TEACHER EDUCATION STUDENTS: THEIR EXPERIENCE OF MATHEMATICS ANXIETY, SELF-EFFICACY, AND TEACHER PROFESSIONAL DEVELOPMENT

by

Amy M. Olson

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As members of the Dissertation Committee, we certify that we have read the dissertation prepared by Amy Olson, titled Teacher Education Students: Their Experience of Mathematics Anxiety, Self-Efficacy, and Teacher Professional Development and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

____ Date: April 25, 2014
Thomas Good

____ Date: April 25, 2014
Debora Levine-Donnerstein

____ Date: April 25, 2014
Heidi Burross

____ Date: April 25, 2014
Darrell Sabers

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

____ Date: April 25, 2014
Dissertation Director: Thomas Good

STATEMENT BY AUTHOR

SIGNED: Amy M. Olson

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DEDICATION

To Matt, Jon, and Wil,

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and for always keeping in mind the Olson Family Motto

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ABSTRACT

This dissertation adds to the teacher education literature by exploring the experiences education students have of mathematics anxiety and self-efficacy for teaching and learning mathematics. Further, the utility of a specific in-service teacher professional development project, focused on improving rational number instruction, in pre-service education is evaluated, and the potential impact of professional development experiences on the anxieties and efficacy beliefs of students before they enter the teaching profession is explored. This study provides evidence of the predictive capacities of teacher efficacy models that incorporate student experiences and feelings of anxiety to better understand task choice. For example, findings indicate that self-efficacy for teaching mediates the relationship between mathematics teaching anxiety, experience, and mathematics subject area preference for teacher education students. Further, there are indications of the potential for teacher education coursework and in-service teacher professional development to decrease students' experience of mathematics teaching anxiety. Finally, evidence is provided that teacher professional development is not only perceived as useful to teacher educations students, but has potential as an intervention for teacher efficacy and anxiety for teaching. Given these findings, it makes sense to further evaluate the ways in which the strengths of pre-service coursework and in-service professional development can be leveraged to best prepare future teachers for their professional roles. Further research is also needed to longitudinally track experiences of anxiety and self-efficacy as students leave teacher education and enter the classroom as professionals.

Keywords: self-efficacy, teacher efficacy, mathematics anxiety, teacher education, mathematics education, teacher professional development

CHAPTER 1: INTRODUCTION

Context of Research

There is currently a great deal of focus on improving teacher education, particularly as research begins to accumulate to demonstrate the economic, time, and skills costs of low teacher retention (e.g., Henry, Bastian, & Fortner, 2011; Kersting, Chen, & Stigler, 2012; Sawchuk, 2013). When teacher turnover is high, the professional field becomes populated with novices. This introduces challenges not only for the new teachers, but also for the students they will work with and administrators who will be responsible for their professional development and retention. Novices are, by definition, much different from experts in the ways they approach problems, the degree to which they understand the available supports, and the degree to which they persevere when faced with setbacks. Thus, it is important to understand how novices approach their first experiences in the field and investigate what can be done to help them be better prepared and more resilient to potential failures as they develop their skill sets.

Major Theoretical Frameworks and Constructs

This study is situated in the self-efficacy theoretical framework. Self-efficacy is a context-specific estimation individuals have of their abilities to organize and execute particular goals to a desired level of success. Self-efficacy is not a global estimation of ability or confidence; individuals hold many efficacy beliefs that reflect their perceptions of different types of skills and the contexts in which they feel more or less confident (Bandura, 1997). Efficacy beliefs guide motivation and behavior, including task choice, effort, persistence, and resilience (Schunk & Pajares, 2005).

Self-efficacy is developed with respect to four types of experiences: mastery, vicarious, social persuasion, and physiological arousal (Bandura, 1997). Mastery experiences occur when individuals successfully perform particular skill sets. Vicarious experiences occur when individuals observe others engaged in mastery experiences. Social persuasion includes verbal messages, particularly of encouragement or discouragement of the possibility of meeting goals. Physiological arousal occurs when the body experiences stress. The physical reactions can be interpreted as positive or negative, and interpretation impacts how physiological arousal influences efficacy.

This study relates to a particular type of efficacy belief called teacher efficacy: beliefs teachers hold with regard to their "capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tscahnnen-Moran & Woolfolk Hoy, 2001). As explained in Chapter 2, a large body of research links teacher efficacy to both teacher behaviors and student outcomes.

In efficacy theory, mastery experiences are considered the most direct evidence of efficacy and thus, have the most influence on an individual's efficacy beliefs (Bandura, 1997). However, this study is situated in the context of novice teachers and thus, the other pathways to the development of efficacy are important. For example, observations of mentor teachers and teacher education faculty (potential sources of vicarious experience), anxiety related to learning and teaching content (potential sources of physiological arousal) and outcome expectancies related to the relative ease or difficulty of teaching tasks (potential sources of social persuasion) are investigated in this study.

The link between teacher efficacy and experience of mathematics anxiety is also explored in this study. Mathematics anxiety may be a general fear of mathematics or a more specific fear of failing in mathematics (Hembree, 1990; Trujillo & Hadfield, 1999). The experience of mathematics anxiety interferes with both mathematical learning and willingness to engage in mathematical behaviors, including teaching (Gresham, 2007; McGlynn-Stewart, 2010). A large body of research indicates that mathematics anxiety and low self-efficacy are prevalent in the pre-service teacher population (Beilock, Gunderson, Ramirez, & Levine, 2010; Brown, McNamara, Hanley, & Jones, 1999; Bursal & Paznokas, 2006; Harper & Daane, 1998; Hembree, 1990; Peker, 2009; Rech, Hartzel, & Stephens, 1993; Swars, Daane, & Giesen, 2006; Tooke & Lindstrom, 1998; Vinson, 2001). This is potentially problematic for the purpose of improving teacher education students' transition to the professional field as teachers, especially given the large body of empirical evidence linking mathematics anxiety, student outcomes, and teacher behaviors. This is further discussed in Chapter 2.

Purpose

The study presented here attempts to investigate ways in which novice teacher education students, particularly those interested in teaching elementary grades, experience constructs known to impact the behaviors of pre-service and in-service teachers (i.e., mathematics anxiety and teacher efficacy beliefs), both as students in teacher education faculty's classrooms and in their own classrooms as future teachers. Further, this study investigates the utility of professional development materials created for in-service teachers to be used as part of pre-service education. The purpose of this portion of the study is to discover if materials can be successfully adapted to use with teacher education students and if these students have different needs than in-service teachers.

Research Questions

The research questions guiding this study are presented here and more fully explained at the end of Chapter 2. Hypotheses are also presented in Chapter 2.

1. To what extent do teacher education students experience:
    a. self-efficacy for teaching and learning mathematics?
    b. mathematics anxiety around the teaching and learning of mathematics?
    c. positive or negative perceptions of outcome expectancies related to teachers, students, and mathematics content?
2. Does self-efficacy for learning mathematics content mediate the relationship between anxiety for learning mathematics content, outcome expectancies about mathematics content, and preferred grade level?
3. Does self-efficacy for teaching mathematics content mediate the relationship between mastery experiences, vicarious experiences, outcome expectancies about teachers and students, mathematics teaching anxiety and subject area preference for mathematics?
4. Does experience with teacher professional development (learning blocks) act to reduce mathematics anxiety, increase self-efficacy, and improve the positivity of outcome expectancies?
5. Are there initial quantitative differences on the survey responses between those students who choose to complete the learning blocks and those students who do not?
6. Are there qualitative differences in the responses to learning block material between this group of teacher education students and the previously collected responses of in-service teachers?

Organization

As described earlier, Chapter 2 presents the literature review, research questions, and relevant hypotheses. In Chapter 3, the methods and procedure are presented. This chapter also includes information about the participants, instruments, and other data sources. Chapter 4 presents analysis, including analyses of reliability, descriptive statistics, regression models, mean comparisons, and qualitative findings. In Chapter 5, the results are summarized and explained. Theoretical and practical implications are discussed. The limitations are evaluated, and future directions are considered.

CHAPTER 2: LITERATURE REVIEW

This literature review covers two constructs important to understanding teacher education students teaching beliefs and behaviors. First, self-efficacy theory is discussed, both generally and in relation to the research in teacher efficacy. Next, mathematics anxiety is introduced as a measure of physiological arousal believed to be particularly influential with the population of teacher education students and in-service teachers, especially those interested in teaching elementary grades. These constructs are used to build research questions that are defined at the end of this section.

Self-Efficacy Theory

In attempting to explain why the effectiveness of social cognitive treatment varied by individual, Bandura (1977) argued that behavioral and psychological change was reliant on motivational variables. In particular, the belief that individuals have in their ability to successfully make a psychological or behavioral change predicts whether or not they will do so. He called this concept "self-efficacy."

Self-efficacy is a *context-specific* estimation individuals have of their abilities to organize and execute *particular* goals to a desired level of success. While there may be some overlap of efficacy beliefs between spheres of activity that require similar skill sets, an individual's efficacy is not a global belief and cannot be measured as a single trait. As Bandura (2006) explains, "One cannot be all things, which would require mastery of every realm of human life. People differ in the areas in which they cultivate their efficacy and in the levels to which they develop it even within their given pursuits" (p. 307). Thus, individuals hold many self-efficacy beliefs that reflect different types of skills and different contexts. Further, individuals within the same context, such as pre-service and in-service teachers, vary in the their final estimation of their own self-efficacies based on their individual experiences with specific goals in particular contexts. The specificity and malleability of self-efficacy beliefs makes this theoretical approach useful in attempting to understand how individuals function in particular contexts, and how individuals' beliefs about themselves and their abilities change over time as they progress from novices to masters in particular contexts.

Development and Outcomes of Efficacy Beliefs

Within a context, self-efficacy is theorized to develop through four general pathways: mastery experiences, vicarious experiences, social persuasion, and physiological arousal (Bandura, 1997). These pathways are depicted in Figure 1 and explained here. Mastery experiences occur when the individual successfully practices and/or performs particular skills. Vicarious experiences build on Bandura's model of observational learning, and include those experiences in which the individual observes others engaging in the practice or performance of relevant skills. As in observational learning, when the individual identifies with the model, observing success will increase self-efficacy and observing failure will decrease self-efficacy. Social persuasion includes encouragement (or discouragement) of the possibility of meeting particular goals. Social persuasion can be delivered in different ways and at different times. For example, a "pep talk" before performance and feedback after performance are both considered forms of verbal persuasion. Just as the extent to which vicarious experiences affect self-efficacy depends on the degree to which the individual identifies with the model, social persuasion varies in effect based on the credibility, trustworthiness, and expertise of the persuader (Bandura, 1986). Physiological arousal refers to the body's reaction to stressful or threatening conditions. Interpretation of these bodily cues as aversive leads to decreases in self-efficacy, while interpretation as excitement may increase self-efficacy.

It seems important to further consider the role of physiological arousal, as a potentially underexplored facet of the development of self-efficacy for novices. Physiological arousal is described as the physical effects the body experiences in a potentially situation, but in terms of development of self-efficacy, the emphasis is placed on the interpretation of these effects rather than the experience itself (Bandura, 1997). Thus, it is the perception of, for example, increased heart rate as excitement or fear that increases or decreases self-efficacy. These physical triggers happen most often in concert with the performance of a mastery experience or the contemplation of a potential mastery experience (given that self-efficacy is a forward-looking judgment). To a lesser extent, physiological arousal may occur when watching others perform a task (vicarious experience) or when receiving warnings or encouragement about a task (social persuasion). Of particular interest in the development of self-efficacy with novices who have little mastery experience to draw upon, is the experience of task-specific physiological arousal, and in particular, anxiety related to engaging in specific tasks or to the contemplation of tasks, a point which will be further expanded upon later in this section.

The theory suggests that self-efficacy is altered as the individual gains further experiences relevant to the four developmental pathways. Because of their direct experiential nature, mastery experiences are theorized to be the most important influences for the development of self-efficacy (Bandura, 1997). Thus, past experiences of one's own success do much more to improve self-efficacy than the observation of another person being successful, encouragement that one has the potential to be successful, or excitement going into the task. In the same way, past experiences of failure are profoundly inhibiting to the development of positive self-efficacy. Though not as explicit in the theory, the other three sources of influence (i.e., vicarious experience, social persuasion, and physiological arousal) are theorized to more strongly influence the development of an individual's self-efficacy when the individual is in the early stages of developing efficacy beliefs (i.e., is a novice) and has few mastery experiences on which to make judgments of future ability.

