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Connections between Pre-service Teachers' Mathematical Dispositions and Self-efficacy for Teaching Mathematics

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Abstract

Mathematical dispositions (MD) and self-efficacy for teaching mathematics (SEFTM) are important elements of teachers' beliefs that significantly influence their behaviors and educational practices in the classroom. This study looked at relationships between pre-service teachers' (PSTs) MD and their SEFTM in connection with other descriptors related to their progress through the teacher education program and prior mathematical experiences. Survey data were collected from 238 PSTs at a midsized university in the US. Results include the finding that PSTs' intended grade-level and subject approximately mirror their MD and SEFTM: those planning to be elementary school (generalist) teachers were slightly behind both middle and high school teachers, who had more positive MD, while both elementary and middles school PSTs were slightly behind high school-level mathematics content PSTs, who had the greatest SEFTM. Additionally, MD was a strong predictor of SEFTM, and both MD and SEFTM appear to be mediated by the influence upon PSTs of their prior mathematics teachers. Implications for teacher education and avenues for further research into these associations are offered.

Introduction

Teachers' beliefs are important. "The beliefs they hold influence their perceptions and judgments, which, in turn, affect their behavior in the classroom", and therefore "understanding the belief structures of teachers and teacher candidates is essential to improving their professional preparation and teaching practices" (Pajares, 1992, p. 307). Moreover, as the consensus of what constitutes school mathematics is perennially revisited and refined, such as is seen in the recent Common Core State Standards in Mathematics (CCSSM) in the United States which places great emphasis on mathematical processes, beliefs will increasingly "play a critical role not only in what teachers teach but in how they teach it" (Battista, 1994, p. 462). In the preparation of teachers, defining the mathematical knowledge needed for teaching and being able to measure the extent to which teachers possess it can inform decisions made by teacher educators, educational administrators and policy-makers (Hill, Ball, Sleep, & Lewis, 2007). However, when it comes to what actually happens in the classroom, it may be that teachers' beliefs are "far more influential than knowledge in determining how individuals organize and define tasks and problems and are stronger predictors of behavior" (Pajares, 1992, p. 311).

For mathematics teacher educators, a great part of their work involves influencing how pre-service teachers (PSTs) think about mathematics and how they see themselves in relation to mathematics. Through their experiences in mathematics content and methods courses PSTs expand their mathematical knowledge and these experiences can often challenge their beliefs about the nature of mathematics and about themselves as teachers of mathematics, at times confirming and at other times disrupting their views. Raymond (1997) argued that "teacher education programs would have a stronger indirect effect on practice if they focused on influencing the beliefs of prospective teachers" (p. 572). However, teachers' beliefs are so complex; being composed of numerous subdomains, which are intertwined and related to each other, including beliefs about the learning and teaching of mathematics, about mathematics assessment and achievement, attitudes or dispositions towards mathematics, pedagogical beliefs, beliefs about the teacher's role in the classroom, and beliefs about one's own ability to do mathematics or to effectively teach mathematics (Beswick, 2012; Nespor, 1987; Upadyaya & Eccles, 2014).

Upon which of these domains then should the educator preparation program apply its efforts? Kagan (1992) drew attention to particular components of teachers' beliefs that have been seen to most highly correlate with classroom outcomes. The first of these is teachers' sense of self-efficacy; that is, their general expectation about the kind of influence they will have on students and their beliefs about their own abilities to effectively complete their professional tasks. The second component is teachers' content-specific beliefs, including the ways in which they orient themselves to specific academic content domains. Partially informed by Kagan's work, the observational study reported in this paper attempted to describe the relationship between these two classes of teachers' beliefs while focusing on PSTs who were enrolled in university-level mathematics content courses.

In particular, this study builds on previous work that has defined intrinsic components of teachers' belief and adds to this work by considering how teachers' beliefs about mathematics and about themselves as teachers of mathematics vary among diverse levels of college mathematics students studying to be teachers. A more clear understanding of the ways in which these beliefs vary among diverse categories of pre-service teachers is absent in the literature, which absence this study aims to ameliorate at least in part. The following section develops the constructs of teachers' beliefs that were central to the study and explains its theoretical framework, leading up to the research questions that guided the study.

Review of Literature

What is the difference between belief and knowledge? The two are closely related. Philippou and Christou (1998) explain the complexity of beliefs as a combination of both subjective knowledge and also feelings about the object or person known. Pajares (1992) differentiates them in this way: "Belief is based on evaluation and judgment; knowledge is based on objective fact" (p. 313). The former is more objective and structured in nature, while beliefs are subjective, being based on the individual's attitudes, values, and experiences. Furthermore, in explaining the relationship between knowledge and beliefs, Nespor (1987) argued for the difference between knowledge in a domain and feelings about that domain by explaining that, at a higher level, beliefs help in clearly defining the goals and tasks upon which domain knowledge may then be applied for carrying out those goals. Alternatively, it has also been observed of PSTs that, although they may believe in certain attributes of good mathematics teaching, they may be unable to successfully apply these in the classroom because of superficial or fragmented content knowledge and limited experience, or rejection of the teachers' responsibility to consistently improve their understanding of mathematics (Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992).

Since beliefs play such an influential role in the creation, development, and progression of attitudes, practices and even knowledge, teachers' beliefs have received much attention in the last few decades, some researchers focusing on in-service teachers' beliefs (Raymond, 1997), while others on the connections between preservice teachers' (PSTs) beliefs and constructivist teaching practices (Savasci & Berlin, 2012; Temiz & Topcu, 2013), and showing that the beliefs held by teachers significantly influence their behavior and educational practices in the classroom (Fenstermacher, 1986; Munby, 1982; Nespor, 1987). Note that in this study, a preservice teacher is defined as a university student enrolled in a university educator certification program, while an in-service teacher is defined as a certified teacher employed by a school district. By defining four components of belief – existential presumption, affective and evaluative loading, and episodic structure – Nespor (1987) showed how teachers' beliefs help them to define teaching tasks, organize knowledge and sort through relevant (and irrelevant) information in the "ill-defined and deeply tangled" (p. 324) context of the teaching profession. Furthermore, beliefs, such as those about mathematics, come from personal experiences with mathematics and include personal judgements about the nature of mathematics and about what it means to learn and teach mathematics, directly influencing teachers' mathematical teaching practices (Raymond, 1997). Consequently, understanding the beliefs that mathematics teachers and prospective teachers hold is essential, especially since teachers' beliefs can impact not only their teaching practices but also their students' academic progress, as, for instance, may happen when teachers accept (or reject) new curriculum innovations (Behar-Horenstein, Pajares, & George, 1996).

Mathematics Teachers' Beliefs

Over the years, some progress has been made in understanding how mathematics teachers' beliefs are constructed, how they change and how teachers' beliefs and past experiences can impact their own and their students' self-efficacy in mathematics. Cooney, Shealy, Arvold (1998) used constructivism and Green (1971) supported three dimensions of belief systems to describe PSTs' beliefs about mathematics and about the learning and teaching of mathematics. Related to this work was Andrews and Hatch's (1999) classification of teachers' conceptions of mathematics as being either: an economic tool, a diverse and pleasurable activity, an essential life tool, or a service provider to other careers. The teachers in the study also saw the teaching of mathematics as either process-oriented or skills-oriented, and characterized by either the establishment of individualized working practices for students, the creation of a cooperative and collaborative classroom, or the creation of a mathematically enriched classroom. In the attempt to describe and classify teachers' beliefs, however, things may not be as well-defined as theory would seem to imply. There is the real possibility of confounding teachers' professed beliefs with their attributed beliefs, i.e., those beliefs that are attributed to teachers by observers and not necessarily professed (or indeed actually or deeply held) by teachers (Speer, 2005).

Notwithstanding this limitation in research methods, studies have shown that mathematics teachers' beliefs are reflected in their teaching practices and even in their students' positive (or at times negative) experiences in the classroom (Stipek et al., 2001). Fortunately, mathematics teachers' beliefs can change (Beswick, 2006; Charalambous, Panaoura, & Philippou, 2009; Peterson, Fennema, Carpenter, & Loef, 1989) and even more positive conceptions can result from carefully crafted interventions. For instance, Wilcox, Schram, Lappan, and Lanier (1991) involved novice teachers in a two year intervention focused on number theory, geometry, and probability and statistics with the surprising results that teachers' perceptions about the role of small-group work and of non-routine problems improved. Similarly, using student interviews and online discussion, Lannin and Chval (2013) observed that elementary-level PSTs moved from a view of mathematics as static, disconnected facts toward seeing mathematics as dynamic activity involving difficult and sense-making tasks for elementary students.

