Of the teachers participating in PD, 90% indicated participation in a mathematics teaching workshop; 75% participated in a professional learning community (PLC), lesson study, or teacher study group; 54% received feedback from a mentor/coach; and 39% attended a state or national mathematics teacher association meeting. SMTs reported PD in multiple areas, including the use of technology for math instruction, inquiry/investigation-oriented teaching strategies, understanding student thinking in mathematics, assessment strategies, use of hands-on manipulatives, and differentiated instruction (Whittington, 2002; Smith, 2013).

Between completion of college coursework through programs accredited by NCATE (programs subscribing to their standards), PD opportunities for in-service teachers, standards documents supplied by educational organizations (e.g. NCTM, NCATE, InTASC, NBPTS), and the large volume of research findings that promote reformed teaching practices, it is fair to say that SMTs have had substantial exposure to information that could shape their pedagogical practices in a reform-based manner. However, as previously mentioned, traditional practices remain dominant in the math classroom. Therefore, there seems to be a disconnect between the knowledge SMTs possess concerning sound pedagogy and their actual practice. In other words, possession of PCK is necessary, but not sufficient for implementing effective pedagogical strategies.

Theories have emerged concerning the beliefs SMTs hold about how students learn mathematics and what constitutes good pedagogy. These beliefs can certainly play a significant role in the eventual practices employed by SMTs (Ball, 1996; Pajares, 1992; Hart, 2002). Like the cultural influence on teaching practices, the study of teacher beliefs is quite extensive and goes well beyond the scope of this study. However, it is important to recognize the work that has been done to theorize the relationship between teacher knowledge, teacher beliefs, and pedagogical practices.

Smith (1996) argued that most SMTs view mathematics as a fixed set of facts and procedures for determining answers. The textbook serves as the authority for mathematical knowledge and the SMTs view their role as being the intermediary between the textbook and the students. These SMTs believe it is their job to provide the students with clear, step-by-step procedures, while the students are to listen and observe the demonstrations so that they will eventually be able to practice them on their own. According to Smith (2013), 94% of SMTs reported that they explain mathematical concepts to the entire class in most lessons. Smith (1996) referred to this as the teaching-by-telling model and identified it as an issue of self-efficacy amongst SMTs. Because this mentality restricts the content that teachers are required to know, SMTs using this approach can feel as though they have mastered the necessary content required for teaching (i.e. they can feel they are successful at their jobs). Furthermore, if SMTs subscribe to the concept that procedures cannot be adequately performed by students until they have been taught how to do them, any eventual mastery of these procedures by the students can be directly attributed to the work of the teacher.

Cooney (1999) not only identified the teaching-by-telling issue, but also noted that the propensity for teachers to *care* about their students often resulted in less than adequate learning environments. Instead of pushing students out of their comfort zones by requiring them to solve open-ended problems that may introduce the potential for failure, SMTs often succumb to students' immediate personal comfort needs as opposed to their intellectual needs. This mentality often results in regression back to the teaching-by-telling approach.

There is also evidence to suggest that SMTs are deficient in their abilities to accurately understand the relationship between their students' symbolic reasoning skills and verbal reasoning skills. Nathan and Koedinger (2000) reported that SMTs tended to believe that math problems primarily involving symbolic manipulation would be easier for students to solve than those primarily requiring verbal reasoning. This belief was strongest amongst SMTs who had the highest levels of mathematical backgrounds. However, Nathan and Koedinger showed the opposite to be true. They referred to this as the "expert blind spot." That is, teachers with higher levels of mathematical content understanding tended to show lower levels of awareness of students' understanding.

Evidence exists that SMT beliefs often do not align with reform-based suggestions. For example, in the most recent Horizon Research, Inc. report on math education Banilower et al. (2013) found that 81% of SMTs believed students should be supplied with definitions of key terms *before* instruction occurs. Similarly, 38% believed they should explain a mathematical idea to students *before* having them investigate it. Also, 39% of SMTs believed hands-on manipulatives should only be used by math students to reinforce concepts already learned. Similarly, it has been argued that pre-service SMTs believed calculators should only be used by students after they have learned the mathematics by hand or mastered the concepts without one. That is, calculators are not viewed as a learning tool, but rather only as a computational device (Walen, Williams, & Garner, 2003). All of these beliefs could certainly be considered contradictory to the NBPTS-endorsed concept of investigative learning and the NCTM's recommendation of using math technologies to build understanding of mathematical concepts.

Curricular materials have been developed in an effort to assist SMTs with the implementation of reform-based pedagogies (NCTM, 2000). However, it has been argued that if SMT beliefs are not consistent with reform-oriented curriculum, teachers will not use the materials as they were intended (Collopy, 2003; Remillard & Bryans, 2004; Remillard, 2005). This was especially true for a SMT who possessed a well-established structure as a teaching-by-telling teacher (Collopy, 2003). Even some SMTs who held reform-oriented beliefs were not able to properly use reform-oriented curricular materials because they had not been properly oriented to them (Remillard & Bryans, 2004).

There has been so much research on SMT beliefs that the focus has now shifted from identifying those beliefs to identifying what can be done to change them (Philipp, 2007). Philipp (2007) posed the following quandary concerning this transition: "How do mathematics educators change teachers' beliefs by providing practice-based evidence if teachers cannot see what they do not already believe?" (p. 309). SMTs in the U.S. are rarely able to witness effective pedagogy, therefore it is difficult for them to change (Ball, 1988; Stigler & Hiebert, 2004; Hiebert, 2003). Philipp noted that for some SMTs beliefs change before practice, but for others changes in practice precede changes in belief. In summary, he believed the most effective change will come when beliefs and practice change simultaneously. He cited PD experiences that provide SMTs with the opportunities to coordinate incremental changes in beliefs with corresponding changes in practice as the greatest potential contributor. Furthermore, the opportunity for SMTs to spend time reflecting on their practices will help align their beliefs with their PCK and with their eventual practice (Philipp, 2007; Shulman, 2000).

Considering that SMTs rarely have chances to interact with their peers and are rarely able to witness effective pedagogy, a social psychology phenomenon known as pluralistic ignorance may be a contributing factor in the perceived influences of their pedagogical practices. Pluralistic ignorance, a term first defined by Katz and Allport (1931), describes a situation in which a majority of group members privately reject a norm, but assume incorrectly that most others accept it. Krech and Crutchfield (1948) described it as “no one believes, but everyone thinks that everyone believes” (p. 388-389). A traditional example used to describe pluralistic ignorance is the case of a university professor who finishes a lecture on difficult to understand material and then asks the students if they have any questions regarding the content. Although a student might have numerous questions (based on his lack of understanding) he does not see any other students raising their hands. Therefore, he assumes that everyone else understands the content and therefore chooses not to ask his question due to the potential embarrassment of looking ignorant in front of his peers. Other students may experience the same feelings, thus the effect of pluralistic ignorance perpetuates the norm that everyone else understands the content, when in fact, it is most likely the case that the majority does *not* understand.

Pluralistic ignorance has been analyzed as a factor in a variety of social contexts, including whites’ attitudes toward segregation (O’Gorman, 1975); drinking practices and beliefs of college campus students (Prentice & Miller, 1993); role relations between prison guards and inmates (Toch & Klofas, 1984); and teachers’ perceptions of their principals’ views concerning pupil control (Long & Willower, 1980). For the current study, the potential effect of pluralistic ignorance was considered in the Q methodology by involving two separate conditions of instruction for the Q sorts. Participants first sorted a list of potential influences on their own personal pedagogical practices. Then, they sorted the items again based on how they believed the items influenced the teaching practices of a *typical* SMT. Comparisons between the two conditions of instruction lead to factors that showed evidence of pluralistic ignorance. This analysis addressed the second research question for the study and will be further discussed in Chapters 3, 4, and 5.

Summary

Although evidence exists that reform-based instructional strategies are effective in educating math students, traditional pedagogical practices by SMTs still remain dominant. There is evidence to suggest that SMTs are adequately exposed to various instructional suggestions through the schools of education, written standards from educational organizations (e.g. NCTM, NCATE, InTASC, NBPTS), and large volumes of research on math education. Yet, the visions of these sources are not being realized in the math classroom.

Multiple factors, including cultural aspects; existing teacher beliefs; and the potential presence of pluralistic ignorance, can influence the pedagogical practices of SMTs. Other specific potential sources of influence will be examined in Chapter 2. These influences eventually comprised the list of items for study participants to sort using Q methodology. The manner in which they sorted the items lead to the identification of the emergent factors (archetypes) that describe the similarities and differences amongst SMTs.

Q methodology will be introduced in Chapter 2 and fully described in the context of the methodology for this study in Chapter 3. Chapter 4 will contain the analysis and results of the study. Chapter 5 will contain a summary with conclusions and recommendations.

CHAPTER 2: LITERATURE REVIEW

The purpose of this study was to examine the perceptions of Secondary Math Teachers (SMTs) concerning the influences that affect teaching practices. Specifically, this study built upon the existing body of knowledge in this area by examining the qualitative aspects of SMTs' opinions through the use of Q methodology and addressed the following research questions:

1. What archetypes of SMTs exist amongst the perceptions of SMTs concerning the influences that affect teaching practices?
2. What differences (if any) exist amongst the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT?

Chapter 1 contained a review of literature pertinent to the overall conceptual framework for this study. The literature review in the following sections builds on this conceptual framework, focusing more on the specific influences that may shape SMTs' pedagogical practices. The review of these potential influences provided the framework for the Q sample of items used in the primary research instrument for this study. Potential influences on SMT practices have been categorized into three sections: apprenticeship of observation, formal education experiences, and in-service experiences.

Apprenticeship of Observation

Teachers tend to teach the way they were taught (Lortie, 1975; Ball, 1988; Pajares, 1992; Handal, 2003; Gardner, 1999; Hiebert, Morris, Berk, and Jansen, 2007; Darling-Hammond, 2006). Lortie referred to this as the apprenticeship of observation. However, his use of the term apprenticeship has sometimes been questioned. In the traditional notion of apprenticeship in a trade, the apprentice is privy to not only the master's specific actions, but also his thinking and reasoning (Mewborn & Tyminski, 2006). Lortie, however, admitted that this was not necessarily the case for teachers. He noted that students will spend roughly 13,000 hours observing teaching before they graduate high school, yet this observation only includes the specific experiences from the student perspective. That is, the student is not able to observe the behind-the-scenes work of a teacher, such as planning or the numerous thought processes that a teacher may go through during the course of a day. Labaree (2004) provided the following summary:

> Apprenticeship of observation shows them a lot about what teachers do but almost nothing about why they do it. What students don't see is the thinking that preceded the teacher's action, the alternatives she considered, the strategic plan within which she located the action, or the aims she sought to accomplish by means of that action. (pp. 57-58)

The apprenticeship of observation exists at multiple levels (Lortie, 1975; Ball, 1988; Pajares, 1992; Mewborn & Tyminski, 2006). It begins early in formal education (primary grades) and continues throughout a pre-service teacher's college education and beyond. As previously mentioned, this is part of the cultural influence that often shapes the beliefs and eventual practices of SMTs. Furthermore, many who choose teaching as a career do so because of positive experiences they had as a student (Pajares, 1992). Therefore, they are often poor agents of social change in education, because they are unable and unwilling to see a need for change in a system that requires reform (Pajares, 1992). It is unlikely that students consciously and methodically mimic their teachers' actions. Rather, they tend to implicitly recall classroom environments, which leads to their perception of what acceptable behaviors are in the classroom (Nespor, 1987). Similarly, Mewborn and Tyminski (2006) noted that students acquire notions of *good* and *bad* teaching based on how particular pedagogical practices have affected them personally. Therefore, the apprenticeship of observation might simply involve future SMTs employing the teaching methods that they perceived to work best for them, not necessarily all of the teaching methods they have experienced.

The apprenticeship of observation can be particularly damaging to the development of pre-service SMTs at the college level if their math instructors do not model effective pedagogical skills. Traditionally, universities tend to recruit mathematicians to comprise their math faculty as opposed to experts in math education (Kilpatrick, 1992). Thus, their teaching practices are often criticized as being overly traditional and lecture-based (Schumacher & Kennedy, 2008; Menges, 2000; CBMS, 2000) since most have never had any pedagogical training (Oleson & Hora, 2012; Boice, 1992). Menges argued that university faculty "fail to use demonstrably effective teaching methods and other data-based information about teaching" (p.7). According to the Conference Board of Mathematical Sciences (CBMS), many university math instructors do not have a vested interest in math education, nor do they have the background training that allows them to model effective pedagogy. Thus, "Students often emerge from their undergraduate experiences with, at best, an unarticulated sense of what it means to be a mathematician" (p. 141). They reported that this is often due to the teaching and learning environment of the typical undergraduate classroom, where "chalk and talk are the primary instructional media" (p. 142). Therefore, it has been suggested that learning to teach mathematics requires pre-service SMTs to overcome the limits of their first-hand experiences as students (Buchmann & Schwille, 1983). Said Ball (1996) of this challenge, "There is as much to unlearn as there is to learn, and what there is to learn is complex and underdeveloped" (para. 11).

The apprenticeship of observation is often *blamed* for the self-perpetuating cycle of ineffective traditional teaching practices. However, it is important to note that this same model should hold true for teachers who had positive experiences as a student (i.e. those who may have learned from an effective teacher who used reform-based methods (Mewborn & Tyminski, 2006)). Therefore, it would be irresponsible to suggest that the apprenticeship of observation is purely negative. Ball (1988) argued that many pre-service teachers enter teacher education programs with ideas and perceptions that do not need to be challenged or altered, but which teacher educators must extend. Furthermore, Lortie (1975), himself, cautioned educators not to over-generalize the effects of the apprenticeship of observation, stating that it would require complex research to confirm his analysis. Mewborn and Tyminski agreed that over-generalization would not allow any explanation for the reforms in instructional practices that *have* taken place.

Formal Education Experiences

Most SMTs (about 76%) have earned a traditional university undergraduate degree in math or math education (Smith, 2013). Banilower et al. (2013) reported that the mathematical preparation (based on college coursework completed) of SMTs is typically good, noting that approximately two-thirds of SMTs have completed or nearly completed math coursework in all seven areas recommended by the NCTM (algebra, geometry, probability, statistics, calculus, number theory, and discrete mathematics).

SMTs are also typically required to obtain teaching licensure before entering the classroom. There are multiple paths to doing this. Smith (2013) reported that 52% of SMTs gained their teaching credential through their undergraduate degrees, 21% through post-baccalaureate credentialing programs, and 21% through master's programs that provided a teaching credential. Only 6% of SMTs have no formal teacher preparation.

Regardless of the path taken to licensure, most SMTs are generally prepared through a combination of math content courses and general education pedagogy courses. Some would argue, however, that the formal education of SMTs through university preparation programs does little to offset the apprenticeship of observation and other cultural influences on SMTs' eventual practice (Kennedy, 1999; Morris, Hiebert, & Spitzer, 2009; Borko et al., 1992; Cole & Knowles, 1993; McDiarmid, 1990; Scherff & Singer, 2012). For example, Kennedy (1999) argued that teacher education programs are weak interventions on already learned knowledge. Due to competing demands and pressures, prospective teachers only attend to some elements of what they are being taught and ignore others (Borko et al., 1992) because they do not see the relevance or the immediate need for the knowledge (McDiarmid, 1990). The theories that pre-service teachers learn about in their teacher education programs often bump up against their practical experiences (Scherff & Singer, 2012). Cole and Knowles (1993) suggested that teachers leave college "ill-prepared for the working realities of schools and for the overall complexities associated with teaching and the roles of teachers" (p. 469). Morris et al. (2009) argued that it is simply unfair to expect new graduates to enter the classroom as expert teachers. Instead, there is a tremendous learning curve they must undertake. "Teaching requires improvisation, conjecturing, experimenting, and assessing. Teachers must be able to adapt and develop practice" (Ball & Cohen, 1999, p. 10). Borko et al. summarized:

> It will never be possible, within the constraints of a single mathematics methods course or even an entire pre-service teacher preparation program, to enable prospective teachers to learn all that they need to know and believe about mathematics and mathematics pedagogy in order to teach effectively. (p. 221)

College coursework. The relationship between mathematical content knowledge, pedagogical knowledge, and student achievement was not the focus of this study. However, participants were asked to distinguish between the potential influences on their pedagogical practices that might stem from their experiences in college courses that were specifically aimed at developing these various areas of knowledge. Therefore, it was important to establish a context between the perceived importance of the two domains that typically comprise the preparation of SMTs (content knowledge and pedagogical knowledge).

Much research exists concerning the two coursework domains and their perceived importance concerning the effective development of SMTs (Darling-Hammond, Wise, & Klein, 1995; Shulman, 1986; Ferrini-Mundy, Floden, McCrory, 2008; Cummings, 2010; Monk, 1994; Rowan, Chiang, & Miller, 1997; Begle, 1979; Cavanagh, 2009; Anderson, 1989; Kennedy, 1999). As previously mentioned, Shulman (1986) provided a summary of how the balance between the emphasis of content knowledge and pedagogical knowledge has shifted over time, thus leading to his recommendation of emphasizing PCK. Ball, Thames, and Phelps (2008) examined two main tracks for math education curriculums. The traditional track involves light coverage of school mathematics (the math that future teachers will teach to their students) plus additional advanced math courses, whose content is above and beyond what would be taught to secondary students. A second track, the one endorsed by Ball et al., involves deeper coverage of school mathematics and an emphasis on PCK. However, they noted that this is not a common curriculum at most universities. Therefore, general coursework still exists that specifically addresses content knowledge and pedagogical knowledge individually.

Because most SMTs have completed degrees in the content they specifically teach, their content knowledge is rarely critiqued (Ferrini-Mundy et al., 2008). Similarly, Cummings (2010) reported that novice SMTs indicated feeling most prepared in math but least prepared in pedagogy. Darling-Hammond et al. (1995) argued that the volume of education coursework completed by SMTs correlated more with teaching effectiveness than did the volume of math courses completed. These arguments would suggest that teacher preparation programs need greater emphasis on general pedagogy courses.

Other research (Monk, 1994; Rowan et al., 1997) has argued that math content courses are of greater importance, suggesting that there is a correlation between teachers' math abilities and student achievement. However, simply compiling credits in math coursework does not necessarily lead to stronger math content knowledge for SMTs (Monk, 1994; Begle, 1979; Cavanagh, 2009; Anderson, 1989; Kennedy, 1999).

Criticism exists concerning the manner in which math content courses are taught at the college level. As previously mentioned, the teaching effectiveness of university math instructors is often questioned. Furthermore, Borko et al. (1992) argued, “The mathematics courses taken by mathematics majors during their first 2 years of university study typically do not stress meaningful learning of mathematics. Rather, they emphasize rote learning of numerous computational techniques” (p. 271). Prospective SMTs fail to understand the connections between the advanced math courses they take in college and the topics of school algebra they will eventually teach (CBMS, 2000). Anderson (1989) noted that the SMTs he has encountered “know lots of facts, definitions, and algorithms, but not very much about the relationships that they will need to master in order to teach well” (p. 98). Ball et al. (2008) provided the following summary:

> Unfortunately, subject matter courses in teacher preparation programs tend to be academic in both the best and worst sense of the word, scholarly and irrelevant, either

way remote from classroom teaching. Disciplinary knowledge has the tendency to be oriented in directions other than teaching, toward the discipline—history courses toward knowledge and methods for doing history and science courses toward knowledge and methods for doing science. Although there are exceptions, the overwhelming majority of subject matter courses for teachers, and teacher education courses in general, are viewed by teachers, policy makers, and society at large as having little bearing on the day-to-day realities of teaching and little effect on the improvement of teaching and learning (p. 404).