Once self-efficacy beliefs are established, they are expected to be fairly stable unless some unusual experience or upheaval requires reassessment. Thus, efficacy is most variable in the novice stages of building context-specific ability sets. However, even after the novice stage, Bandura (2006) argues that powerful mastery experiences may even influence "transformational restructuring of efficacy beliefs…across diverse realms of functioning" (p. 308), which suggests that important successes can potentially give individuals powerful boosts of confidence, even when past experiences of failure have led them to have low self-efficacy. Likewise, important failures can also decimate healthy self-efficacy. It is this focus on the vicarious experiences, social persuasion, and physiological arousal of novices and the importance of scaffolding powerful (and successful) mastery experiences that makes self-efficacy useful in understanding influential aspects of training programs, such as pre-service education.

Figure 1

Model of the Development and Outcomes of Self-Efficacy based on Bandura's Theory

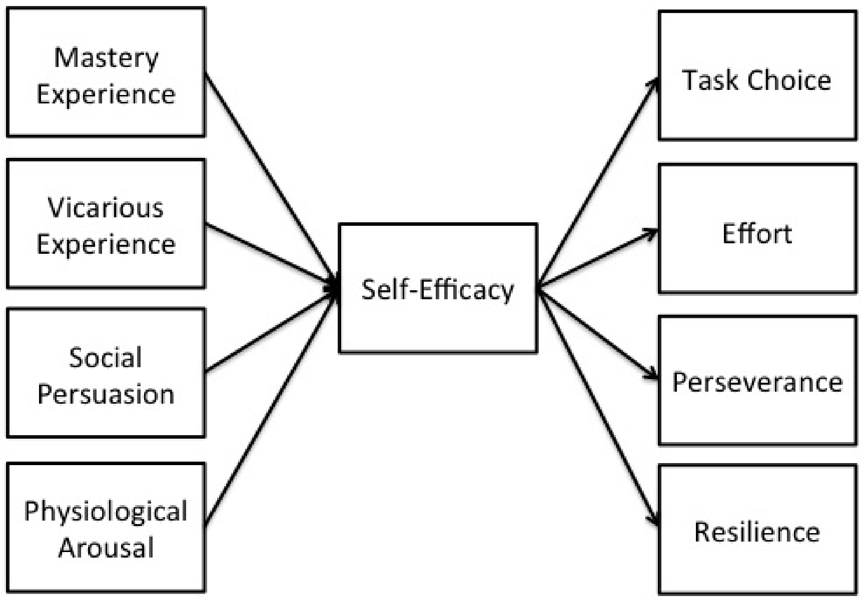


Figure 1 also depicts the expected outcome of efficacy beliefs. Motivation, effort, and persistence in the face of challenge are all linked to self-efficacy (Bandura, 1993). Individuals who believe they will (eventually) be successful are more likely to initially engage in tasks, put in more effort, and persevere if difficulty arises. A good deal of research in classroom settings further suggests that individuals with high self-efficacy are more likely to select challenging goals and use appropriate self-regulation strategies to reach these goals (e.g., see Bandura & Locke, 2003; Pajares, 1996; Schunk, 1990; Zimmerman, 2000; Zimmerman, Bandura, & Martinez-Pons, 1992).

Distinguishing Self-Efficacy from Related Concepts

Self-efficacy differs from actual competence (capacity for success), because self-efficacy is a perception of future ability to succeed, rather than an evaluation of one's actual skill level

(Woolfolk Hoy & Spero, 2005). Individuals regularly over- and underestimate their future competence. Chronic low self-efficacy for particular tasks impedes individuals from engaging in these tasks, while high self-efficacy increases individuals' likelihood of engaging in tasks. However, inaccurately high self-efficacy sets an individual up for frustration and failure. Thus self-efficacy estimates slightly higher than actual competence are healthiest for approaching new goals (Bandura, 1997).

Self-efficacy also differs from outcome expectancy, or the more general belief that particular actions will result in the desired outcome, regardless of who takes those actions (Bandura, 1977). Recall that self-efficacy was initially defined as a person- and context-specific belief that the individual can be successful in making a psychological or behavioral change. Outcome expectancies frame the difficulty of making those changes *for the general person*.

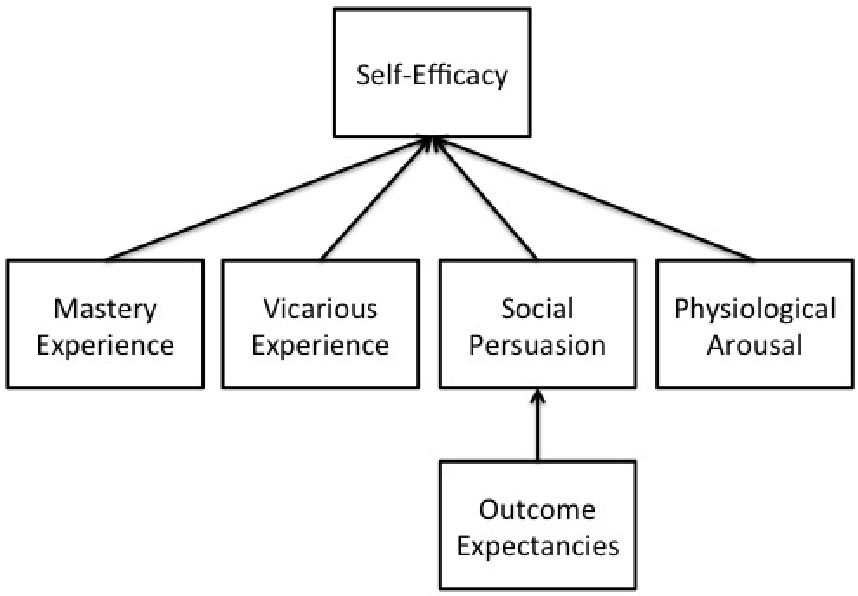
Most commonly, outcome expectancies are framed in contrast to self-efficacy (e.g., Pajares, 1996; Zimmerman, 2000). Yet, although not explicitly modeled in the theory, relevant general outcome expectancies should also influence one's own self-efficacy beliefs by increasing or decreasing (or perhaps even not changing) the perceived difficulty of an individual achieving a successful outcome. In other words, they frame the perceived difficulty of making changes in particular contexts. Further, outcome expectancies may be communicated amongst groups via social persuasion (Bandura, 1993). Thus, outcome expectancies should be modeled along with self-efficacy, particularly when the work is with novices who have few mastery experiences to draw upon in formulating their efficacy beliefs.

An illustration is provided here to further demonstrate the relationship between outcome expectancies and the lower efficacy beliefs of novices. A novice teacher would be expected to have lower levels of self-efficacy for preparing students for an important high-stakes test than a veteran teacher. Prior to any mastery experiences (classroom experiences of preparing students for high-stakes tests) or even vicarious experiences (observing a mentor teacher prepare students for high-stakes tests), the novice would likely hold outcome expectancies (e.g., that preparing for high-stakes tests is relatively easy or difficult for teachers, relatively easy or difficult for students, relatively important or unimportant for student, teacher, or school success, and so forth). It seems likely that these outcome expectancies would influence how the novice interpreted the physiological arousal cues when entering into a first potential mastery experience. For example, the arousal cue of increased heart rate would be more likely to be interpreted as anxiety or nervousness when the task was initially believed to be difficult and important.

Thus, general outcome expectancies act as perceptions of the general difficulty or ease of success in a particular context. They may be based on preconceived notions, social persuasion, or prior learning of social messages, but they are general judgments, and not specific to the individual and thus, often depicted as outside the self-efficacy model. However, it seems likely there is some relationship between general outcome expectancies and self-efficacy. A person with high self-efficacy may perceive a task as simpler than a person with low self-efficacy, but the relationship does not seem absolute. For example, a teacher may have high self-efficacy for classroom management tasks based on past mastery experiences at a previous school. At the school where she is comfortable, she may rate the general outcome expectancy of classroom management for any teacher as relatively easy. However, at a new school, different environmental cues or social messages from fellow teachers could cause her to perceive the task (or the students) as potentially more difficult in general for all teachers, and this perception seems likely to influence her personal self-efficacy to engage in classroom management outcomes. This relationship is depicted in Figure 2, in which general expectancies become part of the social persuasion pathway and thus predict self-efficacy.

Figure 2

General Outcome Expectancy as a Contributor to the Social Persuasion Pathway in the Development of Self-Efficacy



Teacher Efficacy

The development of self-efficacy, particularly for novices, is of interest because of the situation of this work in the the teacher education context. Research suggests that 40% of teachers leave within their first five years of teaching (Gold, 1996), but this is also about the same amount of time it seems to take for teachers to progress from novices to effective teaching masters (Henry, Bastian, & Fortner, 2011; Kersting, Chen, & Stigler, 2012). Thus, the educational context is populated with novice teachers in need of developing self-efficacy for skills associated with long-term student achievement and motivation.

Based on self-efficacy theory, a definition of teacher efficacy would reflect the beliefs an *individual* teacher has of future competence using a *particular* teaching skill. However, like most educational research, the impetus is to link teacher efficacy with student achievement. Thus, Tschannen-Moran and Woolfolk Hoy (2001) offer the following definition: "A teacher's efficacy belief is a judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (p. 783). Like self-efficacy, teacher efficacy is context-specific and multi-dimensional construct, and is expected to reflect judgments on a variety of behaviors associated with students' academic outcomes.

Also like self-efficacy, teacher efficacy is theorized to arise from four developmental sources (mastery experiences, vicarious experiences, social persuasion, and physiological arousal). Tschannen-Moran & Woolfolk Hoy (2007) provide evidence and examples of each of these four pathways for novice and "career" teachers. For example, novice teachers have powerful mastery experiences when they conduct a lesson they perceive to be successful. These experiences have a much less powerful impact on the more experienced career teachers, who have more stable self-efficacy due to a longer history of mastery experiences. Student teaching is filled with vicarious experiences as pre-service teachers work with teacher education faculty and in-service teachers in their classrooms, and indeed, "Teachers entering the field have typically experienced 'apprenticeships' of at least 17 years as students", suggesting the importance of modeling by professors and cooperating teachers within teacher certification programs as well as the importance of students' earlier experience in elementary and secondary classrooms (p. 954). Supporting communications from colleagues and the community are important sources of social persuasion, but novice teachers who rely too greatly on these have lower efficacy beliefs than teachers who rely less on input from others (Tschannen-Moran & Woolfolk Hoy, 2007). Although Tchannen-Moran and Woolfolk Hoy (2007) do not explicitly describe it, communication of negative expectations from colleagues, supervisors, parents, and the community about teachers, students, and achievement should also decrease the efficacy of novice teachers. Physiological arousal may indicate excitement and anticipation for an upcoming lesson or may indicate unhappiness, anxiety, or stress with the teaching experience, but teacher stress is more often studied in relation to academic futility, burnout, and other constructs designed to get at low levels of teacher retention in the field (e.g., Friedman, 2000; Skaalvik & Skaalvik, 2007).

Teacher Efficacy Outcomes

Teacher efficacy is widely explored in the literature; as would be expected by the necessity of pre-service education and in-service professional development, there is interest in understanding a) how teacher efficacy develops throughout a teacher's training and career and b) what, if any, impacts can be made on teacher efficacy at various stages in order to support teachers as they transition from novices to career professionals.

Historically, teacher efficacy was first linked with student achievement in a series of RAND studies (Armor, et al., 1976) and to student motivation in the following decade (e.g., Anderson, Greene, & Lowen, 1988; Midgley, Feldlaufer, & Eccles, 1989). Across the decades of research, teacher efficacy has also been linked to a number of observable "good teaching" behaviors and "best practices", such as teacher planning, organization, time on subject, positive management and instructional strategies, and lower referral rates to special education (Allinder, 1994; Meijer & Foster, 1988; Riggs & Enochs, 1990; Soodak & Podell, 1993; Woolfolk, Rosoff, & Hoy, 1990). Ross (1998) reviewed the first two decades of literature on teacher efficacy and summarized that teacher efficacy was positively associated with six behaviors necessary to be successful in the classroom: (1) learning to use new teaching strategies, (2) using classroom management strategies that encourage student autonomy rather than assert teacher control, (3) providing targeted assistance to low-achieving students, (4) building students' perceptions of their own academic skills, (5) setting attainable goals in the classroom, and (6) persisting even when students fail. Ross's work aligns well with Bandura's (1993) framework that efficacy outcomes can be summarized with respect to task choice (i.e., goal-setting, enacting particular strategies), motivation and effort (i.e., to continue learning new strategies and to put effort into classroom interactions), and persistence and resilience (particularly in cases of student failure or underachievement).