It is in the effort to change and improve PSTs' attitudes toward mathematics that Philippou and Christou (1998) observed the limiting effect that efficacy beliefs play in influencing a person's efforts, persistence, and self-confidence when pursuing goals, facing challenges, and performing new tasks. For instance, self-efficacy beliefs are often a result of prior experience and PSTs' past experiences, existing opinions of testing, and views on the future use of testing, which influence the self-judgments they make about their own testing ability (Beghetto, 2005).

Given the importance of mathematics teachers' beliefs in connection with their practices as well as the potentially mediating role that teachers' self-confidence or sense of self-efficacy might play in connection to teachers' ability to implement practices that align with their beliefs, the purpose of this study was to investigate more directly the relationship between these two elements of teachers' belief: beliefs about mathematics and beliefs about themselves as teachers of mathematics. There are several reasons why investigating the relationship between these two elements might be important. Firstly, it seemed likely that more positive beliefs about the nature of mathematics may be related, even possibly predictive, of greater self-efficacy in teaching mathematics. In this case, one approach to strengthening teachers' self-efficacy in the mathematics classroom might be to support their development of more positive and productive mathematical attitudes and dispositions. Consequently, findings that connect mathematical dispositions and self-efficacy may also have import for the design of experiences for PSTs at the university and for the continuing education of in-service teachers. In the subsequent section, we clarify the theoretical framework that guided the study, resulting in our particular usage of the constructs of teachers' mathematical dispositions and self-efficacy for teaching mathematics.

Theoretical Framework

Raymond defined mathematics teachers' beliefs as "personal judgments about mathematics formulated from experiences in mathematics, including about the nature of mathematics, learning mathematics, and teaching mathematics" (1997, p. 552). Within this perspective on beliefs, and drawing upon findings discussed above regarding teachers' beliefs about mathematics content and about the importance of teachers' sense of self-efficacy for teaching mathematics as two kinds of beliefs particularly important for teachers' practice (Kagan, 1992), we defined for this study two belief constructs of focus: mathematical disposition (MD) and self-efficacy for teaching mathematics (SEFTM), each of which is composed of a smaller sets of beliefs. The purpose of this section is to elaborate these constructs as the theoretical framework of the study.

Mathematical Disposition (MD)

There is evidence that students' experiences in the classroom with mathematics teachers can affect their mathematical dispositions (MD) and that such dispositions impact academic achievement (National Research Council, 2001; Singh, Granville & Dika, 2002; Nicolaidou & Philippou, 2003; Sanchez, Zimmerman & Ye, 2004). When speaking about MDs, an important emphasis concerns the development of positive or productive MDs, versus the consequences of developing or perpetuating negative or unproductive MDs (see Feldhaus, 2014; and Mata, Monteiro & Peixoto, 2012, for instance). At the simplest level a "positive attitude towards mathematics reflects a positive emotional disposition in relation to the subject and, in a similar way, a negative attitude towards mathematics relates to a negative emotional disposition" (Mata, Monteiro & Peixoto, 2012, p. 2).

Like teachers' beliefs, their MDs are complex, not referring to a biological or inherited traits but "more akin to a habit of thought, one that can be learned and, therefore, taught" (Resnick, 1987, p. 41). The National Research Council defines a productive MD as "the tendency to see sense in mathematics, to perceive it as both useful and worthwhile, to believe that steady effort in learning mathematics pays off, and to see oneself as an effective learner and doer of mathematics" (2001, p. 131). In discussing the teacher's role in developing such dispositions in their learners, NCTM's Professional Standards for Teaching Mathematics (1991) argues that teachers should facilitate students' flexibility, inventiveness, and perseverance in engaging mathematical tasks and in their demonstrating confidence in doing mathematics. In this study, we defined teachers' MDs, including the complex habits of thought that lead to productive attitudes and actions toward mathematics teaching, as being composed of three classes of beliefs: beliefs about the nature and usefulness of mathematics, beliefs about the learning of mathematics, and beliefs about the importance of perseverance in becoming successful in mathematics.

Concerning teachers' beliefs about the nature and usefulness of mathematics, Reuben Hersh argued that, "One's conception of what mathematics is affects one's conception of how it should be presented. One's manner of presenting it is an indication of what one believes to be most essential in it." (1979, p. 33). Furthermore, not only do teachers' beliefs about the nature of mathematics directly affect their instruction (Cooney, 1985) but societal beliefs about mathematics also play a role in shaping school curriculum (Dossey, 1992). Some teachers believe (and teach) mathematics to be a static body of knowledge and skills in need of mastery by students while others present the subject as a more dynamic, fluid, problem-motivated, and multilayered subject in need of students' active doing (Dossey, 1992; Wilkins & Ma, 2003). Importantly, these views of the nature of mathematics translate into students' views of the usefulness in (and hence their motivation for) doing mathematics. Students of teachers that present mathematics as static and boring may not see usefulness in studying it (Wilkins & Ma, 2003) while teachers that hold positive views about the nature and usefulness of mathematics are in a very good position to positively change their students' sense of the usefulness of mathematics, their motivation and even achievement in mathematics (Sherman & Fennema, 1977; Perl, 1982; Reyes, 1984). Consequently, positive MDs include beliefs in mathematics as being dynamic (rather than static), as applicable to real life (rather than irrelevant) and as a useful (rather than meaningless) academic pursuit.

Teacher's beliefs about the learning of mathematics fall generally under two broad categories: behaviorist perspectives and constructivist perspectives. The former perspective focuses on the stimulus and its resulting responses with emphasis on reinforcement of desired [mathematical] behaviors (Skinner, 1974), which has been criticized as promoting passive rather than active learning by placing students as merely reactive agents instead of active discoverers (Ertmer & Newby, 1993). Obtaining mathematical knowledge requires critical thinking and active problem solving on the part of the learner (Bonotto, 2013; Gelven & Stewart, 2001; McCormack, 1984): "Knowledge is not received from the outside or from someone else; rather, it is the individual learner's interpretation and processing of what is received through the senses that creates knowledge. The learner is the center of the learning, with the instructor playing an advising and facilitating role." (Ally, 2004, p. 30). For this reason, teachers cannot rely on only one instructional method (Can, 2006), but need to employ multiple perspectives, examples and explanations, and challenging activities that can facilitate their students' knowledge construction (Alsup, 2005; Cobb, Yackel, & Wood, 1993; Steffe & Gale, 1995). Consequently, positive MDs include beliefs about the learning of mathematics that align with constructivism by accepting the multiple (rather than singular) ways of learning and teaching the subject and promoting students' active (rather than passive) discovery of knowledge through their deep reflection on concepts (more than memorization of facts and algorithms).

A final component of teachers' positive MD is their beliefs concerning the need of perseverance in mathematics. The National Council of Teachers of Mathematics (NCTM) standards state that "students should have frequent opportunities to … grapple with, and solve complex problems that require a significant amount of effort… and to … acquire habits of persistence and curiosity, and confidence in unfamiliar situations…" (2000, p. 52). Struggling with complex and challenging problems is at the heart of doing mathematics and teachers should allow their students to experience productive struggle, rather than to save them from this valuable conceptual work, thereby reducing their work to mere numerical manipulations (Warshauer, 2015). Such struggle requires persistence and is closely connected to constructivist learning in the way that it results in students forging connections of new learning with prior knowledge and constructing interpretations for their new findings

(Hiebert & Grouws, 2007). But while some students are not aware of the need for such struggle, believing instead that to be good at mathematics one should be able to solve problems with very little time and effort (Clarke & Clarke, 2003), others have found the connection between perseverance and success, and resulting rewards, in mathematics (Schinck et al., 2008). Consequently, teachers with more positive MDs may be those who believe that mathematical problems and tasks often requires significant (rather than brief) investments of time and effort, that mathematical knowledge and ability is the product of perseverance in difficult mathematical work (rather than any innate or inherited skill), and that all students (rather than only some math people) are capable of learning mathematics at a deep, conceptual level.