In general, measuring SMTs' math content knowledge is difficult. Typically, this has been done through simply analyzing their degrees, counting the number of math courses they have taken, or analyzing their scores on licensure exams. However, none of these suffice as accurate measurements of knowledge for teaching (Ferrini-Mundy et al., 2008). Furthermore, pure pedagogy courses may lack the PCK coverage pre-service SMTs need (Cochran-Smith, & Fries, 2005; Cummings, 2010). This separation between theory and practice has traditionally been a major critique of teacher preparation programs (Darling-Hammond, 2006).

To help bridge this separation it is common for many math education programs to meld the two domains of coursework by requiring methods courses specific to math education, thus providing a potential source of PCK for pre-service SMTs. As previously mentioned, 77% of SMTs have completed such a course (Whittington, 2002). The manner in which these courses are typically offered, however, has been criticized. Despite recommendations such as a team-teaching effort (contributions from both math instructors and education instructors) (Zeichner, 1996), methods courses for pre-service SMTs are generally offered only by the mathematics department (Cummings, 2010). The courses are normally taught by mathematicians who, as previously mentioned, often lack effective pedagogical skills and typically have little vested interest in math education. Thus, the potential effectiveness of these methods courses can be questioned.

Despite the criticisms of the effectiveness of teacher education programs concerning the development of prospective SMTs, various domains of pedagogy preparation could potentially serve as influences on the eventual practices of SMTs. These include classroom management, assessment practices, and use of technology. As discussed below, coursework in these domains might be spotty in teacher preparation programs, yet research has suggested that skills in these areas are vitally important to effective teaching. Furthermore, some of these skills are often emphasized for in-service teachers through PD opportunities.

Classroom management. Classroom management skills have been identified as some of the most valuable skills a teacher can have (Landau, 2001; Good & Brophy, 2002; Wang, Haertel, & Walberg, 1994; Oliver & Reschly, 2007). Torff and Sessions (2009) reported that principals identified deficiencies in classroom management skills as the primary threat to teacher ineffectiveness. Classroom management training for teachers has been shown to improve confidence levels (Gulbrandson, 2008) and has been directly correlated to student gains in standardized test scores (Gottlieb & Polirstok, 2005). Yet, courses devoted solely to classroom management are rarely provided in teacher education programs (Jones, 2006; Landau, 2001). Programs that do not require such a course might sprinkle in classroom management principles into another education course, however, the emphasis in such cases is insufficient and the content is normally taught by a teacher whose primary area of expertise is in a different domain (Landau, 2001). Furthermore, the content taught might only reflect the personal beliefs of the instructors, developed through their own experiences, as opposed to research-based content (Dunn, 2009).

Assessment. Strong formative assessment practices that promote mastery learning have been shown to produce significant learning gains for math students (Black & Wiliam, 1998; Meisels, Atkins-Burnett, Xue, Nicholson, Bickel, & Son, 2003). The use of frequent assessments is a hallmark of education systems in countries that typically outperform the U.S. (Tucker, 2011). Traditionally, however, assessments such as pop-quizzes or final exams or the threat of a failing report card have only been used as an attempt to motivate students (Stiggins, 2005). Rick Stiggins, founder of the Assessment Training Institute, promotes assessment *for* learning, as opposed to assessment *of* learning. He cites the proper use of formative assessment by teachers as a key facet in promoting achievement gains. According to Smith (2013), 64% of SMTs indicated that they were well prepared to monitor student progress during a unit and 71% indicated they were well prepared to assess student understanding at the conclusion of the unit. However, Greenberg and Walsh (2012) of the National Center for Teacher Quality (NCTQ) reported that teacher preparation programs in the U.S. are not providing sufficient training for pre-service teachers in the proper use of assessment. They analyzed three domains of assessment preparation for pre-service teachers (assessment literacy, analytical skills, and instructional decision making). They reported that 52% of secondary teacher preparation programs were adequate or partially adequate in their coverage of assessment literacy. However, for the analytical skills domain and instructional decision domain only 9% and 13%, respectively, were deemed adequate or partially adequate. They summarized that teacher preparation programs are only addressing the use of traditional tests of assessment, as opposed to formative assessment *for* learning, as endorsed by Stiggins.

Even considering this criticism of teacher preparation programs, research has shown that training (outside of undergraduate courses) in formative assessment use for mastery learning can be effective. For example, Verdinelli and Gentile (2003) found that in-service teachers who participated in a master's level course on the assessment strategies for mastery learning, including testing and grading techniques, had positive changes in their beliefs toward assessment for mastery learning and were likely to incorporate these foundations in their teaching methods.

Use of technology. NCTM and NCATE standards for SMTs list the use of appropriate technologies as a key component in developing student learning. The use of technology in the math classroom has been shown to improve students' conceptual understanding (Rakes et al., 2010). Banilower et al. (2013) reported that 66% of SMTs use some form of instructional technology at least once a week, the graphing calculator being the most frequent example. Yet, only 11% of SMTs reported using internet resources at least once a week. Keating and Evans (2001, as cited in Wetzel, Foulger, and Williams, 2008), found that pre-service teachers felt comfortable with technology in their schoolwork and daily happenings but expressed concern about using technology in their future classrooms. Whittington (2002) reported that 77% of SMTs felt adequately qualified to use technology in their instruction, yet this was mostly for drill and practice. Fewer than one-third of SMTs felt prepared to have students using technology for general reference, data acquisition, or collaborative projects.

To address this concern, Mishra and Koehler (2006) built on Shulman's notion of PCK to coin the phrase "technological pedagogical content knowledge" (TPCK), which addresses the phenomenon of teachers integrating technology into their pedagogy. They argued that this was an important and under-appreciated facet of teaching.

Due to calls to include more technology in the math classroom, it is suggested that SMTs need more training in this area (Whittington, 2002), either through their formal coursework in college or through PD opportunities. Wetzel et al. (2008) suggested that educational technology courses in teacher preparation programs should not stand alone. Instead, instructional technology should be addressed at the program level and emphasized throughout a teacher's preparation.

Field experience, practicums, and student teaching. Professional field experience (including practicums and student teaching experiences) is considered to be a critically important part of teacher preparation (Zeichner, 1996; Darling-Hammond, 2006; Wilson, Floden, & Ferrini-Mundy, 2002; Frykholm, 1995) and is consistently valued highly by pre-service teachers (Le Cornu, 2012; Tisher, 1990). For prospective SMTs it has a profound effect on their understanding of how to teach math (Peterson & Williams, 2008). Time allocated to field work in teacher education programs has increased in recent years (Wilson et al., 2002). Bryan and Abell (1999) argued, "The heart of knowing how to teach cannot be learned from coursework alone. The construction of professional knowledge requires experience" (p. 121). Darling-Hammond (2006) suggested that teacher preparation programs need to include extended clinical experiences that are "carefully developed to support the ideas and practices presented in simultaneous, closely interwoven course work" (p. 41). These clinical experiences must expose pre-service teachers to the complex nature of the classroom and provide opportunities to experiment with alternative approaches, share their experiences, and learn from their peers (Harding & Parsons, 2011).

While it is widely agreed that field experiences for pre-service teachers are important, there have been multiple criticisms of the traditional model for structuring them. According to Zeichner (2010), "The disconnect between what students are taught in campus courses and their opportunities for learning to enact these practices in their school placements is often very great" (p. 91). Instead of considering the best environment for the development of the pre-service teacher, the availability/willingness of a cooperating teacher and administrative considerations often determine where pre-service teachers are placed (Zeichner, 1996; Darling-Hammond, 2006). Furthermore, the traditional view of field experience involves the cooperating teacher and cooperating school simply providing a place for pre-service teachers to practice teaching. These cooperating teachers are provided little or no training for their role, nor are they typically relieved of any of their regular duties at school to provide extra mentoring time with their mentee (Zeichner, 1996; Atputhasamy, 2005). Novice teachers often feel vulnerable in their new role, caught between wanting to appear capable of doing things on their own and wanting/needing assistance from their mentor teacher (Scherff & Singer, 2012). Traditional field experiences do not provide the novice teacher with the type of preparation and support they need (Zeichner, 2010). They generally focus only on the immediate performance of the novice teacher and fail to develop long-term mentalities of professional growth (Zeichner, 1996).

Typically, pre-service teachers are placed with only one cooperating teacher, thus limiting their experience (Zeichner, 1996). It has been shown that cooperating teachers have a significant influence on pre-service teachers' instructional practices (Frykholm, 1995). However, while the apprenticeship of observation can certainly develop in this relationship, there is research that suggests pre-service teachers do not necessarily mimic the pedagogical practices of their cooperating teachers. Scherff & Singer (2012) found that pre-service teachers frequently criticize their cooperating teachers' practice and/or students' behavior without a full understanding of the contextual factors and theories at play. When pre-service teachers are at odds with the practices of their cooperating teachers, they may revert back to the teaching practices most familiar to them; the way they were taught (Darling-Hammond, 2006; Cavanagh & Garvey, 2012). Thus, the apprenticeship of observation can work on two levels during field experiences. Observation of a new teacher and new practices can have an effect on a novice teacher's development (i.e. they may begin to use strategies learned from their new cooperating teacher), or this new observation could merely promote strategies learned in the past. Either way, if these clinical placements simply reinforce past experiences they are likely to position student teachers as passive receivers rather than co-creators of knowledge about teaching (Darling-Hammond, 2006).

Another factor that can potentially play a role in the overall development of pre-service SMTs during field experiences is the triad relationship between the university (including the faculty member assigned as the pre-service teacher's supervisor) the cooperating school (including the cooperating teacher) and the pre-service teacher. This facet of the pre-service teacher's preparation has been viewed as inconsistent (Zeichner, 1990; Atputhasamy, 2005). Traditional supervision of student teachers by their university supervisors is predominantly evaluative of specific observable skills (Le Cornu & Ewing, 2008). Too much attention is typically given to classroom management and organization (Goos, 2008). Furthermore, university supervisors tend to give little recognition to the cooperating teacher (Atputhasamy, 2005).

Field-based teacher education (including pre-service teacher supervision) in many teacher education programs is considered second-class work (Cuenca, Schmeichel, Butler, Dinkelman, & Nichols, 2011). Thus, making visits to student teachers becomes tedious and time consuming for university faculty members who typically have other priorities. Since visits to the classroom become infrequent, there is generally a weak relationship between schools and universities in their efforts to develop pre-service teachers (Atputhasamy, 2005; Curenca et al., 2011). Furthermore, there is lack of training for faculty to adequately serve in a supervisory role (Wilson, 2006).

Cavanagh and Garvey (2012) suggested a system where “pre-service teachers collaborate and support each other and supervision is conceived primarily as facilitating a reflective practice” (p. 59). Yet, pre-service teachers have a limited opportunity and limited support to explore, discuss, and reflect on their teaching (Sim, 2006; Cavanagh & Garvey, 2012). Supervision of student teachers should be based on the notion of *educative* mentoring, which is designed to purposefully challenge pre-service teachers’ existing beliefs and practices (Feiman-Nemser, 2001). This is accomplished through prolonged interactions and extensive classroom observations by university supervisors. Overall, Smits (2010) recommended viewing field experiences as “heightened opportunities for the practice of inquiry about learning and teaching, rather than just practicing teaching” (p. 54). Bullock and Russell (2010) proposed that teacher educators have honest and open conversations with prospective SMTs about the limitations of the apprenticeship structure of field experience, “accept[ing] field experience for what it is and what it cannot be” (p. 98).

Despite the criticisms of the traditional field experience models, Darling-Hammond (2006) provided a positive outlook on the progression in this area, citing the emergence of models involving clinical work throughout the entire teacher preparation program and exposure to multiple cooperating teachers. Many of these new models feature calculated placements for pre-service teachers that specifically consider their personal characteristics, the diversity of students, the characteristics of the communities and schools they will eventually teach in, and the particular types of practice they will need in these diverse environments. Furthermore, progress has been made in the developing of relationships between university programs and their partner schools used for field experience placement.

In-Service Experiences

It is widely accepted that beginning teachers fresh out of a teacher preparation program are not expected to be master teachers right away (Borko et al., 1992; Ball & Cohen, 1999; Morris et al., 2009; Cole & Knowles, 1993; Bullock & Russell, 2010; Scherff & Singer, 2012; McDiarmid, 1990; Kennedy, 1999). Effective teaching generally requires continuous adaptation and professional growth. Many potential factors can influence in-service SMTs' instructional practices. The following sections analyze several potential influences identified for this study (via research analysis, professional collaboration, and personal experiences/observations of the researcher). Although these potential influences cannot be specifically placed into mutually exclusive categories (i.e. there are certainly areas of overlap and multiple ways to interpret them), they have been divided into the following four categories for analysis: professional development opportunities, collegiality, policy considerations, and student/teacher characteristics.

Professional development opportunities. Professional development (PD) could be thought of as a blanket term that encompasses nearly all forms of professional growth for a teacher. However, for the purpose of this section, PD will refer to coursework/degrees beyond undergraduate work and the specific opportunities that are available to SMTs via workshops, seminars, conferences, etc.

According to the National Science Board (2012), 54% of SMTs in 2007 had a master's degree. This was an increase from 2003, when only 48% had a master's degree. It is important to note that attainment of such a degree (or specific coursework leading up to the advanced degree) could certainly be an influence on pedagogical practices, yet any direct effects that a master's degree may have on SMTs' instructional strategies will not be specifically addressed here. Instead, this section will focus on PD opportunities traditionally offered within a school district.

Multiple forms of PD exist for teachers. Research has suggested that PD can be quite effective in preparing SMTs to elicit student achievement (Banilower, Boyd, Pasley, & Weiss, 2006; Garet, Porter, Desimone, Birman, & Yoon, 2001; Sample-McMeeking, Orsi, & Cobb, 2012). Guskey (2000) asserted that "one constant finding in the research literature is that notable improvements in education almost never take place *in the absence* of professional development" (p. 4). Weiss et al. (2003) found that PD provides a measurable, but not overly significant, influence on teachers' instructional strategies. They estimated that 31% of the mathematics and science teachers nationally attribute their selection of instructional strategies, at least in part, to their professional development activities. As previously mentioned, Whittington (2002) and Smith (2013) reported fairly substantial participation in PD by SMTs, mostly in the areas of technology integration, inquiry/investigation-oriented teaching, student thinking, student assessment, differentiated instruction, teaching students with special needs, and developing personal mathematical knowledge. However, of the SMTs participating in the various areas of PD, few reported actually making instructional strategy changes based on what they learned (Weiss et al., 2003). The most influential area of PD was technology integration, yet less than half reported changes in their teaching from this PD. In all other areas, less than one fourth reported instructional changes attributed to the PD opportunities.

Research exists that identifies various shortcomings of PD implementation. PD experiences provided by school districts are generally chosen by the administration, providing little voice to the teachers who are supposed to benefit from it, which leads to low personal investment on their part (Sample-McMeeking et al., 2012). Furthermore, PD experiences are only sometimes related to a teacher's specific content area, and are often implemented with a disconnect between the researcher and the teacher (Bishop, 1992). What teachers learn from PD experiences is often determined by their personal and professional histories (Ball, 1996). Stigler and Hiebert (2004) suggested that most of the content learned by teachers in PD never makes it to the classroom. Through interviews of SMTs and video analysis of their classroom instruction, they found that even though teachers reported use of content learned during PD experiences, their actual classroom practice did not reflect implementation. This is often the case for PD opportunities that are structured as one-time experiences (e.g. one day, one workshop, one meeting, etc.) where teachers don't have ample opportunity to further develop what they learned for actual implementation (Chappuis, Chappuis, & Stiggins, 2009; Ball, 1996). The most effective professional development models are thought to be on-site, job embedded, and centered on active learning (Chappuis et al., 2009). They should involve follow-up activities, usually in the form of long-term support, coaching in teachers' classrooms, or ongoing interaction with colleagues (Chappuis et al., 2009; Ball, 1996).

Other potential influences on the instructional strategies of SMTs through PD could include post-graduate support from their university or teacher preparation program. Also, other support networks for SMTs exists. The Noyce Foundation, for example, provides funding and PD opportunities for the training and retention of teachers in the STEM fields.

Collegiality. According to the NCTM (n.d.), SMTs should collaborate with each other to observe, analyze, and discuss teaching and students' thinking. This is a powerful, yet neglected, form of PD (NCTM, n.d.). Whittington (2002) reported that 49% of SMTs meet regularly with colleagues to discuss math teaching issues. Similarly, Smith (2013) reported that 75% of SMTs had participated in a PLC during the past three years. However, only 12% of math and science teachers in the nation indicated that their collaboration with other teachers influences their selection of content (Weiss et al., 2003). Furthermore, only 18% are directly influenced in the instructional strategies and materials they select by their work with colleagues at their school (Weiss et al., 2003).

The emergence of PLCs is becoming common in schools (Chappuis et al., 2009). A learning community is a group of people "involved in some kind of activity that learn together and, more importantly, learn from each other" (Ponte, Zaslavsky, Silver, Broba, van den Heuvel-Panhuizen, Gal, Fiorentini, Miskulin, Passos, Palis, Huang, & Chapman, 2009, p. 197). A typical PLC involves teachers of a specific discipline collaborating to make decisions on content and lesson design. Davis et al. (2009) described the relations among learning community members as "a "collective we" rather than a "collection of me's"" (p. 155)." Kinzer, Virag, and Morales (2011) suggested that the success of a PLC for SMTs depends largely on its ability to establish flexible working protocols focused on mathematics learning. With these protocols in place, SMTs can reflect on the cycle of teaching and learning, and thus have the opportunity to improve lessons for subsequent instruction. Jaworski (2004) noted the importance of stability of membership in a PLC and activity which is sustained over time so that relationships among members can be enriched and members can begin to learn together and from each other.

While participation in PLCs (and the outcomes attributed to them) might be lower than ideal, research has shown positive effects. Hunter and Back (2011) argued that the practice of lesson study (a group of teachers collaboratively planning a lesson over a series of meetings and then analyzing the video-taped implementation of the lesson to make improvements for subsequent implementation) by teachers can indeed provide sustainable PD for teachers in the way of pedagogical practices. Although time intensive, commitment to lesson study promotes professional collaboration, thus developing a strong network of teachers working toward common goals.

One form of collegiality school districts often provide to novice teachers is some form of mentoring or coaching. Smith (2013) reported that 54% of SMTs had received some form of feedback from a mentor/coach in the past three years. Research on the effectiveness of such mentoring has provided conflicting evidence. Most claims for the effectiveness of peer coaching are anecdotal in nature, specifically in how it relates to students' mathematical achievement (Murray, Ma, & Mazur, 2008). Furthermore, the role descriptions of the mentor and mentee in most cases are ambiguously defined (Poglinco, Bach, Hovde, Rosenblum, Saunders, and Supovitz, 2003). Mentoring practices have been shown to promote the retention of novice teachers, yet may not support their development as a teacher (Wang & Odell, 2002). While supporters of reformed teaching suggest mentoring needs to focus on standards-based instruction, Wang and Odell found that most mentoring tends to focus on emotional and technical support of beginning teachers. Even so, they did argue that mentoring can result in novice teachers increasing their abilities to teach in a reform-based manner.