More recently, teacher efficacy theorists have extended early work to look beyond student effects and begun exploring the effects of teachers' efficacy beliefs on their professional behaviors and willingness to continue in the field. For example, recent work provides evidence that efficacious teachers hold more positive goals and aspirations for their own work in the classroom (Muijs & Reynolds, 2002; Woolfolk Hoy & Spero, 2005) and are also less likely to burnout and leave the field (Friedman, 2000; Skaalvik & Skaalvik, 2007).

General Teaching Efficacy (Outcome Expectancies)

Historically, there was some confusion between teacher efficacy (sometimes referred to as "personal teaching efficacy") and the arguably misnamed concept of "general teaching efficacy". General teaching efficacy is an outcome expectancy related to the teachers' general beliefs about the possibility of making changes in student achievement or motivation given context variables. For example, general teaching efficacy might refer to a teacher's beliefs about the possibility of helping improve student success within the context of student variables like socioeconomic level, ethnicity, home language, and so forth (Tournaki & Podell, 2005). These general outcome expectancies frame the difficulty (or ease) of success for teachers in the classroom, and thus, are consistent with the outcome expectancy variable that was hypothesized earlier to be particularly influential for novices.

Collective Teaching Efficacy

In recent years, researchers have begun to measure teacher efficacy as a school-level variable (collective efficacy), and evidence for the link between collective efficacy and student achievement is starting to accumulate (Goddard, 2001; Goddard & Goddard, 2001; Goddard, Hoy, & Woolfolk Hoy, 2000, 2004; Tschannen-Moran & Barr, 2004; Tschannen-Moran & Woolfolk Hoy, 2007). Like self-efficacy, collective efficacy is a belief about the capability a group has to organize and execute particular goals (Tschannen-Moran & Woolfolk Hoy, 2007). It is especially relevant to teaching as teachers work together within school units to reach shared goals (e.g., school is "passing" or academically successful), and these schools are headed by administrative leaders (principals), who are responsible for supporting and evaluating the teachers within particular school units. Teachers within a school have access to similar resources, supports, limitations, and budgets. Schools often serve particular populations of students, and by nature of their work together, teachers receive vicarious experiences and social persuasion from other teachers and administrators within the schools that may affect teacher efficacy via the social transmission of general outcome expectancies, which in turn can affect the perceptions of collective efficacy for the school. Goddard, Hoy, and Woolfolk Hoy (2004) argue that collective efficacy creates normative pressure for teachers to push towards school-level expectations for success, but whether these expectations are positive or negative may depend on other school-level variables.

Interestingly, Woolfolk Hoy and Spero (2005) found that while teacher efficacy and general teacher efficacy (outcome expectancy for teachers) increased across pre-service education, measures of general teaching efficacy dropped significantly between the end of student teaching and the end of the first year of in-service teaching. In fact, these measures dropped to the point at which they were at the beginning of pre-service training, indicating that any improvements in general outcome expectancies made in pre-service education were lost when teachers entered the field and become immersed in particular schools.

Thus, some aspect of fieldwork must impact novices' general outcome expectancies. This paper presents the argument that one source of the detrimental shift is the social transmission of negative outcome expectancies within the school unit. Novices are particularly at risk to be influenced by messages produced in a climate of low collective efficacy because of their unstable efficacy beliefs. Further, if novices have unrealistically high efficacy beliefs supported throughout their pre-service education program, their first difficulties in mastery settings may serve to reinforce negative messages from peers and administrators. More work is needed to understand the complex relationship between novice efficacy beliefs and the social messages and collective efficacies of the schools in which novices teachers are placed.

Improving Teacher Efficacy

Further, given the recent focus on teacher education reform (Sawchuk, 2013) and the economic and skills costs of low teacher retention (Henry, Bastian, & Fortner, 2011; National Commission on Teaching and America's Future, 2003; 2007), it has become increasingly important to develop positive, but realistic, teacher efficacy in pre-service education and support continued positive efficacy beliefs once teachers enter the field. Evidence suggests that it is possible to increase teacher efficacy in pre-service education by providing powerful mastery experiences during student teaching and in the induction year (Mulholland & Wallace, 2001; Woolfolk Hoy & Spero, 2005). However, researchers also caution against establishing unrealistic efficacy beliefs in pre-service education, particularly when these beliefs may lead to disillusionment and burnout when they are not supported by early mastery experiences in the classroom (Friedman, 2000).

There is also a body of work demonstrating that in-service teacher efficacy can be affected by professional development efforts. For example, Zambo and Zambo (2008) demonstrated improvements in teacher efficacy (but not in collective efficacy) following a summer workshop on mathematics problem solving. Ross and Bruce (2007) found that efficacy for a particular teaching behavior, student management, increased following a semester of mathematics skill training, even though more general measures of personal teaching efficacy did not. JohnBull and Hardiman (2013) compared teachers who participated in a cross-curricular intervention over the summer and over a semester. They found that teachers who participated in the longer program improved in both teacher efficacy and outcome expectancy, while teachers in the shorter program improved in only teacher efficacy. Similarly, Fritz, Miller-Heyl, Kreutzer, and MacPhee (1995) found that making impacts in personal teacher efficacy was easier than making changes in outcome expectancies. The evidence suggesting that personal efficacy beliefs are the first to change may imply predictive relationships between personal efficacy and collective efficacy. Further, the difficulty in making and maintaining changes in teacher outcome expectancies supports the argument that outcome expectancies arise from the interaction between the community and the individual and that working to change the individual's beliefs without changing the social messages in the larger community (i.e., the school or program) will not be as effective.

Mathematics Anxiety

Defining Mathematics Anxiety

In addition to teacher efficacy, the construct of mathematics anxiety is of interest in this study. Brady & Bowd (2005) caution that mathematics anxiety is a complex phenomenon defined in multiple ways across multiple fields, and this is true to a point. However, most scholars take one of two perspectives. The first perspective is wholly concerned with the negative physiological sensations associated with anxiety when mathematical tasks are undertaken. Tobias (1978) referred to this as almost a feeling of "sudden death" when confronted with mathematics, but most perspectives are less dramatic. The major themes range from an "unhealthy mood" when actually engaged in mathematics problems (Luo, Wang, & Luo, 2009, p. 12) to a more general "fear of contact with mathematics" (Hembree, 1990, p. 34). The concern is that these negative physiological feelings disrupt the ability to process information and thus, disrupt learning and performance (Gresham, 2007).

The second perspective goes beyond the physiological and emotional responses to anxiety to focus more on the effects that anxiety has on an individual's self-beliefs. This perspective argues that mathematics anxiety is a negative physiological response that occurs not when mathematical tasks are undertaken, but rather when they are perceived to be threatening to one's self-esteem (Cemen, 1987 as cited in Trujillo & Hadfield, 1999). Thus, while some researchers believe than any mathematical stimuli can elicit anxiety, others believe that anxiety is only induced when individuals are in position of losing self-esteem, confidence, or self-efficacy in response to failure feedback.

A recent study of the Program for International Student Assessment (PISA) data suggest that the highest levels of mathematics anxiety occur among students in high-performing nations, such as Korea and Japan (Lee, 2009). This finding lends support to the Cemen (1987) and

Trujillo and Hadfield (1999) definition of mathematics anxiety, one that is more closely tied to the potential impact of failure on self-beliefs than to absolute success or achievement.

Mathematics Anxiety and Students

Mathematics anxiety can occur in academic and non-academic, real-world settings (Jones, Childers, & Jiang, 2012; Newstead, 1998), but it has primarily been examined in the context of interference with performance and learning in academic settings (Gresham, 2007). Often, a developmental approach is taken in order to understand how and why some students move from relatively low levels of anxiety in early schooling to relatively high levels of anxiety in secondary or post-secondary education. For example, researchers have found that mathematics anxiety increases significantly between elementary and secondary school (Brown, McNamara, Hanley, & Jones, 1999; Jackson & Leffingwell, 1999; Trujillo & Hadfield, 1999). Those students who experience anxiety become increasingly unlikely to continue on in advanced mathematics when offered the option. Further, both Hembree's (1990) and Ma's (1999) meta-analyses show significant negative relationships between students' experience of mathematics anxiety and their mathematics achievement within a course and across schooling.

Mathematics Anxiety of Pre-Service Teachers

Research indicates that mathematics anxiety is particularly prevalent among teacher education students (Bursal & Paznokas, 2006; Brown et al., 1999; Hembree, 1990; Peker, 2009; Rech, Hartzell, & Stephens, 1993), and especially with teacher education students interested in teaching primary grade levels (Beilock, Gunderson, Ramirez, & Levine, 2010; Peker, 2009). In fact, both Beilock et al. (2010) and Hembree (1990) report that elementary education students, primarily women, have the highest level of mathematics anxiety of all college majors. This raises the question of whether students select into the elementary education major because they have high mathematics anxiety for learning mathematics in general and for participating in majors that they perceive require more advanced mathematics coursework. If this is the case, it may be that there exists an inverse relationship between grade level that pre-service teachers want to teach at and their level of mathematics anxiety.

Moreover, a body of research links this mathematics anxiety in pre-service teachers to negative outcomes. For example, mathematics anxiety in teacher education students has been associated with negative attitudes about mathematics and required mathematics courses and with preference for learning direct instruction methods and traditional algorithms over conceptual thinking (Brady & Bowd, 2005; Grootenboer, 2008). Similarly, Rayner, Pitsolantis, and Osana (2009) have demonstrated that lower mathematics anxiety scores in pre-service teachers are associated with higher performance in mathematics methods courses, and specifically in conceptual and procedural fraction content.

However, for teachers or potential teachers, Vinson (2001) cautions that mathematics anxiety is more than simply "not liking" mathematics or being reluctant to teach it. In recent years, researchers have begun to distinguish between mathematics anxiety in general (i.e., anxiety around learning and performing mathematics), from the tension teachers experience when they encounter real or perceived deficits in their competence to *teach* mathematics (Peker, 2009). This second phenomenon is referred to as mathematics teaching anxiety. Thus, pre-service and in-service teachers may suffer from both general mathematics anxiety and anxiety for teaching mathematics. Further, both types of anxiety are hypothesized to arise from similar sources – negative experiences with mathematics teachers in their own past (Brady & Bowd, 2005; Stoehr, Carter, & Sugimoto, 2013; Uusimaki & Nason, 2004). For example, Brady & Bowd (2005) found that teachers recalled experiences of being humiliated by mathematics teachers perceived to be uncaring or hostile, or feeling embarrassed for making errors in front of peers, and that these measures were related to their concerns about engaging in mathematics tasks and teaching mathematics.

It would be incorrect to assume that the two types of anxiety are synonymous; Brown, Westenkow, and Moyer-Packenham (2011) found that 35.9% of the pre-service teachers in their sample experienced one type of anxiety without the other (39.6% experienced neither type and 20.8% experienced both types of anxiety). However, little of the wide body of research with pre-service teachers distinguishes between the two types of mathematics anxiety in order to examine the potential differential effects they may have on teacher education.

Mathematics Anxiety of In-Service Teachers

Like the research with pre-service teachers, there are relatively few studies that attempt to disentangle mathematics teaching anxiety from more general mathematics anxiety with in-service teachers. A notable exception is a study by Hadley and Dorward (2011). They measured both and found that general mathematics anxiety was significantly, but not perfectly, correlated with mathematics teaching anxiety ($r = .42$, $p < .001$). In their sample, teachers reported greater levels of general mathematics anxiety (52%) than mathematics teaching anxiety (36%). They also found a small, but positive relationship between general mathematics anxiety and use of standards-based teaching practices from the National Council of Teachers of Mathematics and a small, but negative relationship between mathematics teaching anxiety and student achievement. As an explanation for this seeming contradiction, Hadley and Dorward argue that teachers who are anxious about understanding the mathematics, but comfortable with teaching in general, are more likely to stick closely to recommended practices and approved lesson plans. Teachers who are more anxious about the instructional aspects tend to rely more on worksheets and direction instruction.