Self-efficacy for Teaching Mathematics (SEFTM)

In addition to MD, the second principle element of mathematics teachers' beliefs considered in this study is that of self-efficacy for teaching mathematics (SEFTM). Bandura defined self-efficacy as "one's capabilities to organize and execute the courses of action required to manage prospective situations" (1997, p. 2), which includes the allocation of efforts to effect outcomes in life as well as the thoughts and emotions that guide motivations and behaviors, and also one's beliefs that desired outcomes can (or indeed cannot) be realized (Pajares, 1996). In the context of teaching, self-efficacy relates to teachers' self-evaluation of their ability to impact and promote their students' learning (Guo et al., 2012; Dembo & Gibson, 1985) and to affect their students' performance (Pajares, 1992). As mentioned earlier, teachers' self-efficacy is important since it has been linked to students' academic achievement (Guo et al. 2012; Ashton & Webb, 1986).

Furthermore, since self-efficacy beliefs involve the estimation of one's ability to achieve desired results, they also influence efforts expended and "are strong determinants and predictors of the level of accomplishment that individuals finally attain" (Pajares, 1996, p. 545). Bandura's (1977) classification of self-efficacy along the two lines of efficacy expectations and outcome expectations was applied to teaching by Coladarci (1992) who explained that teachers' efficacy expectations refer to their beliefs in their own ability to enact appropriate instruction for effecting positive changes in children while teachers' outcome expectations are their beliefs that such instruction can and will in fact realize those changes in students. In this study, we consider SEFTM to work along these two lines which we refer to as their general teaching efficacy (outcome expectations) and their personal teaching efficacy (efficacy expectations). As Matney and Jackson (2017) point out, these two dimensions have been frequently referenced in the research literature and "The level of efficacy for these two dimensions may vary for each teacher" (p. 173).

General teaching efficacy involves the belief that effective teaching will positively affect students' learning (Enochs et al., 2000). Such beliefs also influence teachers' selection of curriculum materials and instructional activities because they inform the perceived effort required of them to enact the curriculum as well as their estimation that their students will meet the challenge of the chosen activities (Philippou & Christou, 1998). Perhaps not surprisingly, researchers (Chester & Beaudin, 1996; Dembo & Gibson, 1985) have found that teachers having strong beliefs in the efficacy of teaching conducted more whole-class instruction and were also better able to sustain the engagement of other students while instructing small groups, and to support low-achieving students. For this study, general teaching efficacy is characterized by teachers' belief in their responsibility for students' learning of mathematics in addition to their belief that the application of additional efforts toward effective instruction will result in improved student motivation and achievement in mathematics, and that students' underachievement may be a direct result of ineffective teaching.

The second component of SEFTM, personal teaching efficacy, involves teachers' personal sense of agency in their classroom; that is, their belief in their own ability or inability to effect positive results through personal actions in the classroom (Chester & Beaudin, 1996). Teachers' beliefs in their own ability to bring about the change in their students that they desire is important since this self-efficacy (manifested in self-confidence) has been shown to relate to their development of a classroom environment that is both secure and accepting of all students, while being supportive of individual needs and students' initiatives (Dembo & Gibson, 1985). For instance, Ross and Bruce (2007) found that teachers with high-efficacy used classroom management styles that stimulated students' autonomy and also supported low achieving students by building good relationships with them and setting higher academic standards for them than low-efficacy teachers did.

Moreover, high personal teaching efficacy is manifested in the way that such teachers handle failure, viewing it "as an incentive for greater teacher effort rather than conclude that the causes of failure are beyond teacher control and cannot be reduced by teacher action (Ross & Bruce, 2007, p. 51). Finally, personal teaching efficacy is important since this kind of efficacy influences decisions regarding the amount of effort to expend as well as persistence in the face of adversity (Zeldin & Pajares, 2000). Consequently, it would seem that personal teaching efficacy might inform teachers' commitment to an attitude of perseverance in doing mathematics, which we have previously argued is a component of MD. We close our discussion of the theoretical framework with a visual model (Figure 1) of the variables of teachers' beliefs that we have just presented as components of MD and SEFTM.

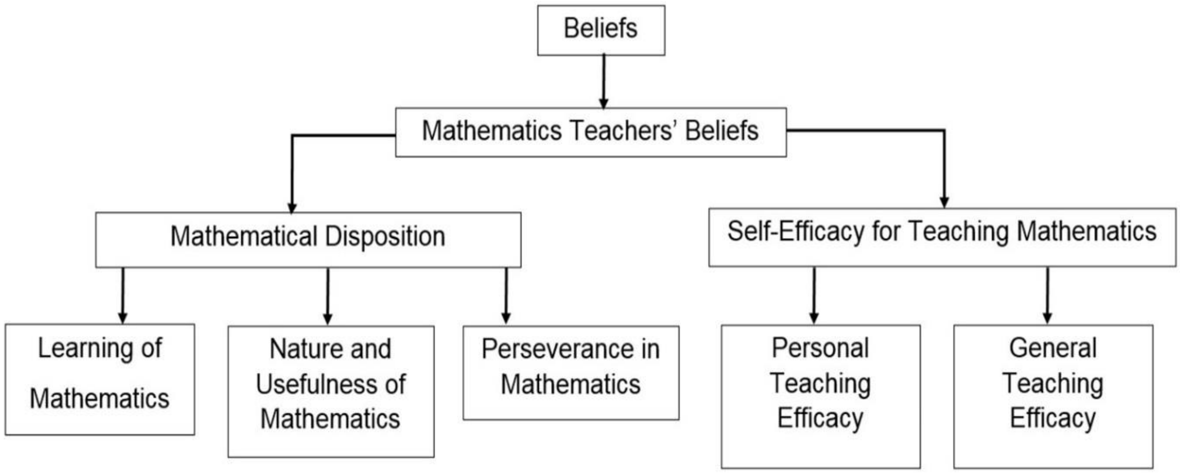

Figure 1. Theoretical framework of mathematics teachers' beliefs

Research Questions

The theoretical framework of this study identifies MD and SEFTM as two important components of mathematics teachers' belief systems. As we have argued, both MD and SEFTM play important roles in teachers' enactment of their responsibilities and in the student outcomes that they achieve. Consequently, these two variables garnered our attention as points of possible influence for improving the prospects of novice teachers having success in their work. In particular, we aimed to understand more fully how MD and SEFTM occur among PSTs who are studying to become elementary, middle or high school teachers and how these belief constructs might be related. Subsequently, the research questions that guided the study included:

1. How do MD and SEFTM differ among PSTs based on the school level and subject they intend to teach, their age and classification in college, as well as the perceived influence of their prior mathematics teachers upon them?
2. For PSTs, what association between MD and SEFTM exists?

Method

The method chosen to approach these questions was quantitative; and a survey was developed and administered to a sample of PSTs. This section defines the qualities of the selected sample and explains the instrument development, including reliability and normality of the measures.

Participants

After we obtained IRB approval of the study, 236 participants from a midsized public university in the southwestern United States were recruited on a volunteer basis and participated in this study. Table 1 gives descriptive statistics regarding the age and gender of these participants as well as several other variables, including the grade level and content area for which they pursued teacher licensure, their university classification, and also the participant's perspective on their prior mathematics teachers' influence on them. Notice that out of the 236 total survey participants, the majority were females, and a little more than half of them were elementary-level PSTs, and about half of them were studying to become "generalists", that is, elementary school teachers that teach all subjects. Less than 10% of the participants were males, with most pursuing licensure for teaching secondary (middle or high) school levels, teaching mathematics or science, and a small number pursuing elementary licensure.

Table 1. Summary of all preservice teacher participants (N=236)

	Elementary	Grade Level Middle School	High School	
Subject				Total (%)
Generalist	133	0	0	133 (56%)
Mathematics	6	54	24	84 (36%)
Science	0	8	11	19 (8%)
Total (%)	139 (59%)	62 (26%)	35 (15%)	236 (100%)
Gender				Valid Total (%)
Missing	*3*	*3*	*1*	*7*
Male	5	25	12	42 (8%)
Female	131	34	22	187 (82%)
Valid Total (%)	136 (59%)	59 (26%)	34 (15%)	229 (100%)
Classification				Valid Total (%)
Missing	*6*	*1*	*0*	*7*
Freshman	5	0	0	5 (2%)
Sophomore	37	9	4	50 (22%)
Junior	66	26	16	108 (47%)
Senior	25	26	15	66 (29%)
Valid Total (%)	133 (58%)	61 (27%)	35 (15%)	229 (100%)
Age				Valid Total (%)
Missing	*0*	*0*	*1*	*1*
18-21	112	29	21	162 (69%)
22-25	16	20	12	48 (20%)
26-30	5	8	0	13 (6%)
31+	6	5	1	12 (5%)
Valid Total (%)	139 (59%)	62 (26%)	34 (14%)	235 (100%)
Influence				Total (%)
Negative	8	0	2	10 (4%)
Neutral	40	19	10	69 (29%)
Positive	91	43	23	157 (67%)
Total (%)	139 (59%)	62 (26%)	35 (15%)	236 (100%)

Data Collection Tool

The survey instrument (see Appendix) used in this study closely aligned with the theoretical framework as detailed in previous section. It consisted of fifty 5-point Likert-scale items, with ten items for each of the three components of MD and ten items for each of the two domains of SEFTM. Moreover, of the ten items in each component, five were positively worded and five were negatively worded (and reverse-coded for analysis), so as to avoid acquiescence bias (DeVellis, 2012). The items in the survey were adapted from instruments used previously by researchers concerned with teacher beliefs and from findings concerning teacher beliefs that informed the constructs MD and SEFTM as they were defined in this study. For instance, several items in Section 1, 2, and 3 of the instrument were adapted from classifications of beliefs about the nature of mathematics from Raymond (1997) and from the Modified Fennema-Sherman mathematics attitude scale (Doepken, Lawsky, & Padwa, 2004).