Neuberger (2012) argued that new SMTs who worked with a mentor to plan classroom lessons emerged with new beliefs about math education and these new beliefs were mirrored in the SMT's instructional strategies. Kohler, Crilley, Shearer, and Good (1997) reported that although more procedural change occurred during peer coaching than when teachers worked independently, teachers questioned the effectiveness of the instructional innovation that they were implementing under the guidance of peer coaches. On a positive note, however, they reported that peer-coaching activities did promote a high level of student engagement in learning. SMTs participating in Murray et al.'s (2008) study reported benefits of peer mentoring (e.g. opportunity to share ideas, techniques, and strategies; communication and support from colleagues), yet they also reported barriers (e.g. scheduling issues, physical distance from their mentor).

Finally, another form of collegiality that exists amongst teachers is participation in professional organizations. For example, The NCTM website advertises nearly 80,000 members. NCTM members have access to the following benefits: award-winning journals, free classroom-ready activities, member-only online teaching resources, discounts on NCTM resources and professional development, member-only grant and scholarship opportunities, advocacy, networking and volunteer leadership opportunities, free access to NCTM's jobs online center, and special offers on insurance plans. Another common professional organization for teachers is the National Education Association (NEA), whose website advertises 3.2 million members (NEA, n.d.). Similar to NCTM membership, the NEA advertises a multitude of membership benefits. Both NCTM and NEA websites offer resources for teaching strategies, classroom management, etc. Also, both offer conferences for members. Smith (2013) reported that 39% of SMTs had attended a national, regional, or state teacher association meeting during the past three years.

Policy considerations. Multiple policies at the district, state, or national level can have an effect on the pedagogical practices of SMTs. These can include state and/or national standards, curriculum guidelines, administrative influences, teacher evaluation systems, parental influence, and the physical environment of a classroom. Several of these potential influences are addressed in this section.

Standards. Ideally, SMTs would begin the first day of a school year with a clear-cut vision of exactly what was going to be taught that year and how it was going to be done. State and/or national standards are provided as a guideline for SMTs to build their long-term curriculum plans. NCATE and NCTM standards for SMTs suggest that these standards must be addressed when planning a curriculum. To accomplish a standards-based approach, many teachers use what is known as *backward design* (Wiggins & McTighe, 2005). This involves the process of first identifying learning goals (based on the standards), then determining levels of achievement (often outlined by benchmarks), and finally designing lessons and shaping pedagogical strategies that aim to accomplish the learning goals. This design is referred to as *backward* because it challenges the traditional method of curriculum planning, which starts with a list of topics to be covered and then proceeds into teaching these topics with no real destination in mind (i.e. no learning goals have been identified).

While NCATE and NCTM promote the use of standards-based teaching in mathematics, research addressing the prevalence of SMTs actually implementing it is somewhat slim. Weiss et al. (2003), however, found that state and district curriculum standards were the number one factor influencing SMTs' content selection. However, they reported these standards were rarely influential in SMTs' choice of instructional strategies. Similarly, Smith (2013) reported that only 24% of SMTs indicated they have strong control over the content they teach, yet 72% indicated strong control over the teaching techniques they employ. This would suggest that SMTs view the standards as highly influential concerning content selection, but much less influential concerning teaching practices. With the recent adoption of the CCSS for mathematics in nearly all states, it will be interesting to monitor new research that addresses this facet of math education.

Curriculum. Traditionally, it has been taken for granted by administrators, teachers, and parents that a textbook will be selected for a particular math class, since there exists an assumption that mathematics learned in the secondary classroom is learned from a textbook (Ewing, 2006; Remillard, 2005). Ball and Cohen (1996) described textbooks and other curriculum materials as "the stuff of lessons and units, of what teachers and students do" (p. 6). Based on the prevalence of reform-based suggestions in curriculum and teaching, it is a common trend for school districts to mandate the use of a single curriculum (Remillard, 2005). Only 20% of SMTs reported strong control over the adoption of a textbook for their classes and 65% reported that only one textbook is used (Smith, 2013).

Traditionally, SMTs have viewed part of their job as covering the text (Romberg & Carpenter, 1986; Remillard, 2005). A great deal of class time is typically spent using the textbook (Nicol & Crespo, 2006; Smith, 2013). Typically, the textbook provides the framework for what is being taught, how it is taught, and the sequence in which it is taught (Nicol & Crespo, 2006; Smith, 2013). In this environment, the teacher simply acts as the mediator between the textbook and the students (Love & Pimm, 1996; Remillard, 2005). Teachers prefer texts that focus mainly on basic skills, which guarantees a stable quality of teaching (Pehkonen, 2004). However, SMTs often feel as though the textbook inhibits their freedom to make individual pedagogical choices, which can lead to feelings of guilt related to their overuse of the textbook, possibly showing concern about their professional competency (Pehkonen, 2004)

Similar research has focused on the concept that the content of a textbook can often be viewed as a replacement for the teacher. Teachers often feel dismissed from the responsibility of providing engaging lessons to students because of the routine approach to the teaching and learning of mathematics that textbooks provide (Lubinski & Jaberg, 1997; Harries & Sutherland, 1999). Because teachers often lack the expertise (Ewing, 2006) and the time (Harries & Sutherland, 1999) to create their own lesson structure, they often rely on textbook schemes to inform their practice, teaching primarily from exercises or chapters in textbooks with little or no conceptual framework for the mathematics being covered (Ewing, 2006).

McNaught, Tarr, and Sears (2010) specifically analyzed two aspects of curriculum materials (mostly the textbook, but also other supplemental materials) use by SMTs. These were content implementation and presentation implementation. They found that teachers rely heavily on curricular materials when choosing what content to teach. Furthermore, teachers' implementation strategies were also influenced by the instructional materials available to them (i.e. SMTs often follow the implementation suggestions of the author). Similarly, Weiss et al. (2003) indicated that the textbook was the second most influential factor in SMTs' selection of both content and instructional strategies.

Research has suggested that while SMTs rely on textbooks for instructional materials, these books often do not facilitate students in making mathematical connections, nor do they emphasize mathematics beyond basic skills (Vincent & Stacy, 2008; Lubinski & Jaberg, 1997; Schoenfeld, 2004; Handal & Herrington, 2003). Too often, curriculum guidelines emphasize content coverage and pacing rather than teaching for understanding (Handal & Herrington, 2003; Ball, 1996). This contributes to *shallow* teaching, especially for new teachers lacking strong mathematical backgrounds (Vincent & Stacy, 2008). Finally, even the style of language chosen by a textbook writer can influence how SMTs present a lesson. Herbel-Eisenmann (2007) found that many textbook "questions" were actually written as imperatives (e.g. "make", "draw", “use”, and “look”). This type of language places more emphasis on procedural tasks and less emphasis on students’ abilities to critically analyze a problem.

Administration. Research aimed at gauging the relationship between administrative influence (e.g. principal observations and involvement) and teaching practices has produced various results. According to Weiss et al. (2003) it is rare that SMTs select content or make pedagogical decisions based on the views of their administrators. However, other studies have shown principal involvement to have significant effects on learning. Robinson (2010) found that teacher perception of the leadership style and school climate correlated positively to math achievement. Likewise, Weller (2010) found potential correlation between principal walk-through observations and Math Measurement of Academic Progress (MAP) scores. Finally, Smith (2013) reported that 74% of SMTs indicated that principal support promoted effective instruction.

The methods of principal supervision of teachers have been often criticized. Administrators are intolerant of less-orderly classrooms and sometimes fail to provide teachers with materials or time to develop their practice (Ball, 1996). According to Torff & Sessions (2009), "Principals’ evaluations have been criticized as inherently subjective (Ambady & Rosenthal, 1993; Blumberg, 1980; Fant & Stevens, 1991; Frase & Streshly, 1994; Kerrins & Cushing, 2000; Machell, 1995; Stodolsky, 1984), open to bias based on gender and physical attractiveness (Ambady & Rosenthal, 1993; Lee, Smith, & Cioci 1993; Rinehart & Young, 1996), and limited by the fact that principals typically lack content knowledge in secondary subjects other than the ones in which they are certified" (p. 130). Nelson and Sassi (2006) suggested that principals need to learn what to look for when visiting math classrooms, moving away from traditional beliefs that equate math success solely with facts, rote knowledge the ability to calculate.

Teacher evaluation systems. As a corollary to administrative influences, many teachers' performances are evaluated for quality through the school districts' teacher evaluation systems. Yet, evaluation systems have been viewed as broken. In 2010, Secretary of Education Arne Duncan stated, "Our system of teacher evaluation… frustrates teachers who feel that their good work goes unrecognized and ignores other teachers who would benefit from additional support" (The New Teacher Project (TNTP), 2010, p. 1). TNTP described the processes involved in most evaluation systems as infrequent, unfocused, undifferentiated, unhelpful, and inconsequential. Similarly, Weiss et al. (2003) found that only 1% of SMTs cited teacher evaluation systems as influential in their selection of content and pedagogical strategies. TNTP noted that teachers' main responsibilities should focus on helping students learn, yet academic progress rarely factors into evaluations. Arguments exist about standardized tests, their importance, their validity, etc. These arguments encompasses an enormous body of research. Shulman noted that many teachers tend to deflect blame when it comes to low student achievement on standardized tests (Falk, 2006). While studying the assessment procedures at two New York law schools, he found that whenever a student failed to pass the Bar exam, the schools blamed themselves for not properly preparing the students. In K-12 education, however, Shulman argued that when students fail to reach proficiency on a standardized test, teachers tend to blame the test (as opposed to themselves). However, correlating effective teaching to student achievement is still an underdeveloped area of research. Agencies such as the Value-Added Research Center (VARC) continue to work on systems that can effectively measure teacher effectiveness through student achievement (VARC, n.d.).

Parental influence. Parental involvement can also influence the work of SMTs. While it has been suggested that teachers' perceptions of greater parental involvement correlate positively with student achievement (Gordon & Louis, 2009) or effective instruction (Smith, 2013), this is rarely cited as a strong influence on SMTs' content selection or instructional practices (Weiss et al., 2003). Parents tend to protest departures from customary practice (Ball, 1996). "Often teachers must defend to parents and administrators things they are trying even before they themselves are convinced or confident about them. A risky prospect at best, being in this position is understandably unappealing" (Ball, 1996, "What do Teachers Bring," para. 10).

Physical environment. Finally, Weiss et al. (2003) reported that 7% of SMTs cited the constraints of their physical environment (including lack of materials, budget issues, class enrollment size, class time length) in which they teach as an influential factor in their instructional strategies.

Student and teacher characteristics. Several aspects of student and teacher characteristics may play influential roles in SMTs' selection of content and instructional strategies. These include standardized test considerations; students' learning styles; teachers' learning styles; classroom demographics; college considerations; teachers' personal beliefs, experiences, and comfort levels with specific material; teachers' knowledge of and adherence to suggestions from classical and/or current research literature in math education; and teachers' prevalence in seeking out additional online or written resources for instructional practice. Several of these potential influences are analyzed here.

Standardized testing. A factor related to teacher evaluation systems that could potentially influences the content selection and instructional strategies of SMTs is the standardized testing of their students. Weiss et al. (2003) found that state and district tests, when combined with accountability systems (rewards and sanctions) for teachers and schools, ranked as the third most influential factor in content selection for SMTs. They reported that 43% of math lessons nationwide identified this as an influential factor. However, this factor was rarely cited in their study (only 7% of lessons) as being influential toward instructional strategy. When it was cited as being influential, however, they reported that the strategy of choice by SMTs was often one of drill and practice. This may lead one to assume that SMTs view standardized tests as a measure of students' computational fluency, as opposed to their conceptual understanding. Furthermore, Bowzer (2008, as cited in McNaught et al., 2010) reported that state testing programs often influence district-issued curriculum guides. Without specific curriculum guides SMTs may focus on certain content because they perceive it is the content likely to be on the standardized test (Stecher & Barron, 2001). According to Smith (2013), 16% of SMTs include practice for standardized tests in their daily lessons. Similarly, SMTs often give preference to content that they believe their students will need to know for college (McNaught et al., 2010).

Personal characteristics. Teacher characteristics, including their knowledge, personal beliefs, and experiences have been shown to be very influential concerning instructional strategy (Weiss et al., 2003). Included in this category for the Weiss et al. study were teacher background, preparation, and interest in the content area; teacher beliefs about content, and what students should know about the content; and teacher beliefs about student learning. Weiss et al. reported that teacher characteristics was the number one factor in teachers' selection of instructional strategies, indicating that 90% of lessons are influenced by these facets. To a lesser degree (28% of lessons), teacher characteristics were also influential in the selection of content.

Student characteristics, including their perceived ability, behavior, proficiency with the English language, and absenteeism were also shown by Weiss et al. to be an influential factors in instructional strategy (52% of lessons) and content selection (16% of lessons). Ball (1996) identified knowledge of students as essential to teaching for understanding. A criticism of U.S. math teachers, however, is that they tend to use the *pedagogy of poverty* approach when teaching mathematics (Haberman, 1991). This refers to a curriculum for underprivileged students that follows a fixed sequence, concentrating only on teaching basic skills, while de-emphasizing problem solving and reasoning (McKinney, Chappell, Berry, & Hickman, 2009).

Use of research findings. As previously mentioned NCATE and NCTM program standards suggest that SMTs demonstrate knowledge of research results in the teaching and learning of mathematics. Using research results to drive instructional strategies was an area conspicuously missing from the Weiss et al. (2003) study, although one could assume that this was included in her definition of teacher knowledge.

Although endorsed by NCATE and NCTM, accepting and using theoretical research results to drive instructional practices is difficult for teachers to do (Labaree, 2003). Teachers may view educational research as "theoretical fiddling while the classroom burns" (p. 18). For example, if a fight were to break out between two students the scholar may want to ponder the social, psychological, economic, or pedagogical reasons that lead to the fight, whereas the teacher would feel the immediate need to break up the fight, not having the luxury of time to theorize about the cause. In other words, teachers are more concerned about the immediate need for having things right in the classroom as opposed to having things straight in their minds. Furthermore, Labaree (2003) argued that regardless of how much data researchers provide or how effectively they make their arguments, teachers can almost always trump any research finding with a counter-example from their own experiences. "From the teacher perspective, researchers can say what they like about the nature of teaching and learning in general, but only teachers have the expertise to speak with authority about the teaching and learning of their own students" (p. 20).

Finally, a related potential influence examined was the prevalence of SMTs to seek out additional teaching resources above and beyond the district-issued curriculum materials. Smith (2013) reported that 56% of SMTs incorporate activities from other sources to supplement what their textbooks were lacking. According to Moore and Chae (2007), the internet has become a source of useful information to help teachers with a variety of tasks (e.g. lesson plans, classroom activities, student management techniques, student motivation techniques). However, they also reported that teachers do not often go beyond simple internet searches (primarily on Google) to investigate further resources, such as emotional or personal support; chat rooms; or shared stories, videos, or ideas that might help improve or critically reflect on their own practice.

Based on the rapid growth of the internet, it is not surprising that teachers are using greater number and wider range of internet resources than ever before (Perrault, 2007). However, she also reported evidence of underuse of online resources specifically designed to support teaching and learning activities (e.g., digital libraries, online periodical databases, and electronic discussion lists).

While research from 2007 would generally not be considered outdated for most facets of education, it certainly could be viewed as such when it comes to topics concerning the internet. Today, there are literally hundreds of websites (far too many to begin analyzing in this dissertation) devoted specifically to teaching and learning, many of which are focused solely on mathematics. The extent to which SMTs use these online resources is not readily evident.

Q Methodology

Q methodology first appeared in 1935. It was pioneered by British psychologist and physicist, William Stephenson. Although Q methodology is often considered a quantitative approach because of its use of factor analysis (Brown, 1996), its primary focus is on the subjective or first-person viewpoints of its participants (Watts & Stenner, 2012). While it has been identified as a qualiquantological tool (Stenner & Stainton-Rogers, 2004), it is important to note that Q does not incorporate data with enough depth or richness to claim connections to paradigms that are typically thought of as qualitative. It does, however, help dimensions of subjective phenomena to "emerge from the data in a manner that reflects a perspective intrinsic to the individuals" (Dennis & Goldberg, 1996, p. 104). Only subjective opinions are at issue in Q (McKeown & Thomas, 1988). A well-structured Q study reveals key viewpoints among its participants that can be understood holistically with a high level of qualitative detail (Watts & Stenner, 2012). Q uses personal perspectives to relay subjective responses, providing a picturesque view of these perspectives when organized into unique factors (Edwards, 2007).

Traditional survey methods involving factor analysis typically use the Pearson product-moment correlation coefficient (Pearson's r). This approach is commonly referred to as R methodology. Normally, R studies involve a large number of participants rating a small number of items on a Likert scale. The items are then measured for correlation amongst each other. Q methodology, however, can be considered an inversion of conventional factor analysis (Watts & Stenner, 2012; van Exel & de Graaf, 2005). The participants (not the items) are measured for correlation. Instead of having a large number of participants being tested on a small number of items, Q involves a small number of participants being tested on a large number of items. As opposed to a traditional Likert scale survey, the items in a Q study are not scored by the participant independently of each other. Rather, the participant is required to sort (rank) the items in relation to each other (e.g. from most desirable to least desirable). For example, if a soft drink company wanted to know more about its customers' drink preferences, it might contrive a taste-testing scenario where participants rank all of the drinks in order from most favorite to least favorite. This would give the company a more holistic view of soft drink preference than a taste-testing scenario that involved each drink being individually rated on a scale of preference. In this latter scenario, a participant may score all of the drinks as "good," which would not provide any further evidence of preference to the company.

Q methodology is a method of *impression*, as opposed to one of *expression* (McKeown & Thomas, 1988). "Under methods of *expression*, respondents are measured for traits, attitudes, and the like from an external point of view" (Kindle location 206). An example of this would be a traditional survey where participants rate individual items that are independent of each other. "With methods of *impression*, on the other hand, the personal, intraindividual significance of 'test stimuli' is of primary importance" (Kindle location 209). The more appropriate approach between the two is determined by the nature of the study. If the behaviors being measured are objective (e.g. height, weight), methods of expression are in order. If the focus of the study is on subjectivity (e.g. soft drink preference), then methods of impression are appropriate. Ernest (2001) provided the following summary:

> The traditional R-methodological approach to research is based on mechanistic and reductionistic principles that focus on the properties of the objects, items, or statements under investigation. In contrast, Q methodology explores a person's perceptions of the objects, as a person compares all the objects, items, or statements in relation to each other (p. 349).

According to Watts and Stenner (2012), "The R methodological system is not capable of defining specific individuals in a holistic fashion and so cannot facilitate a thorough comparison of their individual differences" (p. 22). This issue was the driving force behind Stephenson's invention of Q methodology. Watts and Stenner described Q as "an elegant and very effective methodological system" (p. 18). They also noted Q's flexibility, stating that it holds for almost any heterogeneous material. "You can give your participants just about anything – any set of stimulus you like – and they'll probably be able to place them in order of personal salience" (p. 18). Ernest (2001) agreed. "Whether a person is interested in investigating thoughts, feelings, attitudes, beliefs, values, likes or dislikes, all are subjective and amenable to study using Q methodology" (pp. 348-349).