Most studies with in-service teachers measure general mathematics anxiety, but report on teaching behaviors. Like the research with pre-service teachers, there are associations between mathematics anxiety and less skilled teaching (Gresham, 2007; Karp, 1991; Vinson, 2001; Swars, Smith, Smith, & Hart, 2007). In particular, teachers who score high on mathematics anxiety measures spend less instructional and planning time on mathematics, are less likely to develop students' conceptual thinking, and are more likely to rely on whole-class instruction with heavy emphasis on drilling and worksheets (Bush, 1989; McGlynn-Stewart, 2010; Vinson, 2001).

Connecting Teachers and Students

Based on work with in-service teachers, it is clear that there is a link between the mathematics anxiety of teachers and the eventual mathematics achievement of their student due to poor teaching and/or lack of time spent on mathematical content that teachers feel ill-prepared to teach. However, this is not the only pathway by which students can be affected by their teachers' mathematics anxiety. Mathematics anxiety can also impact students via observation of the teachers' anxious behaviors. Evidence suggests that highly anxious teachers perpetuate not only their anxiety, but also negative attitudes and beliefs about mathematics for their students (Beilock et al., 2010; Brady & Bowd, 2005; Vinson, 2001), thereby affecting student achievement not only through poor teaching, but also through students' lack of motivation and achievement behavior in mathematics. In terms of self-efficacy theory, it may be that the mathematics anxiety of teachers results in modeling vicarious experiences and providing social persuasion that in turn affects students' efficacy beliefs about their own mathematics capabilities.

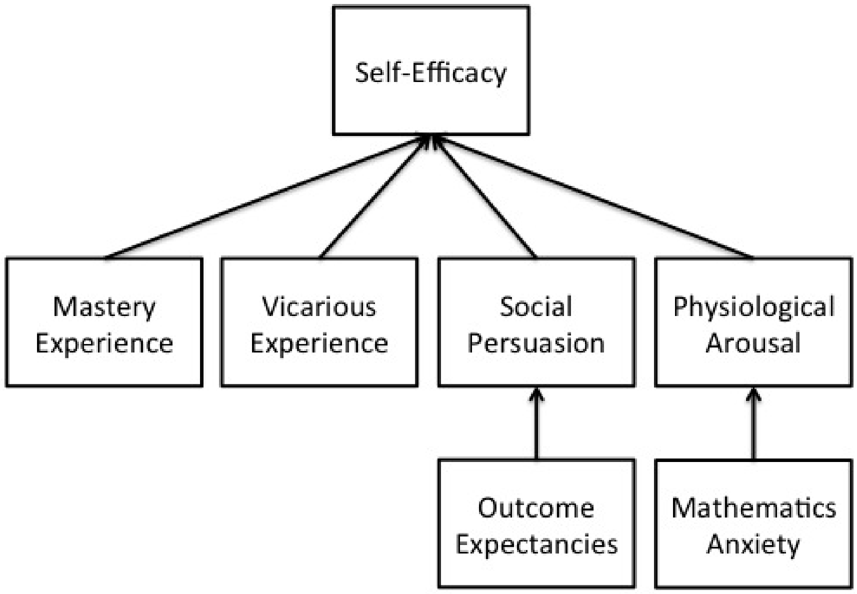
Mathematics Anxiety and Self-Efficacy

As argued earlier, the Cemen (1987) and Trujillo and Hadfield (1999) definition of mathematics anxiety reflects the relationship between the anxiety response and perceptions of self-beliefs, and thus, provides support for the connection between mathematics anxiety and self-efficacy, a form of self-belief. From efficacy theory, mathematics anxiety is a source of physiological arousal that impedes the development of positive self-efficacy. Importantly, Lee (2009) found in the PISA study that mathematics anxiety and self-efficacy for mathematics were independent predictors of mathematics performance, indicating the need to measure them separately, and to assess the degree to which self-efficacy may mediate the relationship between mathematics anxiety and achievement.

Thus, in this study, mathematics anxiety is investigated as a potential source of negative physiological arousal that impacts, but is not synonymous with, self-efficacy for teaching and learning mathematics (Figure 3). Based on the literature, teacher education students, pre-service teachers, and in-service teachers are expected to experience relatively high levels of mathematics anxiety. To the extent that teacher education students feel this anxiety, discomfort, unhealthy mood, or fear when confronted with contemplation of teaching in mathematics (or learning the mathematics content and pedagogy deeply enough to be effective in teaching mathematics), their experience of self-efficacy for teaching mathematics should be negatively impacted.

Figure 3

Mathematics Anxiety as a Contributor to Physiological Arousal Pathway in the Development of Self-Efficacy



Research with pre-service and in-service teachers further documents associations between mathematics anxiety and self-efficacy for teaching mathematics (Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006). Typically, higher mathematics anxiety is associated with lower self-efficacy for teaching mathematics. However, there are some indications that experiences gained in mathematics education methods courses can help decrease general mathematics anxiety (Gresham, 2007; Harper & Daane, 1998; Tooke & Lindstrom, 1998; Vinson, 2001). There is little research into the dosage needed to reduce mathematics anxiety and little evidence for the duration of positive effects. There is also little research distinguishing the various effects of anxiety and self-efficacy for teaching mathematics from anxiety and self-efficacy for learning mathematics during teacher education.

Objectives and Research Questions

In this study, the self-efficacy of teacher education students is investigated with reference to the specific contexts of *learning mathematics* content knowledge necessary for successfully teaching mathematics (i.e., through a teacher education program) and *teaching mathematics* in classrooms (with focus on teaching behaviors, instructional strategies, and student engagement).

Mastery experiences (experiences of teaching and related teacher behaviors in real classrooms) and vicarious experiences (experiences of observing mentor teachers, teacher education faculty, and so forth) are expected to impact self-efficacy for teaching mathematics.

Outcome expectancies relevant to general ease or difficulty for teachers and students to make changes in student achievement are assessed. Additionally, outcome expectancies about mathematical content are also assessed. These measures are used to model beliefs that teacher education students have as they prepare to enter the classroom and are expected to arise from social messages.

Mathematics anxiety is used as a proxy for one type of physiological arousal associated with teaching in mathematics classrooms. Mathematics anxiety is distinguished between learning (general) and teaching contexts. Given the uncertainty in defining the construct about whether it is the mathematical content itself or the concern of potential failure associated with that content, each anxiety measure has embedded items relevant to evaluation.

Descriptive Questions

1. To what extent do teacher education students experience:
    a. self-efficacy for teaching and learning mathematics? Are there particular areas (items) that suggest strong or weak efficacy beliefs?

Hypothesis 1a: Based on theory and the empirical literature, teacher education students are novices and should experience relatively low levels of self-efficacy for teaching and learning mathematics.

b. mathematics anxiety around the teaching and learning of mathematics? Are there particular areas (items) that suggest high or experiences of anxiety?

Hypothesis 1b: Based on the literature, teacher education students should experience high levels of mathematics anxiety for teaching and learning mathematics.

c. positive or negative perceptions of outcome expectancies related to teachers, students, and mathematics content? Are there particular areas (items) that suggest students hold particularly positive or negative expectations?

Hypothesis 1c: The literature suggests that the positivity of outcome expectancies peaks during pre-service teacher education and then declines when teachers enter the professional field. Thus, the hypothesis states that teacher and student expectancies should be positive. In contrast, more negative outcome expectancies related to mathematics content are expected given the high levels of anxiety and low levels of self-efficacy these students are hypothesized to have. Further, low student expectations may also be evident if these teacher education students see themselves as students (and thus, perceive that it is difficult to make positive student achievement gains in mathematics) rather than as teachers.

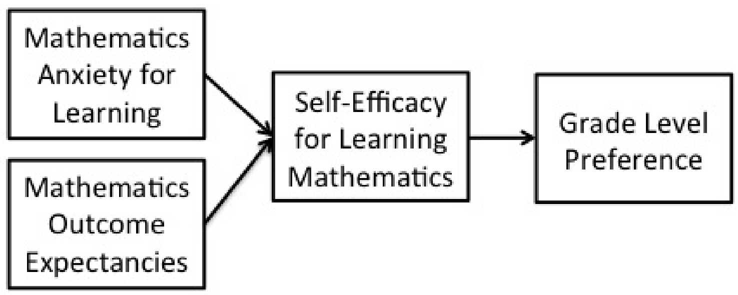
Model Questions

2. Does self-efficacy for learning mathematics content mediate the relationship between anxiety for learning mathematics content and preferred grade level.

Hypothesis 2: Students with higher mathematics anxiety and more negative outcome expectancies about mathematics content will have lower self-efficacy, which will in turn predict preference to teach at earlier grade levels as depicted in Figure 4.

Figure 4

Model 1: Self-Efficacy as a Mediator of the Relationship between Mathematics Anxiety for Learning, Mathematics Outcome Expectancies, and Grade Level Preference

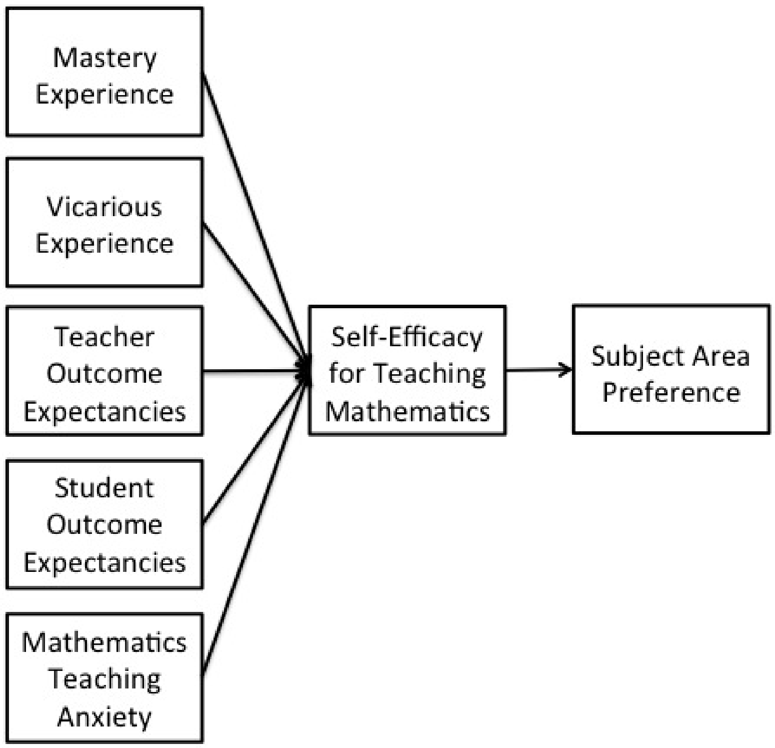


3. Does self-efficacy for teaching mathematics content mediate the relationship between mastery experiences, vicarious experiences, outcome expectancies, mathematics anxiety, and subject area preference for mathematics?

   Hypothesis 3: Students with more mastery experiences, more vicarious experiences, more positive outcome expectancies (teachers and students), and lower mathematics anxiety will have higher self-efficacy, which will in turn result in greater preference for teaching mathematics, as depicted in Figure 5.

Figure 5

Model 2: Self-Efficacy as a Mediator of the Relationship between Experience (Mastery and Vicarious), Outcome Expectancies (Teacher and Student), Mathematics Anxiety, and Subject Area Preference for Mathematics



Learning Block Participation Questions

4. Does experience with teacher professional development (i.e., *Algebra Ready* learning blocks) act to reduce mathematics anxiety, increase self-efficacy, and improve the positivity of outcome expectancies? Is it more difficult to make changes in some constructs than others?

Hypothesis 4: Learning block experience will improve student ratings of self-efficacy and outcome expectancies and decrease ratings of mathematics anxiety. Based on the literature, it will be most difficult to improve outcome expectancies.

5. Are there initial quantitative differences between differences on the survey responses between those students who choose to complete the learning blocks and those students who do not?

   Hypothesis 5: Students with higher self-efficacy and lower mathematics anxiety will be most willing to complete learning blocks.

6. Are there qualitative differences in the responses to learning block material between this group of teacher education students and the previously collected responses of in-service teachers? For example, do teacher education students make different suggestions for improvement, request different additional materials, or have different affective responses to the learning blocks than teachers who are already in the classroom?

   This question is highly exploratory and thus, no hypothesis is made.