Items concerning the learning and teaching of mathematics were adapted from Kloosterman & Stage (1992) and several teaching efficacy items were adapted from Enochs, Smith, & Huinker (2000) as well as Chester & Beaudin (1996). Items were adapted for the survey because of their clarity and utility to serve as indicators of MD and SEFTM, as based upon the “face validity” perceived by the researchers. For the reader’s convenience, the entire research instrument is included in the Appendix. We report that the internal consistency of the survey and its subscales ranged from good to acceptable (George & Mallery, 2003), with Cronbach $\alpha = 0.82$ for the first 30 items, which composed the MD scale, and $\alpha = 0.72$ for the later 20 items, composing the SEFTM scale, and $\alpha = 0.86$ for all 50 items of the survey. The combination of these items from such diverse instruments to form a single instrument that aligns with the theoretical framework proposed here is also a contribution of this study.

Data Collection

The 236 participants individually completed a pen and paper form of the survey under the administration of research staff at the conclusion of a class meeting in one of their education courses. Students were told that the survey was part of a study investigating the connections between MD & SEFTM of preservice teachers. To ensure that no participant turned in more than one survey, and the beginning of each recruitment session, the research staff asked all students who had already taken the survey in another class/course to exit the room, leaving behind only those who had not yet taken the survey. Preservice teachers were informed that participation in the survey was optional and participants completed surveys independently and without communicating with other participants during data collection.

Data Analysis

As the main outcome variable of interest, MD and SEFTM scores were computed for each participant as the sum of entries across all survey items intended to capture those two respective domains. Other factors considered include age, gender, grade level and content area for which they pursued teacher licensure, university student classification, and also participants' perspectives on their prior mathematics teachers' influence on them. The method of person mean substitution (PMS) was used to impute missing values (Downey & King, 1998), of which there were very few. The smallest and largest MD score a participant could make was 30 and 150 respectively, while the smallest and largest SEFTM score a participant could make was 20 and 100 respectively.

Statistical procedures used in this study required meeting conditions such as normality of distribution and/or homogeneity of variance in the data. Our data satisfied these conditions, as verified via the Shapiro-Wilk test and Leven's F test, respectively. For this study, ANOVA, pairwise comparison post hoc tests using the Bonferroni method, and multiple linear regression were utilized to investigate our research questions. Regression diagnostics were performed prior to the regression analyses. When reporting significance, we used the most commonly accepted level of significance, 0.05. In addition to report significance of hypotheses testing, we also report effect size that measures the size of difference or the proportion of total variance attributed to a given factor.

Results

Variations in Mathematical Dispositions (MD) and Self-efficacy for Teaching Mathematics (SEFTM)

In answering the first research question we initially sought to know if and how PSTs differed in the measures of MD and SEFTM based upon the level of school at which they intended to teach (elementary, middle, or high school), the subject they intended to teach (generalist or all subjects, mathematics, or science), their age, their progress in college (classification), the perceived influence of their prior mathematics teachers, and their gender. Based upon the research questions for this study, those are the variables for which data was collected using the survey instrument designed for this study. In this section we analyze differing scores on the MD and SEFTM scales that occurred among a series of pairwise comparisons of PST groups. To begin with, one-way ANOVA tests indicated that there were significant differences between the mean MD and mean SEFTM scores between PST groups differentiated according to their intended teaching grade-level, whether elementary, middle or high school ($F_{2,\,232}$ = 13.054, p < 0.001 for MD, and $F_{2,\,232}$ = 6.168, p = 0.002 for SEFTM) and the effect sizes turned out to be small (η^2 = 0.10 and η^2 = 0.05, respectively). Table 2 presents the full ANOVA tables for these results. Furthermore, Figure 2 suggests that the difference in MD scores potentially exists especially between elementary PSTs and the two secondary groups of middle and high school PST. However, in contrast to the MD scores, the elementary PSTs' SEFTM scores almost caught up to that of middle school PSTs, while both were still lower than the high school PSTs.

Table 2. ANOVA comparison of means by teacher level

	MD					SEFTM				
	Sum of Squares	df	Mean Square	F	Sig.	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2753.684	2	1376.842	13.054	.000	693.588	2	346.794	6.168	.002
Within Groups	24469.119	232	105.470			13043.536	232	56.222		
Total	27222.803	234				13737.124	234			

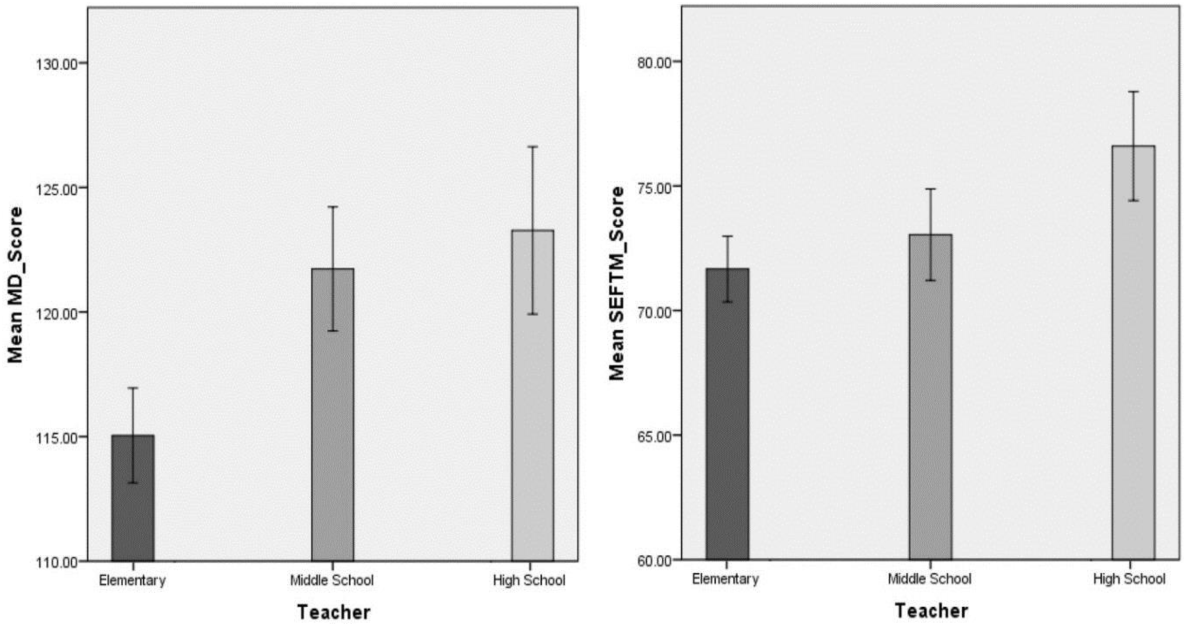

Figure 2. MD and SEFTM by teacher level

To understand these potential differences more precisely, Table 3 presents a series of post hoc test results that compared different groups of PSTs with their respective MD and SEFTM scale scores. In the discussion that follows, results for both MD are presented first followed by those for SEFTM. After this, we return to consider the combined effect of the teacher variables on MD and SEFTM as well as the associations that existed between these two variables.