Although strongly endorsed by several parties, Q methodology has also endured its share of criticism. van Exel and de Graaf (2005) noted that despite its long history, Q is still considered an innovative methodology. Thus, it is often considered suspect by many disciplines or journals. Replicability is the most important type of reliability for Q methodology (van Exel & de Graaf, 2005). The concern with Q, then, is whether or not the same condition of instruction will lead to reliable factors when administered to a different set of participants. The possibility of generalization of results has been questioned due to the small sample investigation of human subjectivity based on the sorting of items with unknown reliability (Thomas and Baas, 1992). In traditional quantitative research this would certainly constitute a reliability issue. However, in Q methodology this criticism is unwarranted (Thomas & Baas, 1992; Brown, 1980) since only a limited number of distinct viewpoints can exist on any one topic. Therefore, a well-designed Q sample of items will contain a wide range of existing opinions, thus revealing the possible perspectives present. In other words, obtaining a large sample size of participants is a non-issue.

In fact, in most Q studies the sample size of participants is typically smaller than the sample size of items (Brouwer, 1999). The aim is to have only four or five participants defining each anticipated viewpoint (factor), and typically only two to four (rarely more than six) factors emerge (van Exel & de Graaf, 2005). Statistically meaningful results can be obtained with as few as 12 participants (Barry & Proops, 2000).

Several other criticisms of Q methodology have emerged over time. For example, it has been suggested that the magnitude of the sorting task is above and beyond the cognitive ability of most people to perform adequately (Bolland, 1985). Similarly, some have criticized the Q-sort process for having too many categories and requiring participants to make too many and too fine distinctions among the items (McKeown & Thomas, 1988). Furthermore, critics have noted that during the sorting process participants are only allowed to place a select number of items into each scoring category, thus not allowing them to freely rank all items. (This sorting process will be further described in Chapter 3). Yet, of these criticisms, McKeown and Thomas rebutted, "…neither the reliability of the technique, nor the quality of the data are undermined by idiosyncratic sortings of the Q-sample" (Kindle location 341).

Q methodology was chosen in this study for multiple reasons. First of all, it has been shown to be a powerful and suitable methodology for exploring and explaining patterns in individual subjectivities (van Exel & de Graaf, 2005). Also, the requirement for only a small number of participants was attractive, especially considering that they did not need to be generated via a random sample. (Selection of participants will be addressed in Chapter 3). Furthermore, Q's method creates "forced choice" for participants, requiring them to prioritize some items over others, reducing the likelihood of reporting bias (Rimm-Kaufman, Storm, Sawyer, Pianta, & LaParo, 2006).

Q methodology has been used in multiple areas of educational research. For example, it was used to examine perceptions of pre-service and in-service teachers as to why they chose the teaching profession (Daniel & Ferrell, 1991); to measure teachers' priorities concerning disciplinary practices, teaching practices, and beliefs about children (Rimm-Kaufman et al., 2006); to examine teachers' attitudes toward inclusion of special education students (Elhoweris & Alsheikh, 2006); and to analyze teachers' perceptions of leadership in the classroom, school, and educational community (Edwards, 2007).

Participants in Q studies often indicate that they have enjoyed the process more than participation in traditional surveys (van Exel & de Graaf, 2005). The flexibility of Q is also attractive. For example, after sorting the items, participants have the opportunity to review and edit their sorts. Also, they have an opportunity to justify some of their selections based on open-ended response items (this will be addressed in Chapter 3). This allows for a greater sense of control amongst the participants, as well as a greater feeling of contribution to the study (van Exel & de Graaf, 2005). "Q sorting perhaps requires greater involvement than standard survey analysis, but apparently does so in a very pleasant and comprehensible manner" (p. 17).

Summary

This chapter has provided a review of the pertinent literature related to the potential influences on the teaching practices of SMTs. It has also provided a description of Q methodology and a rationale for why it is an appropriate tool for this research project. The literature review serves as a basis for the Q set of items that the participants sorted. Through the use of Q-mode factor analysis, these sorts helped identify and define the emergent factors (archetypes) that exist amongst SMTs concerning their perceptions of the influences on pedagogical practices. Chapter 3 will provide specific details concerning the methodology.

CHAPTER 3: METHODOLOGY

The purpose of this study was to explore the perceptions of Secondary Mathematics Teachers (SMTs) concerning the various influences on their pedagogical practices. Through the use of Q methodology the study addressed the following two questions.

1. What archetypes of SMTs exist amongst the perceptions of SMTs concerning the influences that affect teaching practices?

2. What differences (if any) exist amongst the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT?

Design

The strength of Q methodology is through abduction and discovery (Watts & Stenner, 2012), therefore this study did not involve the testing of a pre-determined hypothesis, rather it was exploratory in nature. Upon identifying a series of shared viewpoints amongst the participants, these factors were aligned with demographic information to make potential generalizations about their nature. The nature of generalizations that can be made from studies employing Q methodology are different from those employing R methodology. In R studies, the aim is to identify a group of variables that vary proportionately across a population of persons. The analysis is then focused on identifying underlying constructs in participants' response patterns. However, Stephenson argued that R methodology was not capable of defining specific individuals in a holistic fashion (Watts & Stenner, 2012). Thus, Q methodology was his solution to this problem. In Q studies, each factor "will potentially identify a group of persons who share a similar perspective, viewpoint or attitude about a particular topic, or who seem to be, in this context at least, of a similar *type*" (Watts & Stenner, 2012, p. 18).

To comply with federal guidelines and North Dakota State University policy, this study was submitted to the Institutional Review Board (IRB) for approval. IRB approval ensured compliance and the researcher took measures to ensure privacy and human rights of the participants involved. The following sections discuss the details of the Q study, specifically focusing on the construction of the sortable items (Q set), the composition of the participant pool (P set), and the analysis procedures used to identify emergent factors.

Q set. The Q set contained 41 items for each participant to sort. These items constituted a broad, comprehensive representation of the potential influences on SMTs' pedagogical practices, attempting to limit any redundancy or repetition, based on the literature reviewed in the previous chapters of this dissertation. Watts and Stenner (2012) noted that the perfect Q set is unattainable. However, this does not constitute a methodological problem in the same manner that it might in designing the scale of a traditional survey, since Q methodologists are not interested in predefining particular items. Instead, the goal was to create a Q set that was broadly representative of the entire opinion domain and then have the participants impose their own meanings to the individual items. It is recommended that the items of a Q set are better to be thought of as suggestions rather than statements with pre-determined meanings. This allows for meaning to be developed *a posteriori* as opposed to *a priori*, a defining feature of Q methodology (Watts & Stenner, 2012). Thus items in the Q set were intentionally designed to allow for varying interpretations by respondents. For example, the literature regarding teacher professional development (PD) indicates a great deal of variation in the nature of PD teachers may have experienced (Banilower et al., 2006; Garet et al., 2001; Sample-McMeeking et al., 2012; Guskey, 2000; Weiss et al., 2003; Whittington, 2002; Bishop, 1992; Ball, 1996; Stigler & Hiebert, 2004; Chappuis et al., 2009). Therefore, the item "My teaching practices are largely influenced by the way I have witnessed professional development teachers/presenters teach" would be expected to be perceived differently by different respondents (see appendix A for a complete list of items included in the Q set). Based on the recommendation of Watts and Stenner (2012), each item of the Q set was written so that it could not be analyzed individually, but rather in context with the rest of the items. Therefore, each individual item was intended to be *malleable*, such that each had some relevance to the topic, but only provided potential meaning when combined with the other items.

Creating the final Q set for this study was an intense process. First, a concourse of potential influences on teaching practices was developed to provide the framework for the Q set. Brown (1993) referred to the concourse as "the flow of communicability surrounding any topic" in "the ordinary conversation, commentary, and discourse of everyday life" (p. 94). The development of the concourse for this study aimed to include all of the relevant aspects of the topic at hand. It was to serve as the raw material for the Q set (Brown, 1993).

The researcher, along with members of the research committee, first identified broad domains of potential influences on the teaching practices of SMTs. These were the apprenticeship of observation, formal education/pre-service training, and in-service experiences. Each domain was then further examined to identify specific influences that may exist within them. The extensive literature review provided in Chapter 2 provides the details of this examination. Furthermore, the researcher conducted pilot interviews with practicing SMTs and held collaborative discussions with fellow teacher educators to provide additional insight about the nature of potential influences on teaching practices.

Finally, the researcher relied on his own experiences and observations to contribute to the concourse. Through four years of teaching in a high school math classroom and more than five years of working as a mathematics teacher educator in a university setting, the researcher has had extensive exposure to the various influences that exist concerning the teaching practices of SMTs. The position of teacher educator has provided a unique opportunity for the researcher to be exposed to both the teaching practices of the novice student teachers and to those of the veteran cooperating teachers. This position allows the researcher to experience first-hand the maturation and development of the novice teachers as they transition from life as a student to that of a teacher. Classroom observations and extensive conversations about teaching practices with both the student teachers and the cooperating teachers have provided valuable insight, which largely contributed to the development of the concourse. Along with this unique position, the researcher has gained much insight to the influences on teaching practices through the various workshops and presentations he has conducted with practicing teachers. All of these experiences contributed to the overall concourse development.

In most Q studies the concourse contains a large number of items in which a representative sample is drawn in order to establish the Q set that is eventually presented to the participants (Brown, 1993; Watts & Stenner, 2012). However, this was not the case with the current study. The concourse was not an exhaustive list of items, but rather a collection of thoughts and ideas that were used to generate the 41 specific items that would comprise the Q set. These items captured the full breadth of the concourse, while attempting to limit any redundancy (Watts & Stenner, 2012). The full Q set can be found in Appendix A.

P set. The participants for this study (P set) were practicing SMTs. They were purposefully recruited by the researcher based on their relationship, experience, and expertise with the topic at hand. It is important to note that the P set was not constructed via convenience sampling or random sampling (as might be the case in R methodology). Instead, participants were specifically chosen by the researcher based on their ability to possess a defined viewpoint that *matters* in relation to the subject at hand (Watts & Stenner, 2012). Since the Q set was designed to contain the full breadth of potential influences on teaching practices, the participants recruited for the study were SMTs who were believed to have the ability to provide relative input concerning most or all of the items in the Q set. As opposed to R methodology, Q allows the researcher to legitimately select a participant if it is believed this person will provide an interesting or pivotal point of view (Watts & Stenner, 2012). In this study, the researcher felt confident in his ability to make these selections for the P set based on his extensive experience and intricate knowledge of classroom practices employed by SMTs.

In R methodology, the number of participants is generally considered quite important for demonstrating the validity and reliability of any findings. In general, a high number of participants is desired. However, as previously mentioned, striving for a large P set in a Q study is not considered important. In fact, according to Watts and Stenner (2012), validity and reliability, as understood in R, are not applicable to Q. For example, an R-methodological scale or instrument is said to be valid if it can successfully measure what it claims to be measuring. Typically, large numbers of participants are required to show this. Consider the temperature reading of a thermometer. This number has meaning to us because we have many experiences with what that temperature feels like. Furthermore, specific reference points have been established concerning temperature (e.g. freezing point, boiling point, body temperature, room temperature, etc.). These experiences and reference points are necessary for us to make meaning of a single temperature reading. The same meaning must be established in an R study when measuring a certain variable. A single test score from a single participant would have no meaning because there is no criterion or no other scores to compare it against. However, if we have a large number of test scores from that particular variable we can begin to establish reference points or criterion of *high* or *low* so that one particular score will have meaning when compared to the established criterion. In order to do this, of course, we would need many scores. In Q, however, since there is no pre-established criterion for a person's own point of view (like there is for temperature), this concept of validity has little meaning (Brown, 1980). Watts and Stenner argued that this lack of focus on validity, however, does not stop Q methodologists from demonstrating that the method does indeed deliver what it claims to deliver (the captured viewpoints or perspectives of its participants). According to Brown (1980), the only issue of validity is whether or not the participant "is shamming or may be deceiving himself" (p. 175). For the current study, the inclusion of two conditions of instruction helped to mitigate this threat to validity. A person who might potentially provide socially acceptable responses instead of those that represent his true feelings will typically "give himself away" while operating under a secondary condition of instruction (i.e. one that does not represent his personal views, (Brown, 1980, p. 175)). Thus, the altering of the condition of instruction (inclusion of condition two) allowed for all potential viewpoints to be extrapolated from the participants.

According to Brown (1980), "Large numbers of persons are nowhere at issue since differences are among factor types, or among factors generated by the same person, rather than categorical aggregates" (p. 175). Therefore, obtaining large participant numbers for the current study was not considered important. Instead of creating a *purposeful* set of items and *representative* set of respondents (as would be the case in an R study), the current study established a *representative* set of items (Q set) and *purposeful* set of respondents (P set). Because Q methodology only aims to establish the existence of particular viewpoints and then eventually understand and compare them (Watts & Stenner), a large number or participants was not required. Again, those suspect of the small P set involved in Q methodology can be reminded that the participants in this model actually act as the variables and the items in the Q Set act as the participants. Thus, criticism of a small P set in a Q study would be equivalent to criticism of a traditional survey in an R study not containing enough items. This is not to say that the size of the P set is irrelevant (i.e. the study could not be conducted properly with only one participant), yet an appropriate number of participants for Q studies is typically measured in tens, not thousands.

Traditionally, it has been suggested that R studies involve at least two participants for every one variable analyzed, although more is typically considered better (Kline, 1994). Using this suggestion, the ideal number of participants for the 41 item Q Set in this study would have been 20. It is also important to note that since two separate conditions of instruction were used by each participant (i.e. each person was asked to sort the items twice), 20 sorts can be generated by only 10 participants. Any more than 20 sorts would violate Kline's ratio suggestion given above. In fact, using this ratio as a guide (and the concept that more is better in R studies), the inverted nature of Q would suggest that it is more appropriate to have *less* than 20 sorts than it is to have *more* than 20. Even when considering this rationale, it is still noted that certain journals or disciplines with strong familiarity to traditional quantitative methods might be suspect of the small P Sets involved in Q. In summary, it is suggested that the Q researcher not be overly concerned with the size of the P Set, yet a general rule is that it should be less than the Q Set (Watts & Stenner, 2012; Brouwer, 1999).

Description of Participants

The participants for this study were practicing SMTs. Twenty-two were invited to participate. All were currently teaching in the state of North Dakota. Of the 22 invitees, 19 responded (86.4%). Because recruitment procedures were designed to provide confidentiality to respondents, it cannot be determined which of the 22 invitees actually responded. Of the 19 respondents, 18 of them completed sorts for both conditions of instruction, whereas one participant completed only the sort for the first condition of instruction. Participants were also asked to provide demographic information (gender, age, years of teaching experience, years of math teaching experience, grade levels primarily taught, and highest degree attained (B = bachelor's, M = master's)). Table 1 depicts this information.

Table 1

Demographic Information of Participants

ID	Gender	Age	Teaching Experience	Math Teaching Experience	Grades Taught 5-8	9-10	11-12	Degree
1	Male	41-50	16-20	16-20		X		B
2	Male	41-50	16-20	16-20			X	M
3	N/A	N/A	21+	21+				M
4	Male	41-50	21+	21+		X		M
5	Male	51-60	21+	21+		X		M
6	N/A	31-40	11-15	11-15			X	M
7	Female	41-50	16-20	16-20		X		M
8	Male	41-50	21+	11-15			X	B
9	Female	51-60	21+	21+	X			B
10	Female	21-30	0-5	0-5	X	X	X	B
11	N/A	21-30	0-5	0-5		X	X	B
12	Female	41-50	21+	21+		X	X	M
13	Female	51-60	21+	21+		X		B
14	Female	31-40	11-15	11-15			X	M
15	Male	41-50	21+	21+			X	M
16	Male	21-30	6-10	6-10		X	X	M
17	Female	51-60	11-15	11-15		X		M
18	Female	41-50	21+	21+		X		M
19*	Female	31-40	11-15	11-15		X	X	M

*Only completed sort for Condition One

Recruitment procedures. The P set was comprised of SMTs who the researcher has met and/or worked with in professional settings over the past several years. The invitation to participate and supplying of access information for the Q study followed the guidelines offered by Dillman, Smyth, and Christian (2009). A short, personalized invitation email was sent to each of the 22 potential participants. Attached to this email was the official invitation letter, which contained information about the study and instructions for accessing the online Q sorts, and the informed consent document for the study. Copies of these can be found in Appendix B. To complement the email invitation, physical copies of the invitation letter and the informed consent document were also mailed to the potential participants at their school addresses. The researcher timed each mailing so that they would arrive on the same day as the email. Finally, each mailing included a $10 bill as a token of appreciation for participating. Dillman et al. reported that response rates from potential participants are generally higher when a financial incentive is presented to them up-front, as opposed to other incentives, such as promising them a chance to win a prize through a drawing of all respondents. This pro-active approach brings social exchange into play and encourages respondents to reciprocate by completing the sorts. Furthermore, inclusion of a financial incentive (and personalization of letters/emails) indicates that the respondent's opinions are highly valued, thus helping avoid the bystander effect (i.e. the potential reaction of a respondent that this request can be fulfilled by someone else, not me (Dillman et al., 2009)).

The study was open for nine days. As previously mentioned, there was an 86.4% response rate, which could certainly be considered adequate. It is important to note that in traditional R method surveys eliciting the most responses possible is a key concern. Although response rate is typically not of great concern in Q studies, the researcher strived for a high rate since only 22 invitations were sent out. The overall 86.4% response rate indicated that responses likely faithfully represented the variation sought by the purposeful recruitment procedures.

Instrument

Participants were provided a web link directing them to the online instrument which had been developed using Flash Q sorting software. Upon entering, participants were prompted to create a subject-generated identification code (SGIC) so that their sorts from condition one and condition two could be matched. Typically, a SGIC is used in longitudinal research to anonymously track research respondents over time (Yurek, Vasey, & Havens, 2008). Although the current study did not cover a large span of time, the SGIC used (a four-six character permutation of the first letter of the respondent's birth city, birth month number, number of older siblings, and middle initial) proved useful in matching each respondent's sorts.

As previously mentioned, each participant was asked to do two Q sorts. The first condition of instruction addressed the perceptions of influences on their own teaching practices, whereas the second condition of instruction addressed how they perceived the influences to affect the teaching practices of a typical SMT. The purpose of the two conditions of instruction was twofold. First, it provided a form of mitigation concerning the validity threat that would arise from a participant who may deceive himself by providing socially acceptable responses to condition one as opposed to truthful responses. Secondly, it allowed for eventual analysis of the potential differences between the two sorts, which addressed research question number two.

For each sort the 41 items were randomly displayed one at a time. In the first stage the software provided three "bins" into which each of the items could be dropped: *Least Influential, Neutral,* and *Most Influential*. The respondents had to click and drag each item into one of these bins before the next item in the Q set appeared. Once the respondents had categorized each of the 41 items into one of the three bins, they were then asked to further differentiate each category by placing the items into the sorting array shown in Figure 1. All 41items of the Q set were eventually placed into this array. Items placed toward the left side of the array represented those that were least influential, whereas items placed toward the right side of the array represented those that were most influential.