CHAPTER 3: DATA AND METHODS

Materials

Professional development materials used in this project came from the *Algebra Ready Project* (https://algebraready.oia.arizona.edu). *Algebra Ready* is a program developed by faculty from the Department of Educational Psychology, the Department of Teaching Learning, and Sociocultural Studies, and the Office of Instruction and Assessment at the University of Arizona. The purpose of the project is to provide high-quality teacher professional development in the form of online modules (i.e., "learning blocks"). Learning blocks are designed to improve the instruction of rational numbers (fractions, decimals, and percents) and early algebra concepts (ratios, rates, proportions, equations, and growth functions) in elementary and middle school. They are informed by best practice recommendations from the National Council of Teachers of Mathematics (2000), the National Mathematics Advisory Panel (2008), the National Research Council (2001), and the *Common Core State Standards* (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010).

Teacher professional development materials used in this study came from two *Algebra Ready* learning blocks: *Absolute and Relative Reasoning* and *Key Ideas.* These learning blocks are among the more conceptual learning blocks that have been created. They both focus on basic concepts that undergird the learning and instruction of rational numbers, and thus, were specifically chosen to be useful to education students as they complete their studies. While more applied learning blocks are available, they often ask teachers to try out activities in their classrooms and report back. The teacher education students do not have the same access to students as in-service teachers, and thus the more applied blocks were deemed less appropriate for this audience. Both of the learning blocks used in this study reference fractions, decimals, and percents and also provide video of quality teaching that may serve as vicarious experience of rational number lessons for the participating pre-service teachers.

Participants

Participants included 53 teacher education students enrolled in courses through the College of Education (CoE) at the University of Arizona. Initial recruiting was done with permission of the Dean's Office and involved CoE faculty posting recruitment documents to two student listservs (pre-education student listserv and pre-service teacher listserv). After two weeks, these initial documents were followed up with a secondary recruitment document. With the permission of the instructors, the author additionally recruited from three courses enrolling undergraduate teacher education students.

Additional data were drawn from the feedback of in-service teachers who participated in the learning blocks in the academic year prior to this study. Twenty-four teacher education students, 21 in-service teachers, and 1 in-service Noyce teacher provided feedback to the *Absolute and Relative Reasoning* learning block. Twenty-two teacher education students, 15 in-service teachers, and two in-service Noyce teachers provided feedback to the *Key Ideas* learning block. Noyce Arizona Master Teachers of Mathematics were recruited in the spring prior to this study. These teachers represent an especially skilled sample of mathematics teachers who experience a wide range of professional development as part of their participation in the Noyce Scholars program. The Noyce program is funded by the National Science Foundation with the goal of increasing the number of science and mathematics teachers prepared to teach in high-needs schools.

Procedure

Full recruitment and consenting documentation are presented in Appendix A. At the time of recruitment, potential participants were informed that they would complete two surveys about their feelings about mathematics and evaluate two online professional development lessons created by the *Algebra Ready Project*. They were additionally informed that they would be paid for their time and feedback. At the time of consenting, they were informed that the total pay would be $50 for their work on both the surveys and the learning blocks. The work was expected to take less than three hours, and in most cases, students took approximately two hours to complete all work.

Upon consent, teacher education students completed the first survey, which is described in greater detail in the next section. Once the survey was completed, they were provided with login information to the *Algebra Ready* website, where they gained access to all existing learning blocks. They were specifically asked to review the two learning blocks described earlier. Within each learning block, there are embedded feedback questions. Additional items are presented after completion of a learning block.

Once both learning blocks were completed, teacher education students were emailed a link to the final survey. They were also provided with information necessary for arranging payment for their work.

Sources of Data

Prior to gaining access to the learning blocks and after completing the two assigned learning blocks, participants completed a survey that assessed self-efficacy for teaching and learning mathematics, mathematics anxiety, and outcome expectancies related to mathematics instruction as related to content, students, and teachers. At pretest, the survey also included some demographic information. At posttest, the self-efficacy, mathematics anxiety, and outcome expectancy items were reassessed, and students were also given the opportunity to provide any final thoughts or feedback about their experience with the learning blocks and with the project in general. Full copies of the survey are presented in Appendix B. The following sections describe the source and intent of the items presented in the surveys.

Self-Efficacy

Some items were drawn from the Teachers' Sense of Efficacy Scale – short form (Tschannen-Moran & Woolfolk Hoy, 2001). This instrument is widely used and has well-documented measurement parameters. All scale reliabilities are reported as $\alpha \geq 0.81$. This instrument provides a connection with recent studies with both pre-service and in-service teachers. It was initially designed at Ohio State University to reflect the concerns of teacher education faculty, and thus, the content validity is established in terms of teacher education goals. It has also been used in longitudinal work to look at teacher induction, retention, and professional development (e.g., Tschannen-Moran & Woolfolk Hoy, 2007; Woolfolk Hoy & Spero, 2005). The survey consists of three scales (Student Engagement, Instructional Strategies, and Classroom Management). In particular, the Student Engagement and Instructional Strategies scales were used in this study. Some items were adapted to reflect the mathematics focus of this study (e.g., replacing the more general "school work" with "math").

Consistent with the Bandura (1997) definition of self-efficacy these items reflect specific tasks that teachers must do (e.g., craft good questions, implement alternative strategies, motivate students). Participants are asked to rate "how much" or "how well" they will be able to do these tasks when they enter the classroom.

Additional self-efficacy items have been drawn from the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI, Enochs, Smith, & Huinker, 2000), a revision of the Science Teaching Efficacy Beliefs Instrument (STEBI, Riggs & Enochs, 1990) to reflect mathematics content. Unlike the STEBI, the MTEBI is written to reflect future perceptions of teaching as it was intended to be used with pre-service teachers, and thus, is more closely aligned to the Bandura (1997) theoretical definition of self efficacy as a forward-looking judgment of future capability.

Like the STEBI, the MTEBI measures two factors; the instruments are designed based on the Gibson and Dembo (1984) approach to measuring teacher efficacy beliefs and thus, provides measures of both personal teacher efficacy and general teacher efficacy (outcome expectancy). By providing scales for both, the MTEBI and STEBI allows the user to investigate the relationship between the more specific personal teacher efficacy (α = .88 for the MTEBI and .92 for the STEBI) and the beliefs or outcome expectancies (α = .75 for the MTEBI and .77 for the STEBI) about the general difficulty (or ease) of teaching in general (i.e., the extent to which teacher education students believe teachers can have an effect on student outcomes).

When Enochs, Smith, and Huinker (2000) created the MTEBI, they removed some STEBI items that were related to outcome expectancies about students (e.g., The low science achievement of some students cannot be blamed on their teachers.). The rationale for doing so was to keep the focus cleanly on what they called teacher general efficacy by removing items that placed the locus for achievement on students. However, these general efficacy statements about students seem to capture beliefs that teachers hold that frame the relative ease or difficulty of making changes in students' achievement given the characteristics of students.

Thus, the items that were removed when the MTEBI was created from the STEBI have been included in this study (with minor edits to shift from science to mathematics focus), and five additional items were written to frame the ease or difficulty around the locus of mathematics content rather than teacher or student (e.g., It is more difficult to improve in math than in other subjects.). The intention was to examine if these items form three separate indicators of outcome expectancies.

The validity for MTEBI was demonstrated by using confirmatory factor analysis to test the model (Enochs, Smith, & Huinker, 2000) and for the STEBI, validity evidence was additionally demonstrated by correlations between the scales and variables such as years spent teaching subject, choice to teach subject, teacher self-rating, and principal rating of effective teaching (Riggs & Enochs, 1990).

Mathematics Anxiety

General mathematics anxiety measures were drawn from the Revised Mathematics Anxiety Scale. The original Mathematics Anxiety Rating Scale (MARS, Richardson & Suinn, 1972) was a very widely used measure throughout the 1970s, but considerable problems with the instrument resulted in two popular revisions in the 1980s. The major issue with the MARS was its length (98 items). However, Alexander and Martray (1989) also reported concerns that the original instrument assumed unidimensionality of the construct despite evidence that two or three separate constructs were present. A revised and much shortened two-factor solution (24-item MARS-R, Plake & Parker, 1982) and a three-factor solution (25-item RMARS, Alexander & Martray, 1989) both gained popularity of use with U.S. undergraduate students. Advances in confirmatory factor analysis methodology in recent years has allowed better evaluation of these resulting instruments and further revision, validation, and cross-validation with undergraduate populations. The Baloğlu and Zelhart (2007) revision of the Alexander & Martray (1989) retains three reliable scales: Mathematics Text Anxiety, Numerical Task Anxiety, and Mathematics Course Anxiety. This version has been used with pre-service and in-service teachers (e.g., Wilson, 2012, 2013).

The Hopko (2003) revision of the Plake and Parker (1982) MARS-R retains two reliable scales: Learning Mathematics Anxiety and Mathematics Evaluation Anxiety. This version has also been used in work with pre-service teachers, and of particular interest given the nature of the learning blocks, with pre-service teacher anxiety around fractions (e.g., Rayner, Pitsolantis, & Osana, 2009). It has also been used with in-service teachers and in connecting teacher scores to student achievement in teachers' classrooms (e.g., Hadley & Dorward, 2011).

Many of the items for the two instruments overlap, but the emphasis on anxiety for learning mathematics in the Hopko (2003) revision as opposed to the emphasis on performance of simple mathematical tasks (addition, subtraction, multiplication, and division) in the Baloğlu and Zelhart (2007) revision make it a more appropriate choice for this study. Additional items measure come from Hadley and Dorward (2011). These items are revisions of the Hopko (2003) items to reflect anxiety about teaching and being evaluated as a teacher of mathematics instead of learning and being evaluated as a student of mathematics. These are written as consistent with the MARS-R scales (Hopko, 2003).

Mathematics Proficiency

No attempt was made to assess the students' mathematics proficiency. This was a conscious decision on the part of the researcher to make the study appealing to a wider audience of teacher education students. The literature seems clear that this population is highly anxious about mathematics. In order to make the final learning blocks most useful to both pre-service and in-service elementary and middle school teachers, it is important to capture the needs of a population of students known for high anxiety and low self-efficacy. Thus, no mathematics achievement or proficiency measures that might invoke anxiety were included. However, even with these precautions, it is likely that students who were more comfortable with mathematics content were more likely to participate. The supporting evidence for this belief as well as the implications of this finding will be discussed later.

Learning Block Feedback and Evaluation

Finally, the participants completed feedback items embedded in the learning blocks. Complete feedback items are presented with the other instrumentation in Appendix B. In general, the purpose of the feedback was to assess the utility of the learning blocks for use by teacher education students and pre-service teachers (e.g., What were the two or three most helpful ideas that were presented in this learning block? Is the material presented in the learning block useful to you? Does this learning block provide content that would be useful to pre-service teachers?). Additional feedback questions probed how the students would make use of the material (i.e., What are one or two things you will do with this information?) and if they needed further support or additional materials or explanations to fully utilize the content (i.e., Is there anything else you would like to know?). These same feedback items have also been presented to in-service teachers during the iterative design process through which the learning blocks were created. These questions were included for the purpose of informing project personnel of any specific needs for targeted audiences of the final materials.

CHAPTER 4: RESULTS

Demographics

In order to better understand the results and their generalizability of those results, demographic information is reported in Table 1 as total sample and participating subsample that elected to complete learning blocks. The sample represents the group of teacher education students interested in teaching early and upper elementary grades. The most preferred subject area to teach was science. English language arts was the least preferred subject area to teach, perhaps indicating that participation in the project was less appealing to students who preferred reading to mathematics. Most participants were either in the first or third year of their teacher education programs. As expected, more teacher education students had vicarious experience of observing others teach than had mastery experience of creating and teaching their own lessons.

Table 1

Characteristics of Teacher Education Students as a Percentage of the Sample

Characteristic	Total (*N* = 53)	Participants (*N* = 22)
Preferred Subject Area		
English Language Arts	17.3	13.0
Mathematics	21.2	26.1
Science	36.5	26.1
Social Studies	23.1	30.4
Preferred Grade Level		
Early elementary (K-3)	39.6	34.8
Upper elementary (4-5)	45.3	47.8
Middle school (6-8)	3.8	4.3
High school	11.3	13.0
Years in Teacher Education Program		
Not yet admitted	7.5	14.3
1st year	33.3	28.6
2nd year	12.5	21.4
3rd year	25.0	21.4
4th year	12.5	14.3
Experiences with Mathematics Teaching		
Taken mathematics classes like those they expect to teach	97.8	100.0

Observed teachers giving mathematics lessons	75.5	78.3
Observed teacher education faculty giving mathematics lessons	49.1	47.8
As a student teacher, assisted a mentor teacher with mathematics lessons	35.8	26.1
Designed mathematics lessons	30.2	39.1
As a student teacher, gave own mathematics lessons	20.8	26.1
Participated in mathematics teacher professional development	15.1	17.4

Reliability of Scales

Prior to analysis, the reliability of the four self-efficacy scales (learning, teaching, instructional strategies, student engagement) the two mathematics anxiety scales (learning, teaching), and the three outcome expectancy scales (teacher, student, content) were evaluated to ensure that scales were internally consistent and appropriate to use for analysis. The reliability of the scales is reported in Table 2. All scales had high reliability ($\alpha > .72$) except for two outcome expectancy scales (OES, OEM). Given the low reliability of these scales, they were not entered into model analysis.