The findings in Table 3 confirmed that the MD of elementary teachers were statistically significantly lower than the MD of both middle school and high school PSTs but that there was no significant difference between mean MD scores of middle school and high school PSTs. Furthermore, the difference in MD between elementary PSTs and the two secondary PST groups was illustrated by the relative confidence intervals of the means for these different groups: there was almost a 3-point difference between the upper bound of the CI (confidence interval) of the mean MD scores of elementary PSTs compared to the lower bound of the CI of mean MD scores of middle and high school PSTs.

Several other findings concerning MD are of interest in Table 3. In particular, PSTs' MD varied by content area. On average, preservice mathematics teachers scored 9 points higher (mean = 123.82) than did preservice generalists (mean = 114.84) and preservice science teachers (mean = 114.66). These differences were statistically significant ($p < 0.01$) while there was no statistically significant difference between the mean MD scores of generalists (all of whom were elementary teachers) and preservice science teachers ($p =.998$).

Furthermore, as Table 3 shows, there were also observable differences in MD related to age and to classification (freshman, sophomore, junior, senior). On average, PSTs in the age range of 22-25 years scored 5-6 points higher on the MD scale than did preservice teachers in the range of 18-21 years, mean = 122.57 and 116.61, respectively, with $p < 0.05$. Additionally, senior PSTs scored the highest in the MD scale, scoring an average of 15 points higher (mean = 122.14) than freshman PSTs (mean = 107.21), 8 points higher than sophomore PSTs (mean = 114.90), and 5 points higher than junior PSTs (mean = 117.27). No other statistically significant differences between mean MD scores were observed on the bases of age and classification.

There was also evidence that PSTs' MD scores were related to the influence of past mathematics teachers. Survey respondents self-identified with one of three types of influence that "most of their past mathematics teachers had made upon" them: negative, neutral, and positive. On average, PSTs who claimed to have been positively influenced by former math teachers scored higher (mean = 119.90) in the MD scale than did PSTs who felt that their former math teachers had a neutral influence (M = 114.11).

Table 3. Pairwise post-hoc analyses of differences in MD and SEFTM, using Bonferroni method

		MD					SEFTM				
		Mean Diff. (I – J)	Std. Error	Sig.	95% CI Lower	Upper	Mean Diff. (I – J)	Std. Error	Sig.	95% CI Lower	Upper
(I) Level	*(J) Level*										
Elementary	Middle School	-6.683*	1.641	.000	-10.639	-2.727	-1.377	1.143	.688	-4.134	1.379
	High School	-8.228*	2.032	.000	-13.127	-3.329	-4.934*	1.416	.002	-8.348	-1.52
Middle School	High School	-1.546	2.271	1.000	-7.023	3.932	-3.557	1.583	.077	-7.373	.260
(I) Subject	*(J) Subject*										
Mathematics	Generalist	8.986*	1.459	.000	5.467	12.51	3.717*	1.039	.001	1.211	6.222
	Science	9.163*	2.660	.002	2.748	15.58	4.416	1.894	.062	-.151	8.983
Generalist	Science	.176	2.568	1.000	-6.017	6.369	.699	1.829	1.000	-3.710	5.189
(I) Age	*(J) Age*										
18-21 yrs.	22-25 yrs.	-5.958*	1.820	.007	-10.802	-1.114	-5.600*	1.210	.000	-8.821	-2.38
	26-30 yrs.	-4.867	3.193	.773	-13.365	3.630	-.914	2.122	1.000	-6.563	4.735
	31+ yrs.	.864	3.314	1.000	-7.955	9.683	.221	2.203	1.000	-5.642	6.084
22-25 yrs.	26-30 yrs.	1.091	3.463	1.000	-8.126	10.31	4.6864	2.302	.258	-1.441	10.82
	31+ yrs.	6.822	3.575	.346	-2.692	16.34	5.821	2.377	.090	-.504	12.15
26-30 yrs.	31+ yrs.	5.731	4.434	1.000	-6.070	17.53	1.135	2.948	1.000	-6.712	8.980
(I) Classification	*(J) Classification*										
Freshman	Sophomore	-7.694	5.162	.825	-21.430	6.046	.183	3.551	1.000	-9.269	9.634
	Junior	-10.066	5.034	.280	-23.466	3.334	-2.901	3.463	1.000	-12.12	6.317
	Senior	-14.94*	5.104	.023	-28.524	-1.349	-4.540	3.511	1.000	-13.88	4.806
Sophomore	Junior	-2.373	1.882	1.000	-7.383	2.638	-3.084	1.295	.108	-6.531	.363
	Senior	-7.243*	2.063	.003	-12.735	-1.751	-4.723*	1.419	.006	-8.501	-.945
Junior	Senior	-4.870*	1.719	.030	-9.447	-.293	-1.639	1.183	1.000	-4.787	1.509
(I) Influence	*(J) Influence*										
Positive	Negative	4.357	3.592	.679	-4.306	13.02	2.868	2.451	.730	-3.043	8.779
	Neutral	5.791*	1.591	.001	1.954	9.627	3.376*	1.086	.006	.758	5.994
Negative	Neutral	1.433	3.727	1.000	-7.554	10.42	.5078	2.543	1.000	-5.625	6.641
(I) Gender	*(J) Gender*										
Male	Female	4.700*	1.910	.015	.9362	8.462	2.976*	1.287	.022	.440	5.511

Differences are significant at the .05 level.
Differences reported for the variable "Gender" represent results of independent samples t-test

Surprisingly, there was a statistically significant difference between the mean MD scores of PSTs who selected 'positive influence' compared to those who selected 'neutral influence'; yet, there was no statistically significant difference between the MD scores of those who selected 'positive influence' to those who selected 'negative influence'. There was also no significant difference between the MD scores of PSTs who considered former math teachers to have had a negative or neutral influence on them. We offer a possible explanation for this finding in the discussion below. Finally, there was also an observable gender effect on MD; on average, male PSTs scored 4.7 points higher (mean = 121.88) on the MD scale than did female PSTs (mean = 117.18), $p < 0.05$.

We turn now to discuss the results regarding SEFTM that are seen in the pairwise comparisons given in Table 3. As indicated in the bar graphs of Figure 2, there is evidence that measures of SEFTM in preservice elementary teachers were statistically the same as for middle school level PSTs. Moreover, Table 3 shows a statistically significant different between the mean SEFTM scores of elementary and high school PSTs, yet the difference in mean SEFTM scores of middle and high school PSTs was nearly, but not quite, statistically significantly different ($p = 0.077$). These results are also explained by the relative overlapping of confidence intervals for estimated means seen in Figure 2; CIs for elementary and middle school PTSs clearly overlap, and slightly overlap for middle and high school level PSTs, but they are totally disjoint for elementary and high school PSTs.

Furthermore, when considering their intended teaching subject, PSTs who planned to teach mathematics scored (mean = 75.21) roughly 4 points higher than preservice generalists (mean = 71.49) and 5 points higher than preservice science teachers (mean = 70.79) on the SEFTM scale. There was also a statistically significant difference ($p < .05$) between the mean SEFTM scores of mathematics preservice teachers and generalist preservice teachers. There was no statistically significant difference between the mean SEFTM scores of generalists and science preservice teachers and between the mean SEFTM scores of mathematics and science preservice teachers, though it was very close to being significant ($p = 0.062$).

We also observed some variation in self-efficacy on the bases of PSTs' age. On average, preservice teachers in the 22-25 yrs. age range, scored 5-6 points higher (mean = 77.15) on the SEFTM scale than did preservice teachers in the 18-21 yrs. (mean = 71.55), 26-30 yrs. (mean = 72.47), and 31+ yrs. (mean = 71.33) age range.

However, this difference in the SEFTM scores was only statistically significant ($p < 0.001$) between the two groups of PSTs in the 18-21 yrs. age range and 22-25 yrs. age range; difference between no other age ranges were found to be statistically significant.

Additionally, sophomore preservice teachers generally scored the lowest (mean = 69.90) in the SEFTM scale, closely followed by freshman preservice teachers (mean = 70.08), junior preservice teachers (mean = 72.98), and then senior preservice teachers (mean = 74.62). Senior preservice teachers scored statistically significantly higher than sophomore preservice teachers. No other category interaction was found to be statistically significant.