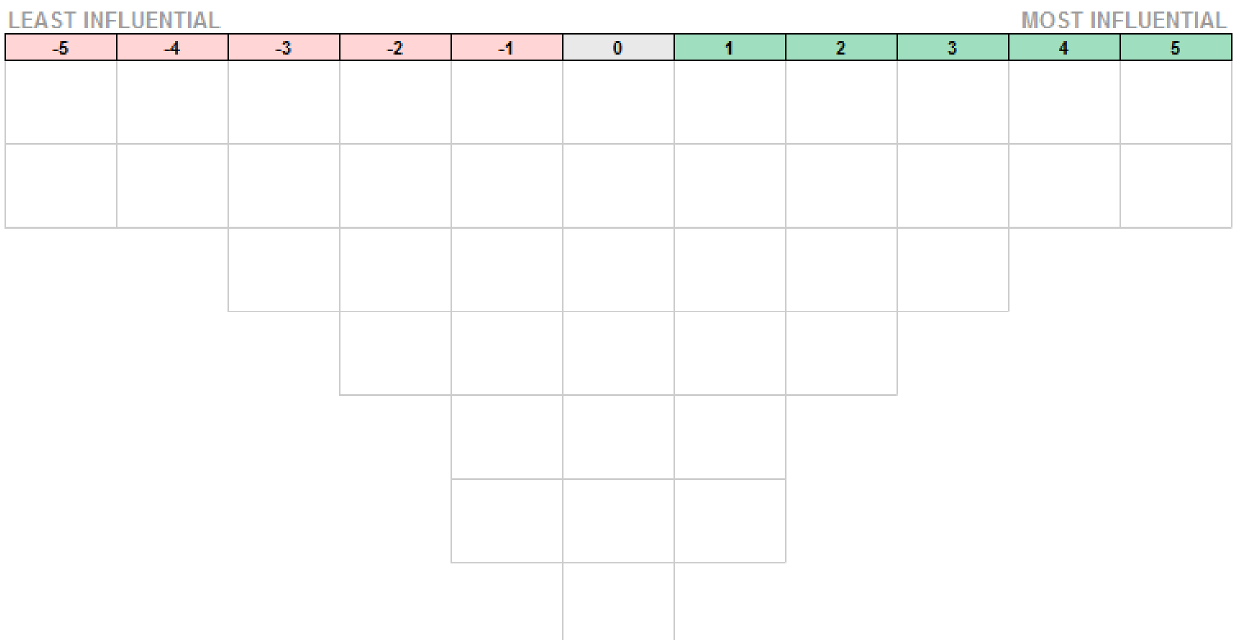

Figure 1. Flash Q sorting array

Starting with the *Most Influential* bin of items, participants were asked to choose the two items from that bin that were the most influential. These two items were to be placed into the two boxes on the far right of the sorting array (column 5). (Note: the order in which the items are stacked into a column is not taken into consideration in the analysis). Then they were asked to do the same with the two items from the *Least Influential* bin, placing these two items into the boxes on the far left (column -5). Moving back to the items in the *Most Influential* bin, they were to select the two remaining items that were most influential and place them into the two boxes in column 4. Then they were asked to do the same for the next two items from the *Least*

Influential bin, placing them in column -4. They continued this back and forth placing of items until all of the boxes were filled. Finally, once the array was complete, they had an opportunity to view the entire grid and make any changes to their sorts until they were satisfied.

After sorting the items into the array participants had the opportunity to provide open-ended responses justifying their selections of the two most influential items and the two least influential items. This was a critical part of the post-sort data gathering process because it allowed for a richer, fuller, more detailed understanding of each participant's Q sort (Watts & Stenner, 2012). The idea was to focus less on the ranking of the items and more on the reasons the respondents felt so strongly about these items. These open-ended responses, along with the demographic information collected, made factor interpretation easier and improved the quality of the overall findings (Watts & Stenner, 2012).

The process for the sort for condition two was completed in the same manner as described above. Only the initial instructions were changed to focus on what respondents believed about typical SMTs rather than themselves. After completion of the second sort, however, participants were asked to respond to two final open-ended items: a) "Were your sorts from Part 1 and Part 2 decidedly different? If so, please explain why." b) "In the following space, please feel free to provide any additional comments, suggestions or insight regarding the ideas presented in the statement cards you were asked to sort." While the purpose of the second item was to merely seek out any additional information that might be pertinent to the study, the purpose of the first item was to specifically gather data that could prove useful when addressing the second research question for this study concerning pluralistic ignorance.

Analysis

As previously mentioned, this study did not involve a hypothesis to be tested through confirmatory factor analysis. Instead, data from the Q sorts were analyzed using exploratory Q-mode factor analysis. This was completed by entering the data into PQMethod 2.33 (Schmolck, n.d.). Because Q-mode factor analysis necessarily requires interpretive, intermediate steps, a full description of the analytic process is provided in Chapter 4.

Assumptions and limitations. This study was reliant on the input of the participating SMTs. It is assumed that each participant provided accurate and insightful data. While there is no way to ensure this, the purposeful recruitment of individuals who would be forthright likely provided a group of participants who faithfully responded to the instrument. Great care was taken to ensure that the instructions for completing the Q sorts were detailed and descriptive. Also, the interface developed by the researcher on the Q Flash software was based on a template that was previously found to be user-friendly, therefore participants should have had little trouble completing the sorting tasks. As previously mentioned, Q methodology has been criticized in the past for its demanding sorting process which may require participants to make too fine of distinctions among the items (McKeown & Thomas, 1988) or is simply beyond the cognitive ability for most people to perform adequately (Bolland, 1985). However, such issues would be expected to manifest mainly in placement of items near the center of the sort-distribution. Therefore, the open-ended items on the instrument and subsequent analyses focused primarily on items toward the extremes of most/least-influential, which should have been the easiest for respondents to discriminate.

Summary

This chapter provided a detailed description of the methods used for data collection. Great care was taken to establish both a robust Q Set and P Set for the study. Flash Q software was used not only to gather numerical data for each of the participants' two sorts, but also demographic information and open-ended responses that supplemented the data from the sorting process. Chapter 4 provides a detailed description of the data analysis and addresses the two research questions for the study.

CHAPTER 4: FINDINGS

The purpose of this study was to examine the perceptions of Secondary Math Teachers (SMTs) concerning the various influences that affect teaching practices. Specifically, the aim was to address the following two questions:

1. What archetypes of SMTs exist amongst the perceptions of SMTs concerning the influences that affect teaching practices?

2. What differences (if any) exist amongst the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT?

Forty-one items were derived from a concourse of potential influences on the teaching practices of SMTs. Participating SMTs sorted these 41 items twice (under two different conditions of instruction) yielding 37 sorts which revealed their perceptions of the potential influences as they pertained to teaching practices. The first condition of instruction asked the participants to sort the items as they pertained to their own personal teaching practices. The second condition of instruction asked the participants to sort the items as they pertained to the teaching practices of a typical SMT.

Data Analysis

The data from the sorts were analyzed using PQ Method 2.33 software. The analysis was started by first correlating each sort with every other sort. Then, principle components factor analysis was performed on the resulting correlation matrix, which yielded an un-rotated factor matrix. Finally, Varimax rotation was carried out on the extracted factors in order to identify those with the greatest number of sorts defining each one. For each factor, the following four values were examined: variance, number of significant sorts (i.e. those that loaded onto a factor), number of confounded sorts (i.e. those that loaded onto more than one factor), and number of non-significant sorts (i.e. those that did not load onto a factor). In typical Q studies only two to four factors will emerge from the data (van Exel & de Graaf, 2005). Therefore, in search of the most meaningful solution Varimax rotation was performed on two, three, four, and five factor possibilities.

In PQMethod, factor loading significance is determined by two criteria, both of which must be met.

1. $|a| > \frac{z}{\sqrt{n}}$, where a represents the individual factor loading, z represents the z-score for the desired confidence interval, and n represents the number of items in the Q set.
2. $a^2 \geq \frac{h^2}{2}$, where a represents the individual factor loading and h represents the communality (i.e. the sum of the squares of all factor loadings for that particular sort). This criterion assures that the individual factor loading accounts for at least 50% of the common variance for that particular sort.

For this study, there were 41 items in the Q set (n = 41) and a z-score of 2.58 was used to establish a 99% confidence interval. Therefore, in order to meet the first condition given above $|a| > \frac{2.58}{\sqrt{41}}$, or $|a| > .403$.

According to Brown (1980), at least four sorts must be significant in order to retain a factor. The 3-factor solution, which accounted for 47% of the variance, satisfied this condition. While the four and five factor solutions accounted for 54% and 60% of the variance (respectively), only three sorts loaded onto the final factor in both cases. Because too few sorts loaded onto the last factor in these two circumstances, both the five factor and four factor solutions were discarded. Complete results from these solutions can be found in the Appendix C.

The archetypes were best represented using the 3-factor solution. Although some of the sorts loaded significantly onto a fourth or fifth factor, these factors did not have characteristics that were particularly unique from the other three. Therefore, most of the differences in the sorts could be accounted for in the 3-factor solution. Table 2 shows the sorts that loaded significantly onto each of the three factors (denoted by X). In this table each Q sort is labeled with a numbered pair, where the first number refers to the participant and the second number refers to the condition of instruction used for that sort (e.g. 1_1 refers to the sort of participant 1 using condition of instruction 1). Note that the 3-factor solution accounted for 47% of the total variance (17%, 18%, and 12% for each factor, respectively). Twelve sorts loaded to factor one, 14 sorts to factor two, and 6 sorts to factor three. Only 5 of the 32 sorts were non-significant and there were no confounded sorts.

Z-scores were calculated for each item in each factor for the 3-factor solution. Ordering the z-scores within each factor from largest to smallest provided the theoretical sort that defines that particular factor. The items at the extremes of the list define a factor in a magnified way: the larger the absolute value of each item's z-score, the more likely its inclusion in that factor is not due to chance. The items with the highest z-scores (most positive) are the items that are the most influential on the teaching practices of SMTs who would theoretically fit into that particular factor. Likewise, the items with the lowest (most negative) z-scores are the items that would be the least influential on the teaching practices of the SMTs who would theoretically fit into that particular factor. The characteristics of these three factors, along with the open-ended responses and demographic information provided by the participants, were used to identify and name the three archetypes of SMTs concerning the perceived influences on pedagogical practices as detailed below.

Table 2

Factor Matrix with Significance Denoted by X

Q Sort	Factor 1	Factor 2	Factor 3
1_1	0.2352	-0.1747	0.7986X
1_2	0.0654	-0.0673	0.8248X
2_1	0.1705	0.6200X	0.1215
2_2	0.2085	0.5853X	0.1685
3_1	0.3042	0.5716X	0.1557
3_2	0.7560X	0.1563	0.1317
4_1	0.3737	0.5015X	0.0138
4_2	0.7289X	-0.0305	0.4323
5_1	0.1230	0.5628X	0.0188
5_2	0.2735	0.2828	0.6090X
6_1	0.3757	0.5956X	0.2119
6_2	0.3111	0.3595	0.4114 (non-significant)
7_1	-0.2653	0.7282X	-0.0573
7_2	0.5255X	0.1672	0.3135
8_1	0.4555X	0.3560	-0.0460
8_2	0.4940X	0.0202	0.0585
9_1	0.2718	0.6714X	0.0062
9_2	0.4717	0.4635	0.2670 (non-significant)
10_1	0.7121X	0.0158	0.0859
10_2	0.7237X	-0.0910	0.1624
11_1	0.4793X	0.3378	0.1631
11_2	0.5750X	0.2524	0.2366
12_1	-0.0283	0.5317X	0.3038
12_2	0.4553	0.1555	0.7017X
13_1	0.1264	0.2144	0.7253X
13_2	0.0118	0.3651	0.5376X
14_1	0.0482	0.5210X	0.2959
14_2	0.1531	0.5556X	0.2621
15_1	0.3908	0.5632X	0.1598
15_2	0.6505X	0.2824	0.3404
16_1	0.3570	0.3817	0.1729 (non-significant)
16_2	0.0042	0.6725X	0.0267
17_1	0.3910	0.3880	-0.2539 (non-significant)
17_2	0.5577X	0.2220	0.4815
18_1	0.0419	0.5598X	-0.0594
18_2	0.4170	0.4244	0.2976 (non-significant)
19_1*	0.5452X	0.3688	-0.1562
% expl.Var.	17	18	12

X indicates significant loading at $p < .01$ and more than half of the common variance explained.
*Participant only completed a sort for condition 1.

Factor one identified the archetype of the *Realist*. Factor two identified the archetype of the *Pragmatist*. Factor three identified the archetype of the *Self-Referent*.

Table 3 demonstrates the factor correlations ranging from .2752 to .4986. Note that there is a moderate correlation between factors one and two, and also a moderate correlation between factors one and three. This indicates that the participants loading onto these factors had similarity in their sorting patterns. However, all three factors were retained because of significant differences that appeared in the overall analysis.

Table 3

Correlation Matrix between Factor Scores

	1	2	3
1	1.0000		
2	0.4294	1.0000	
3	0.4986	0.2752	1.0000

Response to Research Questions

The archetypes were identified and named using the Q sort items ranked at the extremes for each factor, along with the open-ended responses and demographic information provided by the participants. Consensus items (i.e. items that were ranked similarly across all factors) were also considered in the analysis.

Research question one. What archetypes of SMTs exist amongst the perceptions of SMTs concerning the influences that affect teaching practices?

The Q sorts from both conditions of instruction were analyzed together to answer this question. That is, the sorts the SMTs completed concerning the influences on their own teaching practices and the sorts they completed concerning what they believed to be the influences on the typical SMT were equally considered. Regardless of the level of consistency that resulted between the two conditions of instruction, sorts from both conditions can be considered equally valid in the construction of the archetypes since these archetypes are based on SMTs' perceptions of reality, as opposed to reality, itself. In other words, the resulting archetypes may not actually exist in reality, but they do exist amongst the perceptions of SMTs. Therefore, there is no need to distinguish between the two conditions of instruction when initially establishing the archetypes. The sorts associated with each condition of instruction, however, would be of substantive importance when addressing the second research question.

Several consensus items appeared throughout the sorts, partially explaining the correlations shown in Table 3. These items are depicted in Table 4 below. They show no significant differences between the three archetypes.

Table 4

Consensus Items with Array Positions

High Influence

Item No.	Item	Array Positions*		
34	My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences)	5	5	5
36	My teaching practices are largely influenced by what I believe my students will need to know about math for college.	2	3	3

Low Influence

Item No.	Item	Array Positions*		
21	My teaching practices are largely influenced by the post-graduation support offered by my university or teacher preparation program.	-4	-5	-3
14	My teaching practices are largely influenced by what the parents of my students believe is best for them.	-2	-5	-5

* Array Positions for Factors One, Two, and Three, respectively.

Other items showed consensus amongst the three archetypes, yet most of these fell into the middle ground of the arrays (i.e. they had ranking scores that deemed the items to be neutral as far as their level of influence). Therefore, since these consensus items do not provide as much relevance as the consensus items ranked at the extremes, their inclusion in this analysis was not important. The relevant differences between the theoretical sorts of the three archetypes, however, was important. It was these differences that shaped the individual meaning and characteristics of each of the three archetypes. Tables 5, 6, and 7 provide summaries of each archetype's theoretical sort, highlighting the most influential and least influential items for each.

Table 5

Archetype One: The Realist

	Most Influential Items	Z-score	Arrays*		
34.	My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences).	1.883	5	5	5
32.	My teaching practices are largely influenced by the suggested content or implementation strategies offered by the textbook or other curricular materials I use.	1.523	5	2	0
4.	My teaching practices are largely influenced by the way my cooperating teacher(s) taught during my student teaching experience or other field experience/practicums.	1.408	4	-2	2
20.	My teaching practices are largely influenced by the mentoring/coaching I received early in my teaching career.	1.371	4	0	1
38.	My teaching practices are largely influenced by the way I personally prefer to learn math.	1.277	3	0	5
15.	My teaching practices are largely influenced by the teaching practices of my teacher colleagues (e.g. what I have experienced through casual interaction with them).	1.240	3	3	-1
39.	My teaching practices are largely influenced by the math content that I am personally familiar/comfortable with.	1.084	3	-1	4

Table 5. *Archetype One: The Realist (continued)*

	Least Influential Items	Z-score	Arrays*
29.	My teaching practices are largely influenced by a particular learning theory or by well-known/classic research in math education.	-1.806	-5 0 -1
30.	My teaching practices are largely influenced by current research findings in math education.	-1.712	-5 1 0
24.	My teaching practices are largely influenced by the formal training I have received concerning diversity issues (either in college courses or professional development opportunities).	-1.484	-4 1 0
21.	My teaching practices are largely influenced by the post-graduation support offered by my university or teacher preparation program.	-1.336	-4 -5 -3
27.	My teaching practices are largely influenced by the formal training I have received in educational psychology (either in college courses or professional development opportunities).	-1.282	-3 -3 0
25.	My teaching practices are largely influenced by the formal training I have received concerning the developmental psychology of my students (either in college courses or professional development opportunities).	-1.141	-3 -2 0
28.	My teaching practices are largely influenced by the formal training I have received in educating students with special needs (either in college courses or professional development opportunities).	-1.131	-3 -1 -2

*Array positions for Factors One, Two, and Three, respectively.

The name *Realist* for this archetype was derived from the concrete nature in which its members tend to perceive the influences on their instructional practices. The *Realists* are largely influenced by particular people, content, and strategies that are familiar to them. They tend to be compliant with the methods demonstrated or endorsed by other teachers, as well as the suggestions offered by textbooks. Conversely, they tend not to be influenced by abstract items such as educational theories, research findings, or formal training programs.

Of the 12 sorts that loaded onto the *Realist* archetype, 4 came from condition one (self) and 8 came from condition two (typical SMT). When analyzing the demographic information from the participants who provided these sorts, the only evidence of correlation stemmed from the years of teaching experience. Both of the participants in this study who had 0-5 years of teaching experience had their sorts from both condition one and condition two load as *Realists*, as did one other participant. This person had 21 or more years of teaching experience, but only 11-15 years teaching math. The final self-loader (condition one) came from a participant with 11-15 years of teaching experience. The remaining five sorts that loaded as a *Realist* came from the condition two sorts of participants with varying levels of teaching experience.

A defining characteristic of *Realists* is the extensive use of the textbook as a primary teaching resource. Other than the consensus item concerning the influence of past experiences (Item 34), the teaching practices of *Realists* are most influenced by Item 32, which states "My teaching practices are largely influenced by the suggested content or implementation strategies offered by the textbook or other curricular materials I use." This characteristic of *Realists* coincides with that notion that teachers are often over-reliant on the textbook for instructional purposes (Smith, 1996; Ewing, 2006; Remillard, 2005). The textbook provides stability for teachers (Pehkonen, 2004) by dictating what content is taught, how it is taught, and the sequence in which it is taught (Nicol & Crespo, 2006). In some cases, the textbook is viewed as a replacement for the teacher (e.g. "teacher-proofing" the curriculum (Lubinski & Jaberg, 1997; Harries & Sutherland, 1999)). This is especially true for new teachers (Vincent & Stacy, 2008).

Open-ended comments from Q sorts loading on the *Realist* archetype concerning the influence of the textbook were as follows:

"Most teachers that I know depend very heavily upon the textbook for their curricular structure."

"I think that many teachers are so busy that they need the guidance of the textbook in order to teach effectively and efficiently. The textbook can be supplemented by the knowledge of the teacher, but a good textbook will save time, which is something many math teachers do not have."