Table 2

Reliability of Self-Efficacy, Mathematics Anxiety, and Outcome Expectancy Scales for Total Sample at Time 1 (N = 53) and Time 2 (N = 22)

					Item Average		Scale Percent	
Scale	Item Source	*k*	*Time*	*α*	*M*	*SD*	*M*	*SD*
Self-Efficacy to Learn Mathematics Knowledge for Teaching (SELM)	MTEBI (Enochs, Smith, & Huinker, 2000)	4	1	.679	4.16	.49	83.11	9.72
			2	.662	4.25	.46	85.00	9.26
Self-Efficacy to Teach Mathematics (SETM)	MTEBI (Enochs, Smith, & Huinker, 2000)	8	1	.845	3.84	.64	76.75	12.84
			2	.846	3.90	.59	78.07	11.72

Self-Efficacy for Instructional Strategies in Mathematics (SEIS)	TSES (Tschannen -Moran & Woolfolk Hoy, 2001)	4	1	.886	7.16	1.34	79.51	14.89
			2	.916	7.13	1.40	78.03	14.87
Self-Efficacy for Supporting Student Engagement in Mathematics (SESE)	TSES (Tschannen -Moran & Woolfolk Hoy, 2001)	4	1	.852	6.93	1.15	77.04	12.80
			2	.884	7.03	1.05	77.27	12.82
Mathematics Learning Anxiety (MAL)	MARS-R (Hopko, 2003)	12	1	.909	2.40	.83	47.99	16.55
			2	.911	2.30	.81	45.91	16.17
Mathematics Teaching Anxiety (MAT)	MARS-R (Hadley & Dorward, 2011)	11	1	.924	2.50	.85	49.85	16.86
			2	.913	2.26	.79	45.21	15.86
Outcome Expectancies for Teachers in Mathematics (OET)	MTEBI (Enochs, Smith, & Huinker, 2000)	8	1	.715	3.57	.47	71.37	9.47
			2	.786	3.71	.47	73.75	9.90
Outcome Expectancies for Students in Mathematics (OES)	STEBI (Riggs & Enochs, 1990)	4	1	.426	3.25	.58	65.09	11.62
			2	-.065	3.25	.43	65.00	8.59
Outcome Expectancies for Mathematics Content (OEM)	OEM Olson (2014)	5	1	.302	2.83	.45	56.52	9.05
			2	-.038	2.81	.38	56.18	7.56

Descriptive Statistics

Mathematics Anxiety Measures

One intention of this study was to explore the extent to which teacher education students at the University experience mathematics anxiety and self-efficacy around teaching and learning mathematics, as well as their perceptions of the relative ease or difficulty of making changes in student achievement in mathematics with reference to perceptions of teachers, students, and mathematical content. Thus, some purely descriptive analysis is presented in this section. In order to make comparisons clearer, student responses were compared to the initial (raw) item Likert-like scale descriptors as well as transformed to the same metric (percentage of total possible points). Table 2 provides average item values and percent scores across scales. Effect sizes for comparisons use Cohen's *h*, an effect size measure appropriate to use with proportions (Cohen, 1988).

On average at Time 1, teacher education students rated their anxiety for learning mathematics at 47.99% of the total possible score and their anxiety for teaching mathematics at 49.85% of the total possible score, indicating only a very small difference between students' anxiety for learning mathematics and students' anxiety for teaching mathematics (h = .04). Based on percentage scale scores, students tended to respond with anxiety to slightly less than half of the items on the scales. Anxiety measures were rated on a five-point scale from a low anxiety score of 1 ("not at all") to a high anxiety score of 5 ("very much"). The average scores on the mathematics anxiety items fell between "a little" and "a fair amount" on both the learning scale (M = 2.40, SD = .83) and the teaching scale (M = 2.50, SD = .84).

In terms of both learning and teaching, anxiety was highest for items that were set in evaluation contexts [e.g., Teaching: "Preparing students for a 'standardized' math test throughout the week before" (M = 3.13, SD = 1.18), "Waiting for the results of your students' year-end math tests" (M = 3.19, SD = 1.14), "Having a surprise evaluation by an administrator during a math lesson you are teaching" (M = 3.45, SD = 1.17); Learning: "Thinking about an upcoming math test one day before" (M = 3.19, SD = 1.29), "Taking an examination (quiz) in a math course" (M = 3.21, SD = 1.26), "Waiting to get a math test returned in which you expected to do well" (M =

3.15, *SD* = 1.34), "Being given a "pop" quiz in math class" (*M* = 3.49, *SD* = 1.23)]. The lowest levels of anxiety occurred in contexts that attempted to elicit review or studying behaviors [e.g., Teaching: "Looking through the pages in your math series teachers' manual" (*M* = 1.89, *SD* = .99); Learning: "Looking through the pages in a math text" (*M* = 1.64, *SD* = .98), "Watching a teacher work an algebraic equation on the black board" (*M* = 1.81, *SD* = 1.09), "Picking up a math textbook to begin working on an assignment" (*M* = 1.85, *SD* = .98)]. Note that these low-anxiety prompts are most often set in passive context in which the teacher education student is not yet engaged in mathematics tasks or evaluation of mathematics performance. Teacher education students also reported relatively low levels of anxiety for a potentially challenging teaching situation ["Talking to a student who wanted to use a different way to solve a math problem than the way you taught in class" (*M* = 1.83, *SD* = 1.11)], while other teacher responsibilities were rated as more anxiety-inducing [e.g., "Preparing to teach students a new math concept that will be challenging for them" (*M* = 2.74, *SD* = 1.16), "Explaining the rationale for the math curriculum to a parent who stopped by your classroom after school" (*M* = 2.63, *SD* = 1.16). Given that teachers are increasingly expected to make data-driven decisions in their instruction, it is disheartening that the learning item referencing statistics coursework ("Signing up for a statistics course") is rated above the mean for anxiety (*M* = 2.96, *SD* = 1.49).

Self-Efficacy Measures

Items drawn from the MTEBI (Enochs, Smith, & Huinker, 2000) were used to measure self-efficacy to learn the content necessary to teach and self-efficacy to engage in teaching mathematics. At Time 1, teacher education students rated their self-efficacy for learning mathematics knowledge at 83.11% of the total possible score and their self-efficacy for teaching mathematics at 76.75% of the total possible score, indicating they felt more efficacious for learning than they did for teaching (*h* = .16). However, in both measures, the efficacy beliefs of teacher education students were quite high; students expressed high levels of agreement that they will be able to learn and teach content. These items are rated on a five-point agreement scale, then reverse coded, such that the scale ranged from a low self-efficacy score of 1 ("strongly disagree" with an efficacy statement) to a high self-efficacy score of 5 ("strongly agree" with an efficacy statement). Item averages indicate that students tended to fall between "agree" and "strongly agree" with statements about their efficacy to learn, while they fell somewhere between "uncertain" and "agree" on statements about their efficacy to teach.

Teaching items that teacher education students responded to with particularly strong efficacy include "I will typically be able to answer students' math questions" (*M* = 4.26, *SD* = .66) and "I will generally teach math ineffectively", which was reverse coded indicating that teacher education students felt they would be able to teach math effectively (*M* = 4.19, *SD* = .76). In contrast, teacher education students demonstrated lower efficacy when responding to items like "I wonder if I have the necessary skills to teach math" [reverse coded] (*M* = 3.23, *SD* = 1.22) and "Even if I try very hard, I will not teach math as well as I will most subjects" [reverse coded] (*M* = 3.47, *SD* = 1.20). However, even in those cases where efficacy beliefs tended to be weaker, the respondents indicated that they felt "uncertain" rather than openly negative about their future skills.

In terms of learning knowledge necessary to be successful mathematics teachers, teacher education students responded with strong efficacy to the statements "I will continually find better ways to teach math" (*M* = 4.57, *SD* = .61) and "I will understand math concepts well enough to be effective in teaching elementary math" (*M* = 4.36, *SD* = .65). They demonstrated the weakest efficacy for an item that reflects their ability to inspire their students ("I will not know what to do to turn students on to math" [reverse coded]; *M* = 3.79, *SD* = .72) rather than for mastery of content, but again, their efficacy even on this item was quite high ("uncertain" to "agree").

In addition, two self-efficacy scales (self-efficacy for student engagement, SESE, and self-efficacy for instructional strategies, SEIS) from the TSES – short form (Tschannen-Moran & Woolfolk Hoy, 2001) were used to gauge teacher education students' efficacy for specific tasks related to mathematics instruction. Teacher education students responded with similar levels of confidence to all three self-efficacy for teaching scales (*M* = 77.77% across the three scales, *SD* =1.24%). Only a very small difference exists between the highest (SEIS) and lowest (SETM) scoring scales (*h* = .07).

TSES items ask respondents how much they will be able to do with regards to specific classroom tasks. Items are rated from 1 ("Nothing") to 9 ("A great deal"). On average, students rated how much they would be able to do in terms of both instructional strategies and student engagement as "Quite a bit" (SEIS: *M* = 7.16, *SD* = 1.34, SESE: *M* = 6.93, *SD* = 1.15). Two student engagement items were rated less positively: "How much will you be able to do to motivate students who show low interest in math schoolwork" (*M* = 6.79, *SD* = 1.31) and "How much will you be able to do to assist families in helping their children do well in math?" (*M* = 6.68, *SD* = 1.59). The most positively rated item indicated teacher educations students had relatively high levels of efficacy for depth of their understanding of the mathematics content: "To what extent will you be able to provide an alternative explanation or example when students are confused about math?" (*M* = 7.30, *SD* = 1.45).

Outcome Expectancies

Items drawn from the MTEBI (Enochs, Smith, & Huinker, 2000) and STEBI (Riggs & Enochs, 1990), or created to be similar in format (Olson, 2014), were used to measure outcome expectancies that framed the difficulty of making changes in student achievement with respect to the role of teachers, students, and content. Similar to the MTEBI self-efficacy items, outcome expectancy items were rated from a low score of 1 indicating participants "strongly disagree" with the ability for students or teachers to make changes in student achievement to a high score of 5 indicting participants "strongly agree" with the ability of students or teachers to make changes in student achievement.

Teacher education students tended to respond more positively to the teacher scale (71.37%) and student scale (65.09%) than to the content scale (56.53%). However, the difference between student and content scales (h = .18) and the difference between teacher and content scales (h = .31) were small effects.

Teacher items formed an internally consistent scale. Students tended to respond to these items between "uncertain" and "agree". For example, high agreement items included, "The inadequacy of a student's math background can be overcome by good teaching" (M = 3.92, SD = .68) and "When the math grades of students improve, it is often due to their teacher having found a more effective approach" (M = 3.87, SD = .76). A lower agreement item was "If students are underachieving in math, it is most likely due to ineffective math teaching" [reverse coded] (M = 3.13, SD = .96), suggesting that while teacher education students agreed that student achievement was due to teachers' influence, they were less likely to agree that student underachievement was due to teachers' influence.

The student and content items did not form internally consistent scales; however, from an exploratory perspective, examining items allows further insight into teacher education students' beliefs even if the scales are not consistent enough to use as full measures in the models. The student belief items were all reverse coded, resulting in item averages ranging from "disagree" to "agree" on the Likert scaling. Following reverse coding, a high agreement item was "Effectiveness in math teaching has little influence on the achievement motivation of students with low motivation" (*M* = 3.64, *SD* = .88). A low agreement (high disagreement) item was, "The low math achievement of some students cannot be blamed on their teachers" (*M* = 2.77, *SD* = .80). The scale's low reliability may be due to teacher education students' ambiguity of when teachers or students are responsible for achievement. For example, in these items, teacher cannot influence students with low motivation but they should also be held responsible for students' low achievement.