We also observed that PSTs' impression of the influence of their former mathematics teachers played a part in differentiating their SEFTM scores. On average, preservice teachers who had been positively influenced by former math teachers scored higher (mean = 73.87) on the SEFTM scale than did PSTs who were negatively influence by former math teachers (mean = 71.00) or who felt that their former math teachers had a neutral influence (mean = 70.49). Again, there was a statistically significant difference between the mean SEFTM scores of preservice teachers who selected 'positive influence' compared to those who selected 'neutral influence' and no statistically significant difference between the SEFTM scores of those who had selected 'positive influence' versus 'negative influence'. There was no significant difference between the SEFTM scores of preservice teachers who considered former math teachers to have had a negative or neutral influence on them. Finally, there was also an observable gender effect on SEFTM; on average, male PSTs scored 2.9 points higher (mean = 75.02) on the SEFTM scale than did female PSTs (mean = 72.04).

Associations between PSTs' Mathematical Dispositions (MD) and their Self-efficacy for Teaching Mathematics (SEFTM)

Having found several interesting associations between teacher variables and the measures of mathematical dispositions (MD) and self-efficacy for teaching mathematics (SEFTM), we ultimately wanted to know what was the combined effect of these variables upon those measures as well as to what extent the two measures were correlated. Our research hypothesis was that a preservice teacher with a strongly positive mathematical disposition would also have a high self-efficacy for teaching mathematics. Hence, we investigated the relative contribution of the teacher variables with respect to MD and SEFTM, as well the association between MD and SEFTM, using linear regression.

Initially we sought to model MD and SEFTM using the same teacher variables as those presented in Table 3 and the discussion above, and as assessed by our instrument. However, regression diagnostics including tolerance, variance inflation factor and condition index for models that included all of these variables indicated considerable collinearity of the variables, which should be avoided in regression analyses. We were able to trace the cause of the collinearity to two pairs of highly co-dependent teacher variables: teacher level co-depended on teaching subject, and age co-depended on classification. Indeed, neither of these co-dependencies is surprising since, in the US, almost all elementary teachers are generalists (teaching all subjects) while math and science teachers are secondary (middle or high school) teachers, and college students' classifications (freshman, sophomore, etc.) follows their ages for most students. Consequently, the linear regression models presented in Tables 4 and 5 use a reduced set of teacher variables that avoids collinearity. The variables of Level and Subject were combined to form one variable Teacher type with five values: Elementary Generalist (EG), Middle School Math (MM), Middle School Science (MS), High School Math (HM), and High School Science (HS). Additionally, the variable Classification was omitted and only Age was retained as an indicator of PSTs' maturity and/or approximate progress through college. The variable of perceived influence of PSTs' prior mathematics teachers was also retained.

The first two models demonstrate the relative role that the teacher variables of teacher type, age, and influence (of prior mathematics teachers) played in predicting MD and SEFTM, respectively. Recall that the previous section of post-hoc results illustrated the differences in scores on these two scales that were observed in pair-wise comparisons of different classes of teacher variables. The linear regression models given below help us to better understand the relative predictive power of those variables on MD and SEFTM by allowing us to simultaneously consider the effect of each variable while controlling for all others. For the models in Tables 4 and 5, the reference group is of PSTs who planned to be Elementary generalists (Teacher type), were in the age range of 18 -21 years old, and whose prior math teacher had had a neutral influence on them.

When these variables are considered simultaneously, as in the linear regression model of Table 4 below, it is evident that the two statistically significant predictors of gains in MD included Teacher type and Influence of prior mathematics teachers. In particular, while other factors held constant, PSTs who intended to teach mathematics at either the middle or high school level exhibited greater MD (6.758 and 10.477 units greater) than did elementary generalists, which significant difference was also not seen in middle and high school science teachers. Additionally, PSTs who claimed that their prior mathematics teachers had made a positive influence on them exhibited greater MD (5.035 units greater) than did PSTs who claimed only a neutral influence. Notice that when considered simultaneously with these variables, the variable of Age (22 – 25 years) was almost, but not quite, a statistical predictor of differences in MD scores. The three predictors jointly explained 18% of variance in MD.

Likewise, the linear regression models in Table 4 show that when SEFTM scores were regressed simultaneously on the teacher variables, several of these variables were predictors of greater self-efficacy. In particular, while other factors held constant, PSTs who planned to be high school mathematics teachers had greater SEFTM (5.342 units greater) than did elementary generalists, while the middle school math teachers did not exhibit this advantage in self-efficacy. Furthermore, the variables of Age (22 – 25 years old) was a statistically significant predictor of greater self-efficacy for teaching mathematics (4.801 units greater). Additionally, and as with MD, the perceived positive influence of prior mathematics teachers was a predictor of gains (3.028 units more) in SEFTM for PSTs in this model over PSTs who claimed only a neutral influence. Possible explanations for the observed age and influence differences are given in the discussion section. The regression model with nine predictors that are dummy coded teacher variables jointly explained 14% of variance in MD, which is worth to mention but not too high.

Table 4. Linear regressions of MD and SEFTM on teacher variables

	MD on teacher variables				SEFTM on teacher variables			
Variable	B	SE	*t*	Sig.	B	SE	*t*	Sig.
(Constant)	111.093	1.403	79.206	.000	69.009	.973	70.909	.000
Teacher type								
Elem Generalist	Ref							
Mid Sch Math	6.758	1.731	3.905	**.000**	.663	1.201	.552	.581
Mid Sch Science	-1.795	3.821	-.470	.639	-3.127	2.652	-1.179	.239
High Sch Math	10.477	2.306	4.543	**.000**	5.342	1.600	3.338	**.001**
High Sch Science	1.314	3.222	.408	.684	.717	2.236	.321	.749
Age								
18 -21 years	Ref							
22 – 25 years	3.272	1.761	1.859	.064	4.801	1.222	3.930	**.000**
26 – 30 years	3.672	3.047	1.205	.229	1.305	2.114	.039	.617
> 30 years	-.492	3.096	-.159	.874	.538	2.148	.015	.802
Influence								
Neutral	Ref							
Negative	2.943	3.496	.842	.401	.905	2.426	.373	.709
Positive	5.035	1.496	3.365	**.001**	3.028	1.038	2.917	**.004**
Adjusted R^2	.180				.140			

An important result of the linear regression analysis is seen in Table 5, in which SEFTM is first modeled as a function of MD along with the other teacher variables, and then as a function of MD alone. These models give overwhelming evidence of the role that MD plays in predicting SEFTM. While holding other factors the same, one unit increase of MD leads to 0.335 unit of increase in self-efficacy score. PSTs of age (22 – 25 year age range) reported greater SEFTM (3.704 unit greater) than those of age 18-21 years. When controlling other factors, neither Teacher type nor Influence are statistically significant predictors of gains in self-efficacy. The regression model with predictors of nine dummy coded teacher variables and MD jointly explained 33.8% of variance in self-efficacy. Note that by adding MD as predictor for SEFTM, the amount of variance being explained increased to 33.8% from 14% in the previous regression model (see Table 4) with teacher variables only.

Table 5. Linear regressions of SEFTM on teacher variables and on MD

	SEFTM by MD and teacher variables				SEFTM by MD alone			
Variable	B	SE	*t*	Sig.	B	SE	*t*	Sig.
(Constant)	31.777	4.580	6.938	.000	28.357	4.367	6.494	.000
MD	.335	.041	8.274	**.000**	.376	.037	10.215	**000**
Teacher type								
Elem Generalist	Ref							
Mid Sch Math	-1.602	1.089	-1.471	.143				
Mid Sch Science	-2.526	2.328	-1.085	.279				
High Sch Math	1.831	1.467	1.248	.213				
High Sch Science	.277	1.963	.141	.888				
Age								
18 -21 years	Ref							
22 – 25 years	3.704	1.080	3.429	**.001**				
26 – 30 years	.074	1.861	.040	.968				
> 30 years	.703	1.885	.373	.710				
Influence								
Neutral	Ref							
Negative	-.081	2.132	-.038	.970				
Positive	1.341	.934	1.436	.152				
Adjusted R^2	.338				.305.			

Furthermore, the simplified model (on the right) in Table 5, which presents SEFTM as a function of MD alone, gives additional evidence that gains in MD predicted gains in SEFTM. The Adjusted R^2 for this model was .305, whereas it was .338 for the full model, indicating that the greater amount of variance in SEFTM was accounted for by MD than by any other collection of variables. Finally, the scatterplot in Figure 3 illustrates the positive correlation between MD and SEFTM graphically, wherein the coefficient of correlation (Spearman's rho) for MD and SEFTM was .581 with a two-tailed significance of $p = .000$. As Figure 3 indicates, in general, PSTs that had a greater sense of self-efficacy were those having more positive mathematical dispositions. Specifically, a one unit increase in MD score leads to 0.375 unit increase in self-efficacy score.