"Educators are left to determine the implementation and strategies on their own and it is easiest to resort to the resources offered by a textbook. They often feel the textbook drives the class being taught."

Similar to the comfort of the safety net provided by the textbook, *Realists* also take comfort in choosing teaching practices that coincide with the way they personally prefer to learn math (Item 38). *Realists* provided the following quotes concerning this item.

"Personal familiarity and comfort is a powerful force in what teachers will try. If they are not comfortable they will not teach it."

"Teaching the way one personally prefers to learn math is like a default. Educators can feel as though they have taught it well then and it is up to the student to take the responsibility for learning it."

Another defining characteristic of *Realists* is the influence that other teachers have on their teaching practices. Items 4, 20, and 15 are all highly valued by *Realists* when it comes to influences on pedagogical practices. Each of these involves an influence from other teachers. The following open-ended responses were provided concerning the perceived value of Item 4, which reads, "My teaching practices are largely influenced by the way my cooperating teacher(s) taught during my student teaching experience or other field experience/practicums."

"My cooperating teacher was one of the most energetic people I have met in my life. His joy of other people and mathematics was contagious. I stay in contact with him and we share the ups and downs of math teaching."

"This was my first experience really studying the way a teacher taught. My cooperating teacher was a really good teacher in my opinion and I wanted to have a controlled classroom similar to her's."

"This is the first experience in the field of teaching. I've talked to other math teachers that almost didn't continue in the education field after a horrible student teaching experience. I've talked to others that became really good teachers because they learned everything they shouldn't do after a bad student teaching experience. Good or bad, I feel that this is the one most influential factor in a person's teaching."

The following is a quote concerning the perceived influence of Item 20, which reads, "My teaching practices are largely influenced by the mentoring/coaching I received early in my teaching career."

"For the young teachers, the early experiences are a key for development of a teaching attitude for life."

Finally, below is a quote concerning the perceived influence of Item 15, which reads, "My teaching practices are largely influenced by the teaching practices of my teacher colleagues (e.g. what I have experienced through casual interaction with them)." While this quote was supplied by a sort that did not load onto any of the factors, it illustrates well how some teachers perceive the influence of their peers.

"At the high school I teach at the teachers are very giving when it comes to sharing ideas. My colleagues have influenced me, not only the way I teach, but also my organization on how I structure lessons and make up work."

Not surprisingly, *Realists* who are heavily dependent on concrete influences, such as their textbooks and other teachers, are not likely to value abstract influences, such as current research findings in math education (Item 30) or a particular learning theory or classic research in math education (Item 29). *Realists* are primarily concerned with the day to day tasks of teaching, thus they are not necessarily motivated to consider the potential benefits of research findings. They may view research findings as unrealistic or not applicable to the real world, because they are often suspect of the researcher, who they perceive as disconnected from the classroom (Labaree, 2003). The two items (30 and 29) involving the influence of research ranked last in the *Realist* archetype theoretical sort. It could be argued that *Realists* view these potential influences as overly esoteric, thus not applicable to them. Below are two quotes from sorts that loaded onto the *Realist* archetype concerning Item 30, which reads, "My teaching practices are largely influenced by current research findings in math education."

"Maybe it's because I'm a math person or maybe because I'm just cynical, but I feel that 'research' can be spun to show whatever the author wants to show. I think there are tried and true practices that endure through the years as part of human nature. The research also often comes from people who don't have experience in the classroom, so I have a hard time trusting their findings."

"Teachers don't base their decisions on research because they don't have the time."

Similar statements were provided from sorts loading on the *Realist* archetype concerning Item 29, which reads, “My teaching practices are largely influenced by a particular learning theory or by well-known/classic research in math education.”

> *“This is an abstract idea that maybe somehow affects the teacher in how they have developed but not a basis for day to day decisions.”*
>
> *“I'm not convinced that the majority of teachers devote time to educational research. Most time is spent planning each lesson based on the layout of the textbook, delivering the lesson, and giving paper-pencil assessments to gauge student learning.”*
>
> *“I don't think that most math teachers style their teaching around a theory. I think that most teachers combine their personality and experience to teach the way they are most comfortable with and the way that seems to help students the most.”*

If the influence of other teachers such as cooperating teachers from a student teaching experience, mentors/coaches, or teaching colleagues can be considered *high* for the *Realists*, then the influence of the formal training they have received in diversity issues (Item 24), educational psychology (Item 27), developmental psychology of their students (Item 25), and educating students with special needs (Item 28) could certainly be considered *low*. All of these items could be considered abstract rather than concrete. Thus, they carry little value in the eyes of the *Realists*.

Concerning diversity, comments from sorts loading on the *Realist* archetype noted that diversity training in this region typically addresses Native American culture, but does not necessarily address teaching practices designed to help them learn. Furthermore, it was noted that teachers in this region do not typically have a lot of diversity in their classrooms.

One *Realist* comment suggested that most teachers do not even talk about the developmental psychology of students, therefore any training received in this area does not play a large role in the selection of teaching practices. Similarly, according to one *Realist* comment, a common belief in schools is that students with special needs already get too much help, therefore the formal training that is offered in this area is largely disregarded.

Table 6

Archetype Two: The Pragmatist

	Most Influential Items	Z-score	Arrays*
34.	My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences).	2.059	5 5 5
33.	My teaching practices are largely influenced by state and/or national standards.	2.014	0 5 1
40.	My teaching practices are largely influenced by the learning styles of my students.	1.935	1 4 1
10.	My teaching practices are largely influenced by professional development opportunities I have sought out on my own (i.e. not mandated).	1.906	0 4 -2
37.	My teaching practices are largely influenced by what I believe my students need to know about math for their everyday lives.	1.641	1 3 3
15.	My teaching practices are largely influenced by the teaching practices of my teacher colleagues (e.g. what I have experienced through casual interaction with them).	1.306	3 3 -1
36.	My teaching practices are largely influenced by what I believe my students will need to know about math for college.	1.257	2 3 3
	Least Influential Items	Z-score	Arrays*
21.	My teaching practices are largely influenced by the post-graduation support offered by my university or teacher preparation program.	-1.604	-4 -5 -3

Table 6. *Archetype Two: The Pragmatist (continued)*

	Least Influential Items	Z-score	Arrays*
14.	My teaching practices are largely influenced by what the parents of my students believe is best for them.	-1.525	-2 -5 -5
7.	My teaching practices are largely influenced by the beliefs or actions of the university supervisor(s) I had during my student teaching experience or other field experience/practicums that I had in college.	-1.468	0 -4 -4
3.	My teaching practices are largely influenced by the way the instructors of my college education/pedagogy course(s) taught.	-1.069	-1 -4 0
27.	My teaching practices are largely influenced by the formal training I have received in educational psychology (either in college courses or professional development opportunities).	-1.058	-3 -3 0
1.	My teaching practices are largely influenced by the way my high school math teacher(s) taught.	-0.959	1 -3 4
2.	My teaching practices are largely influenced by the way my college math instructor(s) taught.	-0.910	0 -3 1
4.	My teaching practices are largely influenced by the way my cooperating teacher(s) taught during my student teaching experience or other field experience/practicums.	-0.898	4 -2 2

*Array positions for Factors One, Two, and Three, respectively.

The name *Pragmatist* for this archetype was derived from the results-focused nature of the perceived influences. Given all things considered, *Pragmatists* are primarily concerned with what works best. Like the other two archetypes identified in this study, the *Pragmatists* put high value on the influence of prior experiences (Item 34), yet there are other defining characteristics of their perceived influences that make them unique. The theoretical sort of the *Pragmatist* suggests that this archetype includes SMTs who balance multiple things in order to produce what they believe to be the best results. As opposed to the *Realists*, who tend to be more affected by concrete influences, *Pragmatists* tend to be more esoteric in the sense that they draw influence from a variety of sources, such as written standards (Item 33), learning styles of their students (Item 40), and PD opportunities (Item 10).

Of the 14 sorts that loaded onto the *Pragmatist* archetype, 11 came from condition one and only three came from condition two. Therefore, the majority of SMTs in this study (11 of 19) defined themselves within this archetype through their sorting under condition one. However, only two of these 11 participants had their condition two sort also load as a *Pragmatist.* (This inconsistency in loadings will be discussed when analyzing the second research question for the study).

Like the *Realist* archetype, years of teaching experience was a defining demographic characteristic for the *Pragmatist*. Of the eight participants in this study who had 21 or more years of teaching experience, seven of them self-loaded as *Pragmatists*. Of the other four self-loaders two had 16-20 years of experience and two had 11-15 years. This would suggest that the *Pragmatist* archetype is typically comprised of veteran teachers. Furthermore, the indication that little influence is derived from their previous teachers/supervisors (Items 7, 3, 1, 2, and 4) suggests that these influences might simply be too distant from their current teaching practices to have a significant impact. It might also suggest a hint of arrogance amongst this archetype in the sense that they seem to devalue the input of those teachers/supervisors who aided them through their indoctrination to the field.

A conceivably related demographic characteristic, highest degree earned, also correlated with the theoretical sort of the *Pragmatist*. Of the 11 SMTs who self-loaded on this archetype, 10 possessed a master's degree. Furthermore, all three of the condition two sorts that loaded as *Pragmatists* came from SMTs with a master's degree. If possession of master's degree is considered a characteristic more associated with veteran teachers than it is novice teachers, then this is not a surprising outcome.

One of the more defining characteristics of the *Pragmatists* that separates them from the other two archetypes is the perceived influence (+5) of state and/or national standards (Item 33). There is evidence to suggest that the standards drive their instruction more than the textbook, whereas *Realists* tend to teach in the opposite manner (i.e. they let the textbook drive their instruction instead of the standards). The following are open-ended responses provided by *Pragmatist* sorts concerning the influence of state and/or national standards. There appears to be a common theme amongst these statements that defines the pragmatic nature of this archetype when it comes to doing what is necessary to elicit the best results.

> *"I am teaching what is expected at my grade level."*
>
> *"With AYP, the standards are the driving force on every classroom. We have no choice but to prepare students for the standards they will be assessed on and the same standards that we as teachers are held accountable to."*
>
> *"This is what drives our curriculum currently. With common core implementation, we are trying to create a plan that best addresses our students' needs and requirements based on common core."*
>
> *"Common Core implementation is a huge focus for our school district."*
>
> *"The implementation of the Common Core State Standards by the state of North Dakota has provided us with a set of standards that will determine whether our students are college or career ready based on their proficiency levels on the SBAC assessment that will be given in the spring of 2015. These standards provide a clear, consistent understanding of what students are expected to learn, are rigorous, real-world*

applicable, and reflect the knowledge and skills our students need to be college and career ready. With North Dakota a part of the Smarter Balanced Assessment Consortium, school districts will have the opportunity to provide formative interim assessments from a bank of assessment questions provided by SBAC to track progress of students in meeting or exceeding proficiency levels on the summative CCSS assessment that will be given at the end of the students' junior year of high school."

Pragmatists also reported that they are highly influenced (+4) by the learning styles of their students (Item 40), yet were neutral (0) concerning the influence of the way they personally prefer to learn math (Item 38). Again, this is the opposite of the *Realists*, who tend to value their own learning preferences (+3). The following are open-ended responses from *Pragmatist* sorts concerning the influence of their students' learnings styles.

"Understanding that not all students learn in the same way has changed me as a teacher. It is always in the back of my mind."

"Based on the ability or prior knowledge of my students, I will adapt the lesson to meet their needs where they are mathematically and emotionally now."

"I feel we need to know not only the way they learn best but the ways they struggle as well and expose them to both so they are ready for the future"

Finally, *Pragmatists* are unique in their perceived influence (+4) concerning PD opportunities that they have sought out on their own (Item 10). Again, this speaks to the pragmatic nature of teachers in this archetype in the sense that they will strive to do whatever they need to do to elicit the best results. Note that this item specifically refers to PD opportunities that are *not* mandated by the school district. Those PD opportunities that are arranged or required by the school district were designated to Item 9, which *Pragmatists* scored at (-1). This perceived neutral stance or lack of value coincides with the concept reported earlier that teachers have low investment in PD opportunities arranged by their administrators because they have little voice in the matter (Sample-McMeeking et al., 2012) and the focus of such PD opportunities is typically not in their content area (Bishop, 1992). Said one *Pragmatist, "My school district's professional development opportunities are usually not helpful to me in any way."*

The perceived value of Item 10, however, might seem somewhat contradictory to Stigler and Hiebert's (2004) claim that most PD does not actually make it to the classroom. Yet, it is important to note that Stigler and Hiebert studied both the perceived importance of PD and the actual implementation of it. As previously mentioned, they found that even though teachers reported use of content learned during PD experiences, their actual classroom practice did not reflect implementation. Therefore, it is important to recognize that the sorts that produced these results are based on the perceptions of SMTs concerning these various influences, not necessarily the reality of them. That being said, *Pragmatist* sorts provided the following open-ended responses concerning PD they sought out on their own.

> *"When I went through my master's program I feel that made me a much better teacher."*
>
> *"I seek out opportunities that I am interested in learning about, or those that address a particular need I have, so I place a high level of value on these experiences."*
>
> *"It is through professional development on my own that I discovered 4MAT. This philosophy drives all my decisions relating to teaching."*

Table 7

Archetype Three: The Self-Referent

	Most Influential Items	Z-score	Arrays*
34.	My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences).	2.107	5 5 5
38.	My teaching practices are largely influenced by the way I personally prefer to learn math.	1.984	3 0 5
39.	My teaching practices are largely influenced by the math content that I am personally familiar/comfortable with.	1.903	3 -1 4
1.	My teaching practices are largely influenced by the way my high school math teacher(s) taught.	1.665	1 -3 4
35.	My teaching practices are largely influenced by what I believe my students will need to know for state and/or national assessment exams	1.328	1 2 3
37.	My teaching practices are largely influenced by what I believe my students need to know about math for their everyday lives.	0.944	1 3 3
36.	My teaching practices are largely influenced by what I believe my students will need to know about math for college.	0.873	2 3 3
	Least Influential Items	Z-score	Arrays*
14.	My teaching practices are largely influenced by what the parents of my students believe is best for them.	-2.351	-2 -5 -5
31.	My teaching practices are largely influenced by print or online media resources that I have sought out concerning various aspects of teaching (e.g. lesson planning, assessment, engagement, motivation)	-1.627	0 1 -5
7.	My teaching practices are largely influenced by the beliefs or actions of the university supervisor(s) I had during my student teaching experience or other field experience/practicums that I had in college.	-1.418	0 -4 -4

Table 7. *Archetype Three: The Self-Referent (continued)*

	Least Influential Items	Z-score	Arrays*
41.	My teaching practices are largely influenced by the demographic characteristics of my students	-1.328	1 2 -4
21.	My teaching practices are largely influenced by the post-graduation support offered by my university or teacher preparation program.	-1.316	-4 -5 -3
5.	My teaching practices are largely influenced by the way I have witnessed professional development teachers/presenters teach.	-1.202	-1 -1 -3
8.	My teaching practices are largely influenced by state or national professional organizations I am involved in (e.g. NCTM, NEA).	-1.152	-2 1 -3

*Array positions for Factors One, Two, and Three, respectively.

The name *Self-Referent* for this archetype was derived from the self-centered nature in which its members perceive the influences on their instructional practices. *Self-Referents* tend to view their beliefs and opinions as superior to others. Teachers within this archetype are strongly influenced by their personal opinions of teaching, as opposed to other various influences that might contradict their beliefs. Said one *Self-Referent* concerning the items in the Q set, *"…these things sound good on paper but not necessarily were beneficial in reality."*

Of the six sorts that loaded onto the *Self-Referent* archetype, only two came from condition one, whereas four came from condition two. Both participants who self-loaded onto this archetype also had their condition two sorts load correspondingly. The other two sorts from condition two that loaded onto the *Self-Referent* archetype came from participants who self-loaded as *Pragmatists.*

No significant demographic characteristics were immediately evident concerning this archetype. However, it can be noted that both of the teachers who had both sorts load as *Self-*

Referents are well experienced (one with 16-20 years of experience, the other with 21 or more), yet neither have master's degrees (i.e. bachelor's degrees only). This was rare, since most of the participants in the study with this many years of experience had already attained a master's degree.

Several characteristics of the *Self-Referent* archetype are shared with those of the *Realist* and the *Pragmatist*. Again, personal experiences (Item 34) was a consensus item of strong influence across all three archetypes. The *Self-Referents* also share perceptions of strong influence with the *Realists* in terms of the way they personally learn math (Item 38) and the math content that they are personally comfortable with (Item 39). Finally, the *Self-Referents* show relatively strong influence (+3) concerning their beliefs on what students need to know for state and/or national assessment exams, for college, and for their everyday lives (Items 35, 36, and 37). Although not quite as strong, these are items that *Realists* and *Pragmatists* value similarly. It is noteworthy that the *Self-Referents* highly valued Items 34-39 and each of these could be characterized as *I statements*. That is, they all have a similar theme that involves personal beliefs or personal preferences. Furthermore, the items rated as least influential mostly involve the opinions or suggestions of others. This would suggest that *Self-Referents* simply do not care what other people have to say. Overall, the extremes of the theoretical sort for this archetype strongly imply an individualistic nature.

A noteworthy characteristic of the *Self-Referents* is the perceived high influence (+4) of the way their high school math teacher(s) taught (Item 1). *Realists* are relatively neutral on this item (+1) and *Pragmatists* identify this as a weak influence (-3). Said one self-loading *Self-Referent, "I had an excellent high school math teacher that had a good sense of challenging us* *but not to the point of frustration. She had an approach that made us all feel like we could 'get' math."*

The following quote came from a self-loading *Pragmatist* concerning her perceptions of typical SMTs and their reliance on the way their high school math teacher(s) taught.

> *"I often hear from my colleagues during our collaboration time that they find themselves teaching many mathematical concepts/ideas the way in which they were taught in high school. When asking them 'why' they feel this way, usually the answer is that they really don't know any other way to teach. This tells me that there needs to be strong mentoring programs in place, where new teachers are provided with the opportunity to visit other classrooms on a consistent basis in an effort to see a variety of teaching strategies/styles that they may eventually try in their own classrooms. New teachers have also expressed that they teach in the way in which they were taught because that is how they learned the content and it makes sense to them. Until teachers gain experience in a variety of teaching strategies, or are given time and/or the opportunity to attend consistent professional development in the areas of teaching and learning, teachers will continue to resort to what they are most comfortable doing, regardless of whether it is best for their students."*

This idea that *Self-Referents* are typically only interested in their own beliefs and opinions might also explain why they show no value (-5) in seeking out print or online media resources concerning various aspects of teaching (Item 31). This was another glaring difference between the *Self-Referents* and the other two archetypes, who were relatively neutral concerning this item. Said one *Self-Referent, "Few teachers have the time to search out useful ideas in that manner."*

Similarly, *Self-Referents* perceive little influence (-3 and -2, respectively) through involvement in professional organizations (Item 8) and PD opportunities they seek out on their own (Item 10). Furthermore, *Self-Referents* have neutral positions concerning state and/or nationals standards (+1), current math education research (0), and classical research/learning theories (-1). All of these characteristics could be viewed as self-referent. The following are open-ended responses concerning involvement in professional organizations (Item 8).