Given the purported mathematics anxiety of pre-service teachers, it seemed prudent to include items that attempted to measure the degree to which the content area influences the general ease or difficulty of making changes in student achievement. Thus, several items were created to ascertain teacher education students' general beliefs about math. Teacher education students agreed that math requires more effort than other subjects [reverse coded] (*M* = 2.94, *SD* = 1.10), math makes more sense than other subjects (*M* = 3.28, *SD* = .95), people worry more about being successful in math than other subjects [reverse coded] (*M* = 2.11, *SD* = .82). Teacher education students disagreed that math is more difficult than other subjects [reverse coded] (*M* = 3.68, *SD* = .83) and that people like taking math more than other subjects (*M* = 2.11, *SD* = .64).

Note that across the items drawn from the MTEBI and STEBI and used to form self-efficacy to teach and learn mathematics (SETM, SELM) and outcome expectancy scales (OES, OET), as well as the items in the outcome expectancies for mathematics scales intended to be consistent with the other MTEBI and STEBI items, teacher education students responded with the lowest levels of agreement to items that were phrased negatively and intended to be reverse coded. Perhaps the negative framing of the items contributed to the low levels of agreement beyond the intended measure of content and thus artificially lowered agreement. However, the percent agreement with the self-efficacy scales drawn from these sources and those drawn from the TSES are consistent, again suggesting the relatively high levels of self-efficacy in this group.

Model Analyses

The intention of future work is to evaluate models that relate mathematics anxiety, self-efficacy, and (pre-service) teacher outcomes. However, the sample size in the current study is not optimal for modeling approaches. Hence, traditional statistical analyses of observed variables were used, as informed by Hayes (2013), Stevens (2009), and Tabachnick and Fidell (2013). These include binary logistic regression, sequential multiple regression, analysis of mediation, analysis of variance, and dependent-sample t-tests, in addition to the reporting of descriptive statistics and effect size measures. All analyses were performed using SPSS Statistics 20.0 and the PROCESS 2.11 macro created for SPSS by Hayes (2014).

Diagnostics: Tests of Assumptions

Absence of univariate outliers. Univariate outliers occur when cases have very large standardized scores, resulting in departure from normality in the variable's distribution. Outliers affect the regression solution too greatly (i.e., pull the solution toward outlying values), and thus, should be removed prior to regression analysis (Tabachnick & Fidell, 2013). Initial exploration for outliers was conducted using SPSS EXPLORE to test skewness (*sk*), kurtosis (*kur*), and the Kolmogorov-Smirnov (*D*) test of normality for all variables intended to be used in model analysis, including the four self-efficacy variables (SELM, SEIS, SESE, SETM), the two mathematics anxiety variables (MAL, MAT), the reliable outcome expectancy variable (OET), as well as the two dependent variables (Grade Level Preference, Subject Area Preference).

These values are presented in Table 3. Tabachnick & Fidell (2013) suggest that skewness and kurtosis beyond the criterion of z = 3.29 serve as indicators that a distribution has outliers. The *D* test of normality is preferred to the Shapiro-Wilk test with small sample sizes, but like the Shapiro-Wilk, it may be overly sensitive with extremely small samples like those in this study (Tabachnick & Fidell, 2013). Thus, the combination of the three diagnostics was used to evaluate potential violations of assumptions.

No egregious violations in normality were found in skew and kurtosis except on the variable, SEIS (z_{sk} = -3.83, z_{kur} = 3.54, D = .15, p = .004), which exceeded the Tabachnick & Fidell (2013) criteria. A box plot and histogram were used to further assess the departures from normality and identify outliers in the SEIS as per the recommendations of Stevens (2009) and Tabachnick & Fidell (2013). This resulted in removal of four outliers from analyses that used the SEIS variable (Model 2). The students with outlying scores on this variable rated their self-efficacy for instructional strategies as extremely low (SEIS < 20) in comparison to their peers, but their responses on the other variables were not unusual for the sample.

Additionally, exploration of the variables indicated that the sample over-represents teacher education students who hope to teach early elementary (n = 21; 39.6% of the total sample) or upper elementary grades (n = 24; 45.3% of the total sample), while under-representing teacher education students primarily interested in teaching middle school (n = 2; 3.8% of the total sample) or high school n = 6; 11.3% of the total sample). This resulted in removal of participants preferring middle school and high school from the analyses using grade level preference (Model 1).

Table 3

Exploration of Assumptions of Univariate Skewness, Kurtosis, and Normality

Scale	*sk*	z_{sk}	*kur*	z_{kur}	*D*	p_D
Self-Efficacy to Learn Mathematics Knowledge for Teaching (SELM)	-.65	-1.99	.54	.83	.15	.005
Self-Efficacy to Teach Mathematics (SETM)	.41	1.26	.03	.05	.11	.176
Self-Efficacy for Instructional Strategies in Mathematics (SEIS)	-1.25	-3.83	2.28	3.54	.15	.004
Self-Efficacy for Supporting Student Engagement in Mathematics (SESE)	-.28	-.86	-.60	.93	.11	.182
Mathematics Learning Anxiety (MAL)	.47	1.44	-.90	-1.40	.14	.012
Mathematics Teaching Anxiety (MAT)	.53	1.63	-.45	.70	.12	.049
Outcome Expectancies for Teachers in Mathematics (OET)	-.20	-.60	-.47	-.73	.08	.200
Grade Level Preference	1.14	3.47	.65	1.00	.29	< .001
Subject Area (Mathematics) Preference	-.391	-1.18	-1.20	-.65	.23	< .001

Normality, linearity, and homoscedasticity of residuals. Regression assumes that the prediction errors (residuals) are normally distributed around each predicted score and that the relationship between the predicted scores and errors is linear. Homoscedasticity refers to the distribution of residuals. The assumption states that residuals must be normally distributed as opposed to non-normal or heteroscedastic distributions. Observation of the predicted scores against residuals via P-P plots and the distribution of the standardized predicted scores against standardized residuals via scatter plots was conducted following each regression run. Results indicated no major violations of the assumptions of normality, linearity, and homoscedasticity.

Independence of errors. Further, regression analysis assumes that residuals are independent of one another. When the independence assumption has been met, the Durbin and Watson (1951) test should yield a diagnostic value around 2 (i.e., not less than 1 and not greater than 3). Durbin-Watson test values are reported.

Multicollinearity. Multicollinearity among variables results in large standard errors of regression coefficients, reducing power to detect significant predictors. Multicollinearity is assessed using Tolerance and Variance Inflation Factor (VIF) diagnostics. Tolerance is measured by subtracting R^2 from one. VIF measures the correlation of each variable to the others in the model, and thus is consistent with R^2 and the reciprocal of Tolerance. When diagnostics indicate that VIF is low (below 2) and Tolerance is high, the threat of multicollinearity is minimized. However, when the assumption is violated, it becomes more difficult to detect and interpret *b* coefficients. Thus it is important to set criteria for determining when multicollinearity is a valid threat to findings. Historically, measures of Tolerance less than or equal to .2 were used to indicate multicollinearity, but Tabachnick and Fidell (2013) suggest that when Tolerance is as high as .5 or .6, multicollinearity may still be a threat. Thus, both VIF and Tolerance are reported to serve as multiple diagnostics, and in this study, all observed VIF values are below 1.5 and all Tolerance values are above .7, indicating little risk of multicollinearity in the models.

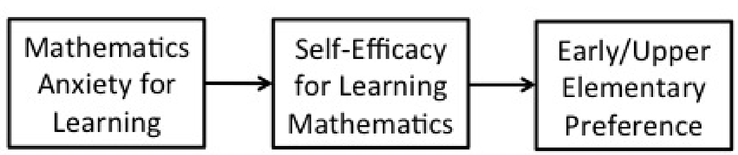
Violation of regression assumptions relates to the power available to detect significance of predictors and also to the accuracy of confidence intervals generated for the *b* coefficients (rather than the estimation of the *b* coefficients). Significance tests and confidence intervals should provide the same information about the utility of a predictor (i.e., a significant predictor should not have zero in the confidence interval). However, this is not always the case. Where minor violations of regression assumptions occur, bootstrapping can be used to generate more accurate confidence intervals as is done in the Hayes (2014) procedure. Kirk (2008) suggests that when confidence intervals indicate the utility of a predictor, it should remain in the model even if statistical tests suggest that it is not significance. Given the robustness of the Hayes (2014) confidence intervals, this decision rule was adopted for the following model analyses.

Model 1: Grade Level Preference

Based on the literature, it was hypothesized in the first model (Figure 4) that higher levels of mathematics anxiety and more negative outcome expectancies associated with mathematical content would lead to lower levels of self-efficacy, which in turn, would predict that teacher education students' preference for teaching earlier grade levels. However, the low level of reliability associated with the mathematics outcome expectancies makes it inappropriate to include these in testing the model. Thus, the revised hypothesis (depicted in Figure 6) suggests that self-efficacy is a mediator in the relationship between anxiety for learning mathematics and grade level preference. Further, the restriction of range in the grade level preference variable resulted in revision of the analysis to test if anxiety (MAL) and self-efficacy around learning mathematics content (SELM) significantly predicted teacher education students' preference for teaching early elementary (K-3) or upper elementary grades (4-5), *N* = 46.

Figure 6

Revised Model 1: Self-Efficacy for Learning Mathematics as a Mediator in the Relationship between Anxiety for Learning Mathematics and Grade Level Preference



The PROCESS 2.11 macro developed by Hayes (2014) was used to estimate the direct and indirect effects of mathematics learning anxiety (MAL) with the self-efficacy for learning mathematics factor (SELM) as a mediating variable. Given the small sample size, this approach has the advantage of using a single significance test for mediation (and thus increasing protection from familywise alpha errors) as well as built-in bootstrapping methods to generate confidence intervals for the indirect and mediated effects that makes the analysis more robust to potential violations of assumption of normal distributions of scores. Further, it is appropriate to use with the binary outcome, grade level preference.

In the binary logistic regression analysis, the dependent variable was grade level preference, the independent variable was anxiety for learning mathematics, and the proposed mediating variable was self-efficacy to learn mathematics. Table 4 reports the regression of anxiety for learning mathematics and self-efficacy for learning mathematics on grade level preference. Figure 7 reports the total, direct, and mediation effects. There was no support for the hypothesis; a test of the full model with the predictor and hypothesized mediator against a constant-only model was not statistically significant $\chi^2(2, N = 45) = 2.787$, $p = 0.248$. The McFadden's *D* effect size, an effect size measure appropriate to use with logistic regression, was .04, and only 57.1% of early elementary and 70.8% of upper elementary teacher education students were correctly classified. Thus, the anxiety and self-efficacy measures around learning mathematics do not reliably distinguish between teacher education students interested in teaching early elementary or upper elementary grades.

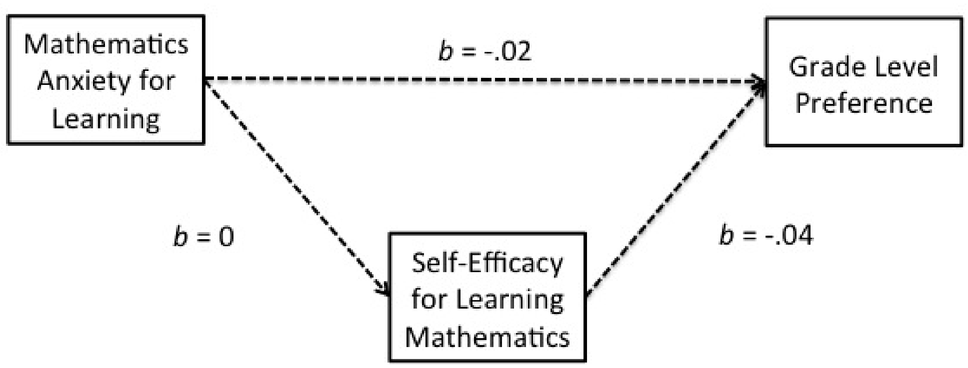
Table 4

Correlations and b Coefficients for Logistic Regression of Mathematics Learning Anxiety (MAL) and Self-Efficacy for Learning Mathematics (SELM) as Predictors of Grade Level Preference

	Zero-Order *r*				
Variable	SELM	MAL	*b*	*p*	Bootstrap 95% CI
Constant	-.16	-.17	4.41	.134	[-1.36, 10.18]
SELM		-.10	-.04	.241	[-.10, .02]
MAL			-.02	.206	[.05, .01]
Direct Effect			-.02		[-.06, .01]
Indirect Effect			.00		[0, .02]

Figure 7

Non-Significant Predictors in the Relationship between Anxiety for Learning Mathematics, Self-Efficacy for Learning Mathematics, and Grade Level Preference