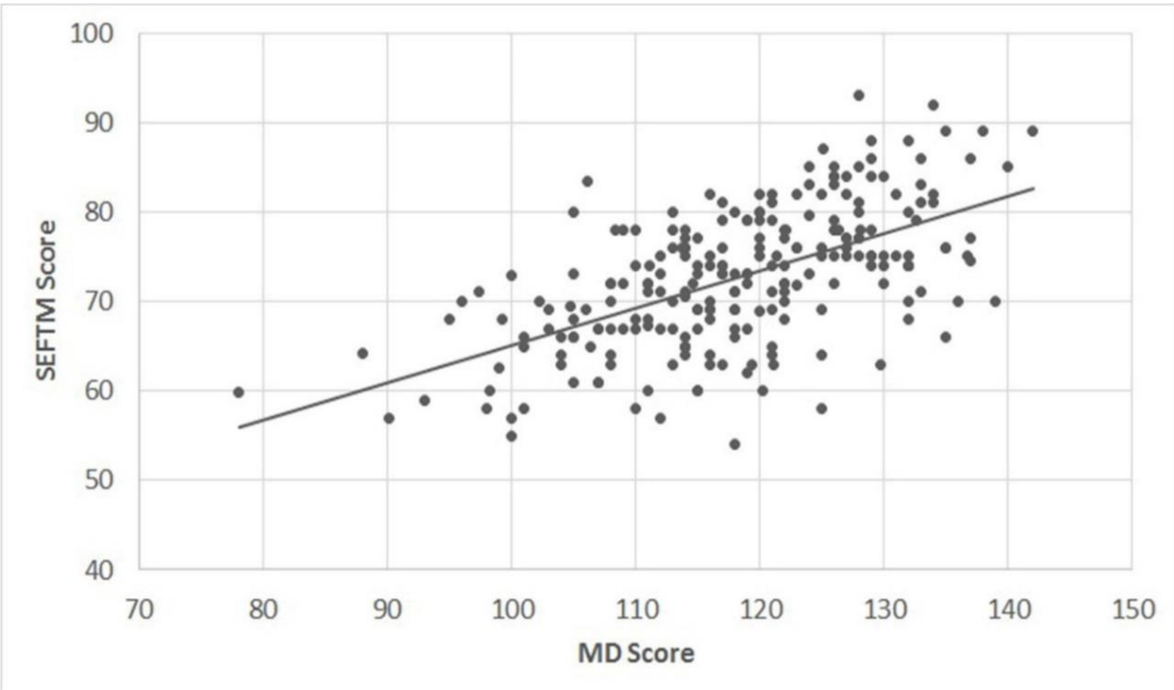

Figure 3. Scatterplot of SEFTM scores by MD scores

Discussion

This study contributes to research into teachers' mathematical dispositions and self-efficacy by specifically investigating the relationship between these two variables as seen among PSTs when viewed in connection with some common descriptors related to teacher preparation. Given the strong association of MD and SEFTM, as indicated in the regression models of the previous section, it may not be surprising that both MD and SEFTM scores were differentiated in similar ways by the other variables considered in this study. To better understand these findings we briefly review them and discuss their implications.

When considering the variable of teacher level, we found that secondary level (both middle and high school) PSTs had more positive MDs than did their elementary preservice teacher (PST) counterparts. This difference is mirrored in studies that have shown that elementary teachers' mathematics knowledge is weak and that they lack a deep, conceptual understanding of even basic mathematics concepts (Becker, 1986; Grootenboer & Zevenbergen, 2008). For instance, among 25,000 elementary teachers in one study, only 25% of the teachers had positive attitudes towards teaching mathematics (Berenson et al., 1991). A possible explanation for the difference in MD among PSTs could be that elementary-level PSTs typically have a scantier academic mathematical preparation than do middle and high school-level PSTs, partially because of completing fewer mathematics courses in college than the secondary teachers.

Similarly, SEFTM also varied by teacher level, but not in quite the same way as did MD: high school-level PSTs had more self-efficacy than did the elementary-level PSTs, but no significant difference was noted between high school and middle school level PSTs or between elementary and middle school level PSTs. Thus, for MD, both of the secondary levels of PSTs were more positive, while for SEFTM the middle school PSTs were in a middle position of approximate equivalence with both the elementary and high school levels, although PSTs at those two levels differed from each other. Self-efficacy is connected to curriculum choice and to a teacher's desire to engage in challenging teaching practices (Chester & Beaudin, 1996), which may confirm our findings that SEFTM was partially differentiated by teacher level. Elementary and middle level PSTs may be prone to choose those levels because of the interaction between their inflated perceptions of the difficulty of more advanced math study with their deflated self-confidence for teaching that subject.

Similarly, PSTs pursuing to be mathematics content teachers had more positive MDs than did generalists or science teachers, and also greater SEFTM than generalists, but not science teachers. Consequently, there is evidence that the subject a PST desires to teach is reflected in his or her MD and SEFTM. One explanation for this finding may be that the desire to study and eventually teach mathematics or science is a result of previously held positive or productive attitudes towards the subject. On the other hand, since mathematics is incorporated into many branches of science, it was surprising that, while SEFTM was statistically equivalent for both math and science PSTs, MD for generalists was nearly equivalent to that of science PSTs. However, since only 8% of PSTs in our sample pursued science teaching, it is also possible that a more robust sample might yield different results.

In our sample of PSTs, males had slightly (about 5 points) more positive MD and slightly greater (about 3 points) SEFTM than did the female PSTs. This finding is similar to those of other studies that have shown, for instance, that mathematics performance is differentiated by gender in favor of males in higher grades and in college (but not in elementary school; Hyde, Fennema, & Lamon, 1990) and that gender moderates the relationship between math anxiety and math performance (Miller & Bichsel, 2004, p. 604), with males having greater math anxiety in basic math performance skills than females while females have greater math anxiety than males in applied math performance. One probable explanation for the observed gender difference in this study is that female PSTs were overwhelming generalists by content choice rather than math or science teachers, and generalists typically scored low on the MD and SEFTM scales as noted above.

For both MD and SEFTM, age was a mediator of differences and in similar ways. More positive MD and greater SEFTM both appeared in PSTs who were in the "middle" of the range of typical college-aged students. That is, PSTs in the 22-25 yrs. and 26-30 yrs. age ranges scored slightly higher than those in the 18-21 and 31+ age ranges and PSTs in the 22-25 yrs. range scored slightly higher than both the younger and older ranges (but with statistical significance only in comparison to the 18-21 yrs. range). Perhaps there exists a sort of "peak" of positive MD and SEFTM for PSTs in the middle age ranges, when PSTs are most confident in their math abilities and positive towards teaching a challenging subject like mathematics. Another possible explanation may be that younger PSTs have not yet acquired a great deal of college-level mathematical knowledge and, as a result, have less positive MD and also perceive their own ability to teach the subject as insufficient (SEFTM).

Conversely, older PSTs may be more likely to have been out of school for numerous years and feel weaker in their content knowledge, resulting in diminished confidence to positively affect students' mathematical learning.

In comparison, both MD and SEFTM followed an approximately linear pattern with respect to PSTs' classification in college, with both variables approximately increasing as students progressed from freshmen to seniors. Seniors had (statistically significantly) more positive MD than all classifications and also greater SEFTM than sophomores (being slightly greater than both freshman and juniors as well, but without statistical significance). A plausible explanation for this is that seniors, who are the most advanced in their educational certification program, may also have the most content and pedagogical knowledge, and feel more positive and confident toward mathematics as well as better equipped to teach it because of particular field experiences.

When compared to PSTs whose prior mathematics teachers had made a neutral or negative influence on them, PSTs whose prior mathematics teachers had made a positive influence on them had slightly more positive MD and slightly greater SEFTM. For both MD and SEFTM this result was statistically significant only between the positive and neutral groups and not, surprisingly, between the positive and negative groups. We expected that those who claimed "positive influence" would have more positive MD and or great SEFTM than those who stated "negative influence". Perhaps another study of these variables might find different results.

Indeed, the number of PSTs that claimed a negative influence was very low (10 respondents, or less than 4% of the sample), which may not have provided an adequate comparison. However, one interpretation of our particular finding might be that, when it comes to MD and SEFTM, for PSTs, the mere existence of strong feelings about the influence, whether positive or negative, that their prior mathematics teachers had upon them might affect more similar kinds of persistent beliefs about mathematics than does a general lack of feeling about that influence, as evidenced by claiming the neutral effect of prior mathematics teachers. Whether or not this is the case, our study does provide evidence that PSTs who claimed to have been more positively influence by their prior mathematics teachers tended to have more positive MD and greater SEFTM.