> *"None of my colleagues are members of any professional organizations."*
>
> *"I just do not have time for involvement in other organizations and would prefer to seek the resources out myself."*

Finally, *Self-Referents* are unique in their perceptions of the influence of student demographics on their teaching practices (Item 41). While they scored this item at (-4), *Realists* and *Pragmatists* scored it at (+1) and (+2), respectively. The following are open-ended responses from sorts loading onto the *Self-Referent* archetype concerning this item.

> *"All students taught same material.... students treated individually on the affective level... but on the subject content, all the same."*
>
> *"These should not be considered in how we should teach... all deserve the same education"*

While these statements indicate that *Self-Referents* tend to ignore or devalue the demographic makeup of their classrooms, the following quote from a *Realist* who scored this item at (+5) provides a different viewpoint (and possibly a different interpretation of the item).

> *"Especially in the current school, the students are quite diverse, especially in the areas of English language proficiency and parent support at home. I try to vary my instruction using a lot of visuals, and I work with some of my lower kids to develop study skills."*

Research question two. What differences (if any) exist amongst the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT? To investigate this question, each participant's loadings from the two sorts were analyzed to see how they compared to each other (i.e. did the two sorts load to the same archetype or were they different?) Table 8 illustrates these results. Those participants whose sorts loaded to the same archetype are marked with an asterisk.

Table 8

Self-Loaded Archetype to Typical SMT Loaded Archetype

Participant	Self-loaded Archetype	Typical SMT loaded Archetype
1*	Self-Referent	Self-Referent
2*	Pragmatist	Pragmatist
3	Pragmatist	Realist
4	Pragmatist	Realist
5	Pragmatist	Self-Referent
6	Pragmatist	non-significant
7	Pragmatist	Realist
8*	Realist	Realist
9	Pragmatist	non-significant
10*	Realist	Realist
11*	Realist	Realist
12	Pragmatist	Self-Referent
13*	Self-Referent	Self-Referent
14*	Pragmatist	Pragmatist
15	Pragmatist	Realist
16	not significant	Pragmatist
17	not significant	Realist
18	Pragmatist	non-significant
19	Realist	not completed

*Indicates Self-loaded Archetype and Typical SMT loaded Archetype as the same

Eleven of the 18 participants who completed both sorts had different perceptions concerning the influences on their own teaching practices versus the influences of a typical SMT. Table 9 illustrates this contrast.

Table 9

Contrast from Self-Loaded Archetypes to Typical SMT Loaded Archetypes

	Condition 2 (typical SMT)			
Condition 1 (self)	Realist	Pragmatist	Self-Referent	Non-significant
Realist	3	-	-	-
Pragmatist	4	2	2	3
Self-Referent	-	-	2	-
Non-significant	1	1	-	-

Interestingly, not one of the self-loading *Realists* or self-loading *Self-Referents* loaded to a different archetype under condition two. However, the self-loading *Pragmatists* showed a high propensity for change from condition one to condition two with 9 of the 11 participants either loading onto a different archetype or not loading onto an archetype at all. When asked if there were differences between the two sorts, participants provided multiple comments, most of which were consistent with the way their sorts loaded (i.e. those who noted little change between their two sorts did indeed provide sorts that loaded consistently, and those who noted much change provided sorts that contrasted with each other).

The consistency of the self-loading *Realists* and *Self-Referents* from condition one to condition two provides an interesting glimpse of their perceptions concerning the various influences on teaching practices. They seem to believe that other typical SMTs are influenced in the same manner that they are (i.e. they are not unique). This especially makes sense for the self-loading *Realists*, since a defining characteristic of this archetype is the propensity to be influenced by other teachers. If they believe their teaching practices are similar to other teachers it is not surprising that their two sorts would be consistent.

Conversely, the condition two sorts of the self-loading *Pragmatists* provide evidence that they think of themselves as unique. This is somewhat ironic, considering the *Pragmatist* archetype was the most popular amongst the condition one sorts (11 of the 19 participants self-loaded as *Pragmatists*). This contrast certainly provides evidence that pluralistic ignorance is present amongst SMT perceptions concerning influences on teaching practices. The following are quotes from self-loading *Pragmatists* whose second sorts were decidedly different than their first sorts. It is noteworthy that each quote indicates a perception of uniqueness.

> *"My background is different from others. We all perceive things differently and I think of myself as being fairly unique."*
>
> *"I am a veteran teacher who strives daily to create the best learning environment that I can for my students. For me this means that I am continually taking advantage of professional development opportunities within my school district as well as with the state of ND, while also taking on a number of leadership roles. Many teachers that I work with do not share that passion, and are oftentimes ignorant of new and creative ways to teach and to learn. It isn't that these teachers are not capable of becoming better, it is more that they feel they are doing a sufficient job in the classroom and do not need to 'fix what is not broken.'"*
>
> *"As a sometimes nontraditional math teacher, I try to focus on teaching to the different learners in my room. This takes time and courage... something some traditional teachers and sometimes I don't always have."*

Summary

This chapter presented the results of the data after it was entered into PQMethod 2.33. The analysis revealed a 3-factor solution. These three factors were used to identify and name the three archetypes of SMTs that exist amongst the perceptions of SMTs concerning the influences on teaching practices. These archetypes are the *Realists*, the *Pragmatists*, and the *Self-Referents.* The demographic information and open-ended responses provided by the participants were used to describe each archetype and the two research questions for this study were addressed using this 3-factor solution. Chapter 5 provides additional discussion concerning these archetypes and suggestions for future research.

CHAPTER 5: DISCUSSION

The purpose of this study was to explore the perceptions of Secondary Math Teachers (SMTs) concerning the influences that affect teaching practices and also investigate the possible existence of pluralistic ignorance concerning the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT. Specifically, the aim was to address the following two questions:

1. What archetypes of SMTs exist amongst the perceptions of SMTs concerning the influences that affect teaching practices?
2. What differences (if any) exist amongst the way SMTs perceive the effects of influences on their own teaching practices versus the way they perceive the effects of these same influences on the teaching practices of a typical SMT?

Nineteen SMTs from North Dakota participated through the use of Q methodology. They sorted a list of potential influences under two conditions of instruction (one pertaining to themselves and the other pertaining to their beliefs concerning the typical SMT). The data were collected and analyzed, resulting in the identification and description of three archetypes: The *Realists*, the *Pragmatists*, and the *Self-Referents*. Furthermore, there was evidence to suggest the existence of pluralistic ignorance amongst the participants based on the inconsistency between their two sorts. The following paragraphs provide brief summaries of the traits of each archetype identified in the study.

Description of the Archetypes

Realists tend to have their teaching practices be largely influenced by concrete factors, as opposed to those that are abstract. *Realists* exhibit a sense of compliance by highly valuing the input of particular people or things that they are familiar with. These include the textbook/curriculum materials they use, other teachers (e.g. cooperating teachers, mentors/coaches, colleagues), and the ways they personally prefer to learn math. *Realists*, however, lend little to no value to mathematics education research findings or particular learning theories. Similarly, they are not influenced by much of the formal training they have received in areas such as diversity, educational psychology, developmental psychology of their students, or educating students with special needs.

Pragmatists tend to be more esoteric when it comes to the influences on their teaching practices. They tend to balance multiple factors while exhibiting a very student-centered approach that does not exist in the other two archetypes. As opposed to the concrete influences valued by *Realists*, *Pragmatists* tend to value abstract influences, including state and/or national standards, the learning styles of their students, professional development (PD) opportunities, and the personal needs of their students. *Pragmatists* derive little to no influence from their past teachers (e.g. high school teachers, college teachers, university supervisors). Finally, *Pragmatists* seem to be open to change, whereas the other two archetypes seem *set* in their ways, as is evident by their tendency to only look locally for teaching influence.

Self-Referents tend to highly value their own beliefs and opinions. They could be thought of as rugged individualists who tend to be anecdotal concerning their teaching practices. They are primarily influenced by their own experiences, the way they personally prefer to learn math, the math content they are personally familiar/comfortable with, and their personal views of what their students primarily need. *Self-Referents* lend little to no value to the influence of print or online media resources concerning various aspects of teaching, nor are they influenced by the views of previous university supervisors, the effect of PD opportunities, or the demographic makeup of their classrooms.

Discussion of Archetypes

All three archetypes seem to hold a shared sense of striving to do what *works* or do what is *right* for their students. However, they seem to have different underlying assumptions and expectations concerning the various influences that will help them achieve their goals as teachers. The shared viewpoints amongst the three archetypes speak to the existence of memes in math education and the overall influence of teacher culture (Stigler & Hiebert, 2009; Hiebert, 2003; Bullock & Russell, 2010), yet the differences between the archetypes suggest that SMTs have distinctly different viewpoints concerning the best ways to teach.

Explanation of consensus items. Item 34 needs to be recognized for its shared importance amongst all three archetypes. It states "My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences)." All three archetypes ranked this item at (+5). This is not surprising. As previously mentioned, "Teaching requires improvisation, conjecturing, experimenting, and assessing. Teachers must be able to adapt and develop practice" (Ball & Cohen, 1999, p. 10). Said one *Realist*:

> *"I think that the most important thing math teachers can do is make changes and adapt based on experience. If I try something and it doesn't work, I either change it or skip it the next year."*

Although this item was ranked +5 for all three archetypes, the open-ended comments concerning this item provided qualitatively different viewpoints. *Realists*, for example, commented that the simple accumulation of years of experience indicated to them what *worked* or did not *work*.

They tended to have a very basic, surface-level view of how personal experiences guided their teaching practices. Conversely, *Pragmatist* comments focused on reflective teaching, observing students, and using direct feedback from students to modify their lessons. Their comments had a more student-centered theme to them. Finally, *Self-Referent* comments indicated a more teacher-centered viewpoint. One *Self-Referent* commented that the experiences most influential to him were derived directly from how he was taught and how he learned math. Similarly, another *Self-Referent* commented that teachers revert to their own histories and value their own experiences more than those of others.

The high ranking of Item 36, "My teaching practices are largely influenced by what I believe my students need to know about math for college" provides evidence that SMTs amongst all three archetypes view college as a normal/expected transition for their students after finishing high school. This is not surprising considering that all 19 participants in this study were currently teaching in North Dakota, a state historically known for sending a high percentage of its high school graduates directly to college (NCHEMS, n.d.).

The strongest of the consensus items that were ranked as low influence by all three archetypes was Item 14, "My teaching practices are largely influenced by what the parents of my students believe is best for them." This item was especially strong (-5) for the *Pragmatists* and the *Self-Referents*. Through their open-ended responses, participants indicated that most parents do not know what is best for their children when it comes to math education. They are typically not aware of the standards, nor are they able to make informed suggestions/requests concerning pedagogical practices. A couple participants mentioned that parents need to be kept informed about their child's progress and that they can be used to help provide suggestions for motivational purposes. However, the majority of responses concerning this item indicated that any suggestions offered by parents concerning math teaching practices are typically not given credence.

Not surprisingly, all three archetypes indicated little influence for Item 21, “My teaching practices are largely influenced by the post-graduation support offered by my university or teacher preparation program.” This is a relatively new practice amongst teacher preparation programs, therefore many of the participants indicated that this was a non-existent influence on both their personal teaching practices and those of typical SMTs. They either indicated that they did not receive any post-graduation support from their teacher preparation program or that even when such support is available they do not see SMTs taking advantage of it.

Emergence of Archetypes and Pluralistic Ignorance

As previously stated, the archetypes that emerged from this study are based on the perceptions of SMTs concerning the influences on pedagogical practices. These archetypes may or may not mirror what archetypes actually exist in reality. The potential presence of pluralistic ignorance also contributes to this relationship between perception and reality. For example, the *Self-Referent* archetype was derived from six sorts, four of which came from condition two. Therefore, it can be argued that this archetype exists more in perception that it does in reality. In fact, it is almost hard to believe that a SMT would self-load onto this archetype. Doing so would more or less admit ignorance of the ways other SMTs do things, while also displaying a level of teacher-centeredness that colleagues might find reprehensible. However, it is much easier to believe that SMTs may perceive other SMTs as fitting into this archetype. This certainly provides evidence for the existence of pluralistic ignorance. It is noteworthy that both participants who self-loaded as *Self-Referents* are experienced veterans (16-20 years and 21+ years, respectively), yet neither has a master’s degree (bachelor’s only). Of the 11 participants with 16+ years of math teaching experience, only three had not yet earned a master's degree, two of which were the self-loading *Self-Referents*. This may be an indication of the potential effects earning a master's degree has on teacher perceptions. While this potential correlation was not a focus of the current study, it may provide a compelling question for future research.

The most interesting characteristic of the *Self-Referents* is the high influence they derive from their high school math teacher(s). This certainly gives support to Lortie's (1975) notion of the existence of the apprenticeship of observation. Yet, would the lack of perceived influence from the *Realists* and the *Pragmatists* concerning this item refute Lortie's position? Again, it is important to recognize that the data from these sorts were based on SMTs' perceptions, not necessarily reality. As previously mentioned, Nespor (1987) reported it is unlikely that students consciously and methodically mimic their teachers' actions. Rather, they tend to implicitly recall classroom environments, which leads to their perception of what acceptable behaviors are in the classroom. Therefore, the apprenticeship of observation may still exist with *Realists* and *Pragmatists* even if they did not readily identify this through their sorts.

Although the *Self-Referents'* perception that they are largely influenced by the way their high school math teacher(s) taught could be considered a contradiction to the self-centered nature of the archetype, it could also serve as an indicator that they simply do not see a need for change in their teaching practices. As previously mentioned, Pajares (1992) reported that many who choose teaching as a career do so because of positive experiences they had as a student. Therefore, they are often poor agents of social change in education, because they are unable and unwilling to see a need for change in a system that requires reform. This could very well explain how *Self-Referents* can be both influenced by the practices of their high school math teacher(s) and by their own personal viewpoints at the same time (i.e. they might see these as one and the same). As previously mentioned, Mewborn and Tyminski (2006) noted that students acquire notions of *good* and *bad* teaching based on how particular pedagogical practices have affected them personally. Therefore, the apprenticeship of observation might simply involve future SMTs employing the teaching methods that they perceived to work best for them, not necessarily all of the teaching methods they have experienced. Again, this would explain the propensity of *Self-Referents* to rely solely on their own beliefs and opinions.

The strongest evidence of pluralistic ignorance in this study emerges when considering the manner in which *Pragmatists* inaccurately tend to believe that they are unique. As previously mentioned, the self-loading *Pragmatists* showed a high propensity for change from condition one to condition two with 9 of the 11 participants either loading onto a different archetype or not loading onto an archetype at all. One might argue that *Pragmatists* view this as a way to maintain their identity as the superior SMTs in a school district. If they believe they are unique in what they are doing for their students (i.e. doing everything in their power to provide the best learning environment for them), how is it possible that so many math students are showing mediocre achievement? The only explanation would be that *other* math teachers are not providing the same quality education that they are. In other words, if *Pragmatists* were to lose their sense of uniqueness, it would require them to shoulder some of the blame for poor student achievement, which might make for an uncomfortable realization. Therefore, it is not surprising that *Pragmatists* would view most typical SMTs as either *Realists* who rely narrowly on textbooks and the teaching practices of others or *Self-Referents* who are blindly repeating what they have always done because they only believe in their own methods. Further investigation of this pluralistic ignorance might make for interesting future research.

Finally, there is evidence to suggest that these archetypes are not rigid in the sense that teachers are always going to be a member of one or the other. Instead, it is possible that teachers may transition from one archetype to another at varying times in their careers for various reasons. Said one *Realist:*

"It was interesting how many of the ideas were related to the formal education received as an educator and how little that seems to affect my teaching practices now that I have been out in the field as an educator for a number of years."

As previously mentioned, of the eight participants in this study who had 21 or more years of teaching experience, seven of them self-loaded as *Pragmatists.* This could suggest that teachers become more pragmatic as they gain experience. For example, some of the concrete influences that primarily affect the *Realists* (e.g. cooperating teacher) might simply be too far removed from the current experiences of the *Pragmatists* to have a significant effect. The following two quotes came from self-loading *Pragmatists* whose second sorts loaded as *Realists*.

"*Many of the cards I sorted I originally put into the neutral column, and then had to change to either the 'Least influential' or 'Most influential' columns to fit into the table. Upon reading through them, it was difficult to lay them out in the table because at specific points in my career some of the cards may have been much more important than they are for me today. Experience has played a major factor in my becoming the successful teacher that I am today, along with taking advantage of PD opportunities and learning from others."*

"When I answered part 2 I tried to think about what it was like when I was a younger teacher and what influenced me."

Another explanation for the 21+ year veterans mostly loading as *Pragmatists* might be that pragmatic teachers are simply able to *survive* longer in their teaching careers (i.e. the attrition rate for those who teach pragmatically may not be as high as the rate for those who are less pragmatic). The potential correlation between teaching experience and the pragmatic viewpoints concerning influences on teaching practices would provide yet another compelling topic for future research.

The Theorist Archetype

As previously shown in Table 3 there were moderate correlations between the theoretical sorts of the three archetypes. Specifically, it was demonstrated that the *Pragmatists* have some shared viewpoints with the *Realists* (.4294 correlation) and the *Realists* have some shared viewpoints with the *Self-Referents* (.4986 correlation). The weakest correlation, however, exists between the *Pragmatists* and *Self-Referents* (.2752 correlation). The weak correlation between these two archetypes supports the overall descriptions of the two archetypes provided in this dissertation. That is, the *Pragmatists* tend to demonstrate a very student-centered approach, whereas the *Self-Referents* tend to be more teacher-centered.

The comparison of the three archetypes begs the question: Which archetype is the best? Does an ideal archetype exist? While these questions leave much room for debate, the researcher sorted the items himself to provide the *Theorist* archetype. Although this archetype is derived from only one sort from one teacher educator, it may well represent what teacher education programs and accrediting agencies would hope for from SMTs. Table 10 summarizes the *Theorist* archetype, indicating the array position for each item from this sort and the comparing array positions from the other three archetypes.

Table 10

The Theorist Archetype

	Most Influential Items	Theorist	Arrays*		
33.	My teaching practices are largely influenced by state and/or national standards.	5	0	5	1
34.	My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences).	5	5	5	5
18.	My teaching practices are largely influenced by what I learned from the math teaching methods course(s) I took in college.	4	2	-2	1
10.	My teaching practices are largely influenced by professional development opportunities I have sought out on my own (i.e. not mandated).	4	0	4	-2
30.	My teaching practices are largely influenced by current research findings in math education.	3	-5	1	0
40.	My teaching practices are largely influenced by the learning styles of my students.	3	1	4	1
29.	My teaching practices are largely influenced by a particular learning theory or by well-known/classic research in math education.	3	-5	0	-1
	Least Influential Items	Theorist	Arrays*		
38.	My teaching practices are largely influenced by the way I personally prefer to learn math.	-5	3	0	5
39.	My teaching practices are largely influenced by the math content that I am personally familiar/comfortable with.	-5	3	-1	4
37.	My teaching practices are largely influenced by what I believe my students need to know about math for their everyday lives.	-4	1	3	3
14.	My teaching practices are largely influenced by what the parents of my students believe is best for them.	-4	-2	-5	-5

Table 10. *The Theorist Archetype (continued)*

	Least Influential Items	Theorist	Arrays*		
36.	My teaching practices are largely influenced by what I believe my students will need to know about math for college.	-3	2	3	3
12.	My teaching practices are largely influenced by the teacher evaluation system my school district has in place.	-3	-2	-1	-2
35.	My teaching practices are largely influenced by what I believe my students will need to know for state and/or national assessment exams.	-3	1	2	3

*Array positions for Factors One, Two, and Three, respectively.