Related to the influence that prior mathematics teachers have on PSTs was our finding in the linear regression models (Tables 4 and 5) that, when that influence is taken together with PSTs' teacher type, and age, it remains a significant predictor of gains in both MD and SEFTM. This finding seems to confirm the impact that mathematics teachers can have upon future teachers by influencing their beliefs about mathematics and about themselves as doers and teachers of mathematics. Furthermore, more positive MD was also shown to be a very strong predictor of greater SEFTM in this sample of PSTs, eclipsing all other predictors. This finding is important because it indicates a positive correlation between these two dependent variables: as the observed MD becomes more or less positive, the observed SEFTM also increases or decreases. Since high self- efficacy teachers are those that engage in challenging teaching practices, have higher expectations of their students, and take more responsibility for student learning upon themselves, teacher education programs and professional development providers might focus on increasing or enhancing pre- and in-service teachers' mathematical dispositions as a way to promote their self-efficacy for teaching and, thereby, boost student achievement.

A limitation of the findings of this study is related to the extent to which they can be generalized. As with many studies, the sample in this study came from a geographically narrow region, which limits the diversity of cultures and beliefs systems represented in survey responses. The sample of 236 mostly female, mostly elementary school level, PSTs used in this study came from one university in the southwestern US, all of whom were voluntary participants in the research. Hence, it is likely that the findings of this study entail a natural bias of some sort, or other details that might not endure replication in a different context. Nevertheless, we suspect that the strong association between MD and SEFTM, as measured by our instrument, would probably hold in other regions and that at least some other predictors, such as teacher type and the prior influence of mathematics teachers, might be observed as well. We close with recommendations for more robust research along these lines as well as applications of our findings to teacher preparation.

Conclusion

This study has taken a step toward understanding the relationship between MD, a quality stressed by the National Research Council as one of the five strands of mathematical proficiency (2001), and self-efficacy (SEFTM), which has been linked to student success (Ross & Bruce, 2007). There are several avenues of further research that might be profitably pursued toward promoting that success. Specifically, this study has considered PSTs only, but it would be interesting to know how MD and SEFTM vary among in-service teachers at the elementary, middle school, and high school levels, and at different levels (years) of expertise. It is conceivable that measures of MD and SEFTM may change over the course of teachers' careers from pre-service, to novice, to more experienced, and an understanding of the experiences that affect positive changes in these would be a valuable contribution. For instance, Lannin and Chval (2013) suggest that it is possible to challenge the preconceived beliefs of elementary preservice teachers by incorporating student interviews and online discussions, where participants are required to discuss and reflect on their own or others beliefs using student artifacts and classroom videos. Additionally, Matney and Jackson (2017) showed that field-based vicarious experiences improve the teaching efficacy of PSTs. Instruments like the one used in this study might be useful for testing the short and long-term outcomes of similar interventions aimed at confronting in-service teachers' beliefs in the context of summer professional development for example.

Given the strong association between MD and SEFTM observed in this study, not only researchers, but also teacher educators and professional development providers may find value in focusing their curriculum and educational activities on one element of beliefs, say MD, with the goal of improving not only MD thereby but also SEFTM. Additionally, researchers might look more closely to determine which of these two beliefs is more readily influenced in teachers so that professional developers and policy makers can focus efforts. Finally, the particular finding of this study that the perceived positive influence of prior mathematics teachers was associated with gains in MD and SEFTM merits more rigorous investigation into the ways in which PSTs' prior experiences as mathematics students impacts their later dispositions and self-efficacy beliefs of about teaching mathematics.

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Appendix. Survey Instrument

Instructions: Read each item carefully and circle the response (Strongly Disagree, Disagree, Uncertain, Agree, Strongly Agree) which most closely describes your feeling toward each statement.

Item #	Section I	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	Mathematics is an unrelated collection of facts, rules, & skills.	1	2	3	4	5
2	Mathematics is dynamic, problem driven, & continually expanding.	1	2	3	4	5
3	Mathematics can be surprising, relative, doubtful, and aesthetic.	1	2	3	4	5
4	Doing well in mathematics is not important for my future.	1	2	3	4	5
5	Mathematics is a worthwhile, necessary subject.	1	2	3	4	5
6	Mathematics is fixed, predicable, absolute, and applicable.	1	2	3	4	5
7	I will use mathematics in many ways as an adult.	1	2	3	4	5
8	Taking mathematics is a waste of time.	1	2	3	4	5
9	I study mathematics because I know how useful it is.	1	2	3	4	5
10	I don't expect to use much mathematics when I graduate.	1	2	3	4	5
Item #	**Section II**	**Strongly Disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
11	Memorizing and mastering algorithms is how people learn math.	1	2	3	4	5
12	As a student of math, my role is that of an autonomous explorer.	1	2	3	4	5
13	Mathematics can be learned without textbook or paper-and-pencil activities.	1	2	3	4	5
14	There is only one way to learn mathematics.	1	2	3	4	5
15	All students can learn mathematics.	1	2	3	4	5
16	As a mathematics student, I am an active learner.	1	2	3	4	5
17	Many students are just not able to learn mathematics.	1	2	3	4	5
18	My learning of math depends solely on the teacher.	1	2	3	4	5
19	There are many ways to learn mathematics.	1	2	3	4	5
20	As a student of math, I passively receive knowledge from the teacher.	1	2	3	4	5
Item #	**Section III**	**Strongly Disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
21	By trying hard, I can become smarter in mathematics.	1	2	3	4	5
22	If I can't solve a math problem quickly, I quit trying.	1	2	3	4	5
23	Ability in mathematics increases when one studies hard.	1	2	3	4	5
24	I can get better in mathematics if I make the effort.	1	2	3	4	5
25	If I can't do a mathematics problem in a few minutes, I probably can't do it at all.	1	2	3	4	5
26	I feel I can do mathematics problems that take a long time.	1	2	3	4	5
27	Hard work can increase my ability to do mathematics.	1	2	3	4	5
28	I can't get smarter in mathematics, even if I try.	1	2	3	4	5
29	I'm not very good at solving mathematics problems that take a while to figure out.	1	2	3	4	5
30	Ability in mathematics is not influenced by hard work.	1	2	3	4	5

Item #	Section IV	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
31	I will continually find better ways to teach mathematics.	1	2	3	4	5
32	I do not know what to do to turn students on to math.	1	2	3	4	5
33	I will find it difficult to use manipulatives to explain to students why mathematics works.	1	2	3	4	5
34	I know how to teach mathematics concepts effectively.	1	2	3	4	5
35	I wonder if I have the necessary skills to teach mathematics	1	2	3	4	5
36	I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	1	2	3	4	5
37	I will typically be able to answer students' questions.	1	2	3	4	5
38	Even if I try very hard, I will not teach mathematics as well as I will most subjects.	1	2	3	4	5
39	When teaching math, I will usually welcome student questions.	1	2	3	4	5
40	I will not be very effective at monitoring math activities.	1	2	3	4	5
Item #	**Section V**	**Strongly Disagree**	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
41	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	1	2	3	4	5
42	If parents would do more to support their children in school, I could do more to help them as their teacher.	1	2	3	4	5
43	If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	1	2	3	4	5
44	The teacher is generally not responsible for the achievement of students in mathematics.	1	2	3	4	5
45	The inadequacy of a student's mathematics background can be overcome by good teaching.	1	2	3	4	5
46	When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.	1	2	3	4	5
47	A teacher can have only limited influence on a student's motivation.	1	2	3	4	5
48	There is a limited amount that teachers can do to raise the performance of students who begin school with low abilities.	1	2	3	4	5
49	Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	1	2	3	4	5
50	Teachers are not a very powerful influence on student achievement when all factors are considered.	1	2	3	4	5

Tell us a little about yourself.

Gender: M F   Age: 18-21   22-25   26-30   31+   Estimated math GPA (4-pt scale): _______

Are you a: freshman   sophomore   junior   senior

What kind of teacher are you studying to become (circle one): elementary   middle school   high school   none

What subject will you teach (circle one): Mathematics   Science   All Subjects (Generalist)   Other

Most of my math teachers have had a: 1) positive   2) negative   3) neutral   influence on me.