The *Theorist* is mostly influenced by the standards that are designed to drive instruction. These are the standards that have been approved and adopted for the school district, thus SMTs should adhere to them. Note that influence from the standards is in direct opposition to some of the other influences that ranked low in this sort (e.g. what I believe students need to know for assessment exams, for college, and for their everyday lives). Theoretically, standards-based teaching should already consider these factors. Therefore, there should be little need to focus on them individually.

Similar to the three archetypes identified in the study, the *Theorist* also values the influence of personal experience. Although the *Theorist* would rank this item high in his sort, he would so with caution since he also values the influence of learning theories and research findings in math education. While it is typically accepted that SMTs should engage in reflective practice and make adjustments to teaching practices based on experiences (Ball & Cohen, 1999), it is also important to note that anecdotal experiences can often conflict with research findings (Labaree, 2003). Therefore, it is important to strike a balance between these influences. They should work *with* each other, as opposed to *against* each other.

Another example of conflicting influences in the *Theorist* sort is the influence of students' learning styles (+3) versus the preferred learning style of the teacher (-5) and his content familiarity (-5). Finally, the *Theorist* would want SMTs to be influenced by what they have learned through their formal education. In particular, the content of math methods courses taken in college should theoretically be directly aligned to the tasks and challenges of a practicing teacher. Furthermore, SMTs should understand that no teacher education program can fully prepare them to be effective teachers right away (Kennedy, 1999; Morris, Hiebert, & Spitzer, 2009; Borko et al., 1992; Cole & Knowles, 1993; McDiarmid, 1990; Scherff & Singer, 2012). Therefore, serious investment in PD opportunities is vital to improvement (Banilower, et al., 2006; Garet et al., 2001; Sample-McMeeking et al., 2012; Guskey, 2000).

When compared to the three archetypes identified in the study, the *Theorist* archetype would bear most resemblance to that of the *Pragmatist.* However, it is not surprising that the *Theorist* archetype did not emerge from the Q sorts in this study. As previously mentioned, the theories that pre-service teachers learn about in their teacher education programs often bump up against their practical experiences (Scherff & Singer, 2012). Furthermore, teachers often find it difficult to implement suggestions from research findings. They may view research findings as unrealistic or not applicable to the real world, because they are often suspect of the researcher, who they perceive as disconnected from the classroom (Labaree, 2003). Therefore, what a *Theorist* views as appropriate may not be viewed as feasible or applicable by a practitioner.

Since the *Theorist* archetype described here is the result of only one Q sort, further research would be needed to establish this archetype (or similar archetypes). A comparison of desired archetypes derived from a P Set of teacher educators and/or researchers in math education versus the archetypes that emerged from the current study could potentially provide interesting results. Assuming that a well-defined *Theorist* archetype does indeed exist, teacher educators could potentially use this archetype as a model for practice. How do teacher preparation programs get their pre-service teachers to model this archetype? How do school districts get their teachers to think like a *Theorist*? These are interesting questions that could be pursued in future research endeavors.

Potential Weaknesses of the Study

Several participants noted that they had difficulty in sorting the items under condition two. One participant felt the second sort was an exercise in guessing. Another noted that she only knows a few other math teachers (e.g. those she teaches with or has met at PD opportunities), therefore her knowledge of what influences the typical SMT is quite limited. Finally, one participant stated that he tried to think of the other math teachers at his school while doing the second sort, but had difficulty predicting what influences their teaching strategies. As previously mentioned, SMTs in the U.S. are rarely able to witness effective pedagogy from their peers (Ball, 1988; Stigler & Hiebert, 2004; Hiebert, 2003), therefore the difficulties these participants cited while trying to complete their second sorts are not surprising. Even considering this potential weakness it is important to note once again that the archetypes derived from the Q sorts were based on the perceptions of SMTs. Therefore, even if a participant felt as though he was *guessing* while sorting under condition two he would still be providing accurate data concerning his perceptions of a typical SMT, regardless of how accurate his viewpoints were concerning reality.

Finally, as previously mentioned, it has been suggested that the magnitude of the sorting task is above and beyond the cognitive ability of most people to perform adequately (Bolland, 1985). Similarly, some have criticized the Q-sort process for having too many categories and requiring participants to make too many and too fine of distinctions among the items (McKeown & Thomas, 1988). Recognizing that these issues could potentially introduce weaknesses to the study, the researcher used great care in constructing a Q set that contained items believed to be both relevant and significant for the participants. Furthermore, the P set was purposefully constructed with these challenges in mind (i.e. participants were selected specifically for their assumed ability to adequately differentiate between the items). Finally, the defining features of each archetype came specifically from the items ranked at the extremes of the sorts and the open-ended comments that accompanied them. Therefore, it is assumed that even if participants had trouble differentiating between some of the items, these items were most likely sorted into the middle of the array, where their placement was not as relevant to the analyses. It was assumed that participants would have little trouble distinguishing between items they felt strongly about (the items at the extremes of the array), therefore focusing the analyses on these items helps to mitigate against the potential weaknesses outlined above.

Conclusion

As previously mentioned, a problem that exists in math education is the apparent disconnect between what is believed to be effective pedagogy and what actually takes place in the classroom. This disconnect exists between the views of educational organizations (e.g. NCTM, NCATE, InTASC, NBPTS) and the actual practice of SMTs (Weiss et al., 2003). It exists between what is learned in college campus courses and what pre-service teachers are able to implement in field experience practice (Zeichner, 2010). It exists between what SMTs report as benefits from PD and what they actually do in their classrooms (Stigler & Hiebert, 2004). And it exists between the findings/suggestions of researchers and the adherence of SMTs (Bishop, 1992; Labaree, 2003). The research questions addressed in this study help to explain some of the reasons behind this disconnect. The aim of this study was to use Q Methodology to understand the participating SMTs' perceptions, not to generalize. Archetypes of SMTs were identified and described, yet further research is required to confirm the nature in which these archetypes exist. Therefore, replication of these results is necessary before more broad generalizations can be made.

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APPENDIX A: Q SET

1. My teaching practices are largely influenced by the way my high school math teacher(s) taught.
2. My teaching practices are largely influenced by the way my college math instructor(s) taught.
3. My teaching practices are largely influenced by the way the instructors of my college education/pedagogy course(s) taught.
4. My teaching practices are largely influenced by the way my cooperating teacher(s) taught during my student teaching experience or other field experience/practicums.
5. My teaching practices are largely influenced by the way I have witnessed professional development teachers/presenters teach.
6. My teaching practices are largely influenced by what I learned during my student teaching experience or other field experience/practicums that I had in college.
7. My teaching practices are largely influenced by the beliefs or actions of the university supervisor(s) I had during my student teaching experience or other field experience/practicums that I had in college.
8. My teaching practices are largely influenced by state or national professional organizations I am involved in (e.g. NDCTM, NDEA)
9. My teaching practices are largely influenced by professional development opportunities arranged or required by my school district.
10. My teaching practices are largely influenced by professional development opportunities I have sought out on my own (i.e. not mandated).
11. My teaching practices are largely influenced by the views, directives, or philosophies of my administration (e.g. principal, superintendent)
12. My teaching practices are largely influenced by the teacher evaluation system my school district has in place
13. My teaching practices are largely influenced by the physical environment in which I teach (e.g. budget issues, class enrollment size, class time length)
14. My teaching practices are largely influenced by what the parents of my students believe is best for them.
15. My teaching practices are largely influenced by the teaching practices of my teacher colleagues (e.g. what I have experienced through casual interaction with them).
16. My teaching practices are largely influenced by formal collaboration with my teaching colleagues (e.g. professional learning community (PLC)).
17. My teaching practices are largely influenced by what I learned from the math content courses I took in college.
18. My teaching practices are largely influenced by what I learned from the math teaching methods course(s) I took in college.
19. My teaching practices are largely influenced by what I learned from the education/general pedagogy courses I took in college.

20. My teaching practices are largely influenced by the mentoring/coaching I received early in my teaching career.
21. My teaching practices are largely influenced by the post-graduation support offered by my university or teacher preparation program.
22. My teaching practices are largely influenced by the formal training I have received in assessment practices (either in college courses or professional development opportunities)
23. My teaching practices are largely influenced by the formal training I have received in classroom management practices (either in college courses or professional development opportunities)
24. My teaching practices are largely influenced by the formal training I have received concerning diversity issues (either in college courses or professional development opportunities)
25. My teaching practices are largely influenced by the formal training I have received concerning the developmental psychology of my students (either in college courses or professional development opportunities)
26. My teaching practices are largely influenced by the formal training I have received in educational technology (either in college courses or professional development opportunities)
27. My teaching practices are largely influenced by the formal training I have received in educational psychology (either in college courses or professional development opportunities)
28. My teaching practices are largely influenced by the formal training I have received in educating students with special needs (either in college courses or professional development opportunities)
29. My teaching practices are largely influenced by a particular learning theory or well-known/classic research in math education.
30. My teaching practices are largely influenced by current research findings in math education.
31. My teaching practices are largely influenced by print or online media resources that I have sought out concerning various aspects of teaching (e.g. lesson planning, assessment, engagement, motivation)
32. My teaching practices are largely influenced by the suggested content or implementation strategies offered by the textbook or other curricular materials I use.
33. My teaching practices are largely influenced by state and/or national standards.
34. My teaching practices are largely influenced by what I have come to believe worked well in the past (i.e. I refine my teaching based on my own experiences)
35. My teaching practices are largely influenced by what I believe my students will need to know for state and/or national assessment exams

36. My teaching practices are largely influenced by what I believe my students will need to know about math for college.
37. My teaching practices are largely influenced by what I believe my students need to know about math for their everyday lives.
38. My teaching practices are largely influenced by the way I personally prefer to learn math.
39. My teaching practices are largely influenced by the math content that I am personally familiar/comfortable with.
40. My teaching practices are largely influenced by the learning styles of my students.
41. My teaching practices are largely influenced by the demographic characteristics of my students

APPENDIX B: INVITATION LETTER AND INFORMED CONSENT DOCUMENT

NDSU NORTH DAKOTA STATE UNIVERSITY

Fellow Math Education Colleague,

I am writing to ask for your participation in my dissertation study that I am conducting with the Educational Doctoral Program at North Dakota State University. I am asking secondary math teachers like you to provide information about the various factors that influence teaching practices.

Your responses to this study are very important and will help in the advancing of the research literature in math education. The respondent pool for this study is quite small. I have specifically identified you as a secondary math teacher who can provide useful data.

This is a Q methodology study that is conducted similar to a survey. There will be two parts. In Part 1 you will sort a list of 41 items based on how influential you believe each to be on your teaching practices. In Part 2 you will sort the same 41 items based on how influential you believe each to be on the teaching practices of "typical" secondary math teachers. The two parts together will take you about 20-30 minutes to complete. Please be sure to complete this by **Friday, October 25th**.

Please review the attached consent form. To imply consent to participate, you can begin the Q sorts at this link: **http://www.ndsu.edu/pubweb/edp-hill/wirth/**

Your participation in this study is entirely voluntary and all of your responses will be kept confidential. Not even members of the research team will know what responses came from you. No personally identifiable information will be associated with your responses in any reports of this data. Should you have any further questions or comments, please feel free to contact me at jamie.wirth@vcsu.edu or 701-845-7734.

My dissertation work is extremely important to me. I appreciate your time and consideration in participating. It is only through contributions from secondary math teachers like you that we can successfully complete this study.

Many thanks,

Jamie Wirth
Education Doctoral Student
North Dakota State University

NDSU NORTH DAKOTA STATE UNIVERSITY

Informed Consent Information

Perceptions of Secondary Math Teachers concerning the influences on their pedagogical practices

Hello. My name is Jamie Wirth and I am a graduate student / doctoral candidate from the School of Education at North Dakota State University. I am working with Dr. Nathan Wood and Dr. Brent Hill on a research study related to the influences on the pedagogical practices of secondary math teachers.

Educational researchers have studied influences on the teaching practices of secondary math teachers, however, most of this research has involved quantitative survey data. The current research aims to explore the subjective, opinion-based data concerning these influences. That is the purpose of our study: to identify the various viewpoints that exists amongst secondary math teachers.

Because you have been identified as a secondary math teacher who can provide a valuable contribution, we would like you to complete two Q sorts of the 41 individual statements pertaining to the influences on pedagogical practices. You will be provided with a web link that will take you to a secure, online form in which you will provide instructions on how to complete the sorting process. This should take you about 20-30 minutes to complete. No identifiable information will be collected from you. Your responses will be completely anonymous. Not even members of the research team will know what responses came from you.

It is important that you understand that you have the right to decline participation in this study. Furthermore, should you start the process and choose to quit, you may do so at any time with no penalty. Please note that we do not anticipate any risks to you throughout the study. The benefits of this study for you are the satisfaction of knowing you contributed valuable information for the advancement of research in math education and the $10 incentive provided as a "thank you" for your time.

Only I, Dr. Wood, and Dr. Hill will have access to the data and it will not be shared with anyone else. If you have any questions or complaints about this study that you are not comfortable addressing to me, Dr. Wood, or Dr. Hill, you can contact the NDSU Human Research Protection Office at 701.231.8908 (Toll-free at 1-855-800-6717) or ndsu.irb@ndsu.edu.

If you have questions for me or if you would like to receive a copy of the results, please feel free to contact me. My contact information is listed below, along with Dr. Wood's and Dr. Hill's.

Thank you for your time.

My contact info: Jamie Wirth, Doctoral Candidate – NDSU Education Doctoral Program, School of Education, NDSU. Instructor, Department of Mathematics, Valley City State University, 101 College St SW, Valley City, ND 58072, (701) 845-7734, Jamie.wirth@vcsu.edu

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APPENDIX C: FOUR AND FIVE FACTOR VARIMAX ROTATION SOLUTIONS

Four Factor Matrix with an X Indicating a Defining Sort

	Loadings			
QSORT	1	2	3	4
1_1	0.2674	-0.1661	0.7924X	0.1055
1_2	0.1164	-0.0206	0.8576X	0.0124
2_1	0.1960	0.6839X	0.1641	-0.0096
2_2	0.1983	0.5706X	0.1443	0.1961
3_1	0.3001	0.5718X	0.1395	0.1649
3_2	0.7182X	0.0831	0.0350	0.3253
4_1	0.3357	0.4400	-0.0560	0.2940
4_2	0.6740X	-0.1665	0.2845	0.4971
5_1	0.0775	0.4835X	-0.0542	0.3219
5_2	0.2890	0.2832	0.5936X	0.1827
6_1	0.3288	0.5040	0.1162	0.4204
6_2	0.2283	0.1714	0.2391	0.6478X
7_1	-0.2802	0.7170X	-0.0561	0.1204
7_2	0.5317X	0.1698	0.2896	0.1373
8_1	0.5214	0.5130	0.0616	-0.2885
8_2	0.5053X	0.0472	0.0575	0.0027
9_1	0.2418	0.6302X	-0.0425	0.2598
9_2	0.4303	0.3771	0.1714	0.4032
10_1	0.7275X	0.0524	0.0825	0.0077
10_2	0.7458X	-0.0488	0.1633	-0.0122
11_1	0.4568X	0.2952	0.1040	0.2530
11_2	0.5512X	0.2007	0.1655	0.2839
12_1	-0.0011	0.5806X	0.3429	0.0191
12_2	0.4233	0.0493	0.5898	0.4674
13_1	0.1193	0.1552	0.6674X	0.3236
13_2	0.0518	0.4202	0.5796X	0.0162
14_1	-0.0558	0.2974	0.1064	0.7177X
14_2	0.0369	0.3113	0.0506	0.7834X
15_1	0.3870	0.5647X	0.1406	0.1710
15_2	0.6632X	0.3013	0.3237	0.1357
16_1	0.3981	0.4706X	0.2280	-0.0861
16_2	-0.0154	0.6478X	0.0041	0.1899
17_1	0.3209	0.2761	-0.3649	0.3596
17_2	0.4945	0.0697	0.3273	0.5726
18_1	0.0176	0.5290X	-0.0882	0.1754
18_2	0.3742	0.3312	0.1988	0.4124
19_1	0.5295X	0.3649	-0.1854	0.1157
% expl.Var.	16	16	11	11

Five Factor Matrix with an X Indicating a Defining Sort

Loadings

QSORT	1	2	3	4	5
1 1_1	0.2076	-0.1226	0.8508X	0.0279	0.0194
2 1_2	0.1092	0.0904	0.8447X	0.0055	-0.1388
3 2_1	0.1810	0.6515X	0.1242	0.0034	0.2460
4 2_2	0.2550	0.5759X	0.0646	0.2569	0.0821
5 3_1	0.2253	0.4592	0.1786	0.1006	0.4434
6 3_2	0.7147X	0.0083	0.0729	0.2665	0.2250
7 4_1	0.1636	0.1993	0.0972	0.1219	0.7469X
8 4_2	0.6120	-0.2684	0.3992	0.3663	0.2995
9 5_1	-0.0500	0.2855	0.0512	0.2063	0.6120X
10 5_2	0.1911	0.2279	0.6638X	0.0861	0.3282
11 6_1	0.3357	0.4270	0.1074	0.4111	0.2858
12 6_2	0.2710	0.1324	0.2348	0.6477X	0.1139
13 7_1	-0.2466	0.6927X	-0.1380	0.1978	0.1410
14 7_2	0.6348X	0.2561	0.1987	0.2051	-0.1679
15 8_1	0.4373	0.4425	0.0872	-0.3516	0.3626
16 8_2	0.3828	-0.0751	0.1753	-0.1363	0.4053
17 9_1	0.3559	0.6466X	-0.1673	0.3685	0.0081
18 9_2	0.5305	0.3977	0.0879	0.4687	-0.0074
19 10_1	0.7549X	0.0597	0.0699	-0.0061	0.0300
20 10_2	0.7329X	-0.0585	0.1914	-0.0674	0.0875
21 11_1	0.3840	0.1760	0.1742	0.1615	0.4066
22 11_2	0.5711X	0.1709	0.1622	0.2661	0.1369
23 12_1	0.0165	0.6112X	0.2737	0.0682	0.0707
24 12_2	0.4401	0.0631	0.5995	0.4396	0.0494
25 13_1	0.0730	0.1491	0.7052X	0.2700	0.1521
26 13_2	0.0965	0.5161	0.4926	0.0812	-0.0932
27 14_1	-0.0114	0.2339	0.0930	0.7368X	0.1562
28 14_2	0.0837	0.2286	0.0428	0.7958X	0.1975
29 15_1	0.3187	0.4547	0.1768	0.1071	0.4371
30 15_2	0.6340X	0.2623	0.3440	0.0817	0.2410
31 16_1	0.4113	0.4883X	0.1765	-0.0650	0.0961
32 16_2	-0.0053	0.5954X	-0.0413	0.2233	0.2284
33 17_1	0.1358	-0.0206	-0.1738	0.1609	0.8100X
34 17_2	0.4811	0.0000	0.3799	0.5053	0.2310
35 18_1	-0.0720	0.3813	-0.0321	0.1089	0.4789X
36 18_2	0.3279	0.2271	0.2495	0.3437	0.3628
37 19_1	0.5943X	0.3419	-0.2450	0.1554	0.0845