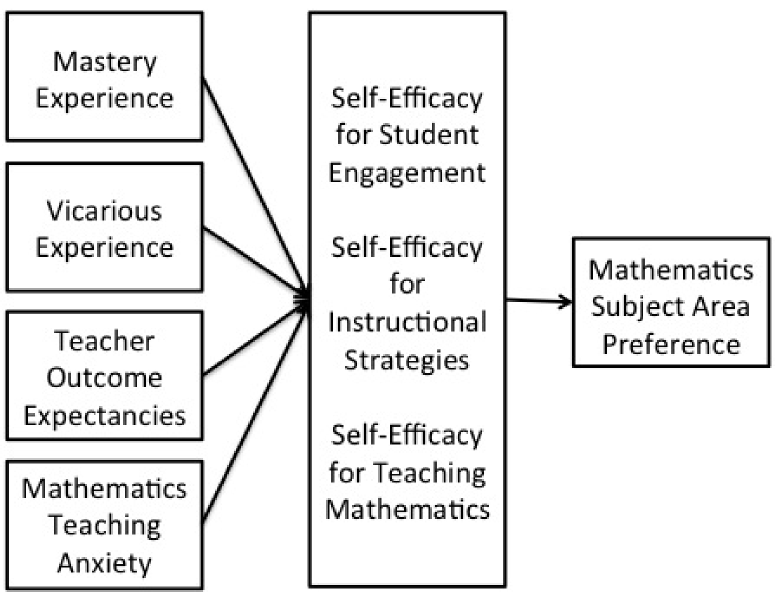


Model 2: Subject Area Preference

Model 2 hypothesizes that teacher education students' experience of self-efficacy for teaching mathematics (SETM, SEIS, SESE) should predict their global preference for teaching mathematics (as compared to other core subject areas). Self-efficacy theory further suggests that experience (vicarious and mastery) and anxiety (physiological arousal) should predict self-efficacy. In addition, the argument presented in this paper suggests that outcome expectancies (general efficacies) should likewise influence self-efficacy, particularly for novices. Model 2 (Figure 8) thus predicts that self-efficacy for teaching mathematics (SETM, SEIS, SESE) mediates the relationship between mathematics teaching anxiety (MAT), outcome expectancies about teachers' and students' influence on students' mathematics achievement (OE), vicarious and mastery experiences (VE), and global preference for teaching mathematics (in comparison to other core subject areas).

Figure 8

Revised Model 2: Relationship between Anxiety for Teaching Mathematics, Outcome Expectancies for Teaching Mathematics, Self-Efficacies for Teaching Mathematics, and Subject Area Preference for Mathematics



Model 2 questions include:

1. Do any of the measures of self-efficacy (SESE, SEIS, SETM) predict the outcome of preference for teaching mathematics?

2. Do any of the factors (MAT, OE, VE, ME) theorized to predict self-efficacy do so?
3. Does self-efficacy mediate the relationship between predictive factors and the outcome?

Given the complexity of the model and the relatively low ratio of participants to predictors, the model was first pruned of all non-significant predictors prior to evaluation of the potential mediation effect. Thus, each of the three model questions was addressed independently. However, to account for the potential for familywise alpha errors, each question was addressed with a Bonferroni corrected alpha ($\alpha = 0.05/3 = 0.017$).

As noted earlier, preliminary evaluation of assumptions indicated that four participants were extreme outliers on the self-efficacy for instructional strategies variable (SEIS), leading to non-normal distribution ($z_{sk} = -3.83$, $z_{kur} = 3.54$, $D = 15$, $p = .004$). These participants were removed from analysis, resulting in a sample size of $N = 48$.

Model 2A hypothesizes that participants' experience of self-efficacy for teaching mathematics (SETM, SEIS, SESE) should predict their global preference for teaching mathematics (as compared to other core subject areas). SPSS REGRESSION was run with preference for mathematics as the dependent variable and the three self-efficacy for teaching variables as independent variables (predictors). Table 5 displays the results of the regression analyses for this question.

Exploration of residuals was undertaken. The Durbin-Watson test of independence of errors was acceptable ($DW = 1.77$), and diagnostics for multicollinearity suggested a low level of multicollinearity threat (SESE: *Tolerance* = .71, *VIF* = 1.40; SEIS: *Tolerance* = .71, *VIF* = 1.42; SETM: *Tolerance* = .93, *VIF* = 1.07). Residuals were also examined with P-P plots, suggesting little need to be concerned with the distribution of residuals. However, scatterplots indicated some potential that residuals were associated with the categorical outcome variable.

Consistent with the hypothesis, R = .48, $F(3, 45)$ = 4.49, p = .008, with R^2 = .23, and 95% CI [0.04, 0.42]. The adjusted R^2 value of .18 indicates that a little less than one-fifth of the variability in overall confidence is predicted by SETM, SEIS, and SESE. However, only the regression coefficients for self-efficacy to teach mathematics (b_{SETM} = 1.15, p = 0.001) differed significantly from zero, 95% CI [.47, 1.83]. Self-efficacy for mathematics instructional strategies (SEIS, p = 0.610) and self-efficacy for student engagement in mathematics (SESE, p = 0.869) did not significantly contribute to students' preference for teaching mathematics.

Table 5

Correlations and b Coefficients for Standard Multiple Regression of Self-Efficacy for Teaching Variables (SESE, SEIS, SETM) on Subject Area Preference for Mathematics

		Zero-Order *r*					
Model	Variable	SESE	SEIS	SETM	*b*	*p*	95% *CI*
2A	Math Preference	.12	.18	.48*	-33.83	.361	[-107.67, 40.01]
	SESE		.53*	.22	-.06	.869	[-.84, .71]
	SEIS			.24	.22	.610	[-.64, .1.08]
	SETM				1.15	.001	[.47, 1.83]
2B	Constant				-20.82	.338	[-64.08, 22.45]
	SETM				1.15	< .001	[.60, 1.71]

* $p < .001$

The SESE and SEIS variables were removed; neither their *b* coefficients nor their CIs suggested keeping them in the model. The participants who had scored as outliers on SEIS were returned to the sample given that they were not outliers with respect to their responses on the SETM variable, resulting in N = 52.

The revised model resulted in R = .51, $F(1, 50)$ = 17.54, p < 0.001, with R^2 = 0.26, 95% CI [.06, .46]. Adjusted R^2 = .25, indicating that approximately one quarter of the variability in subject area preference is predicted by the single self-efficacy variable, SETM. With only one predictor in the model, there was no need to review collinearity diagnostics. The diagnostic for independence of errors was again acceptable (*DW* = 1.94) as was the P-P plot of the residuals.

For the second question, self-efficacy theory suggests that experience (vicarious and mastery) and anxiety (physiological arousal) should predict self-efficacy. Further, the argument presented in this paper suggests that outcome expectancies (general efficacies) should likewise influence self-efficacy, particularly for novices. Thus, an SPSS REGRESSION model was run to explore whether experience (ME, VE), mathematics teaching anxiety (MAT), and outcome expectancies (OET) predicted the SETM variable (Model 2C). Regression results are reported in Table 6.

Table 6

Correlations and b Coefficients for Standard Multiple Regression of Experience (ME, VE), Mathematics Teaching Anxiety (MAT), and Outcome Expectancies for Teachers (OET) on Self-Efficacy for Teaching Mathematics (SETM)

		Zero-Order *r*						
Model	Variable	VE	ME	OET	MAT	*b*	*p*	95% *CI*
2C	SETM	.39**	.10	-.49***	-.28*	102.71	< .001	[76.28, 129.14]
	VE		.37**	-.12	-.09	.14	.007	[.04, .23]
	ME			-.11	-.26*	-.05	.317	[-.16, .05]
	MAT				.13	-.33	< .001	[-.51, -.16]
	OET					-.25	.134	[-.57, .08]
2D	SETM					87.50	< .001	[76.95, 98.05]
	VE					.13	.005	[.04, .22]
	MAT					-.34	< .001	[-.51, -.16]
2E	Math Preference					21.93	.479	[-39.80, 83.65]
	SETM					.83	.013	[.18, 1.49]
	MAT					-.44	.059	[-.89, .02]
	VE					.05	.658	[-.18, .28]
	Indirect of MAT					.27		[-.64, -.08]
	Indirect of VE					.10		[.02, .25]

* $p < .05$, ** $p < .01$, *** $p < .001$.

Analysis of residuals indicated no major concerns. The Durbin-Watson test of independence of errors was acceptable (*DW* = 1.95), and diagnostics for multicollinearity suggested a low level of multicollinearity (VE: *Tolerance* = .85, *VIF* = 1.18; ME: *Tolerance* = .83, *VIF* = 1.21; MAT: *Tolerance* = .97, *VIF* = 1.02, OET: *Tolerance* = .91, *VIF* = 1.10). Residuals were also examined with P-P plots and scatter plots, suggesting no need to be concerned with the distribution of residuals.

Consistent with the predicted relationships, $R = .62$, $F(4, 48) = 7.45$, $p < .001$, with $R^2 = 0.33$, and 95% CI [.14, .52]. The adjusted R^2 value of .33 indicates that one-third of the variability in overall self-efficacy for teaching mathematics is predicted by the combination of anxiety, vicarious experience, outcome expectancy, and mastery experience variables. Regression coefficients for anxiety ($b_{\text{MAT}} = -.33$, $p < .001$, 95% CI [-.51, -.16]) and vicarious experience ($b_{\text{VE}} = .14$, $p = .007$, CI 95% [.04, .23]) differed significantly from zero.

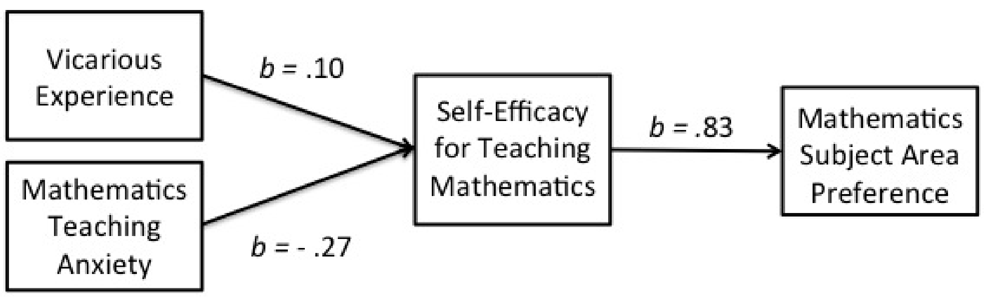
The non-significant predictors were removed and the model was re-run, resulting in $R = 0.59$, $F(2, 50) = 13.24$, $p < 0.001$, with $R^2 = 0.35$, and 95% CI [0.15, 0.55]. The adjusted R^2 value indicated that 32% of the variability in subject preference is predicted by the combination of anxiety for teaching mathematics and anxiety for vicarious experience. $b_{\text{MAT}} = -.34$, $p < .001$, with 95% CI [-.51, -0.16], and $b_{\text{VE}} = 0.13$, $p = 0.005$, with 95% CI [.04, .22].

Following the revision of the model, residuals were again examined. The Durbin-Watson test of independence of errors was acceptable (*DW* = 1.84), and diagnostics for multicollinearity suggested a low level of multicollinearity (*Tolerance* = .99, *VIF* = 1.02). Residuals were also examined with P-P plots and scatter plots, suggesting no need to be concerned with the distribution of residuals.

Finally, the mediation effect (Model 2E) was tested using PROCESS 2.11. In order to test two independent variables (MAT, VE), Hayes (2013) recommends that PROCESS 2.11 be run twice, each time with one of the independent variables as the predictor and the other as a covariate. Although this does not allow for a single test of the total indirect effect across all independent variables, it does afford estimates and tests for each independent variable.

Figure 9

Significant Predictors in the Relationship between Vicarious Experience, Mathematics Teaching Anxiety, Self-Efficacy for Teaching Mathematics, and Subject Area Preference for Mathematics



In the first run, the dependent variable, subject area preference, was predicted from mathematics teaching anxiety (MAT), vicarious experiences (VE) were treated as a covariate, and the self-efficacy measure (SETM) was treated as a potential mediator. In the second run, the dependent variable, subject area preference, was predicted from vicarious experience (VE), mathematics teaching anxiety (MAT) was treated as a covariate, and the self-efficacy measure (SETM) was treated as a potential mediator. Model 2E was significant; $R = .55$, $F(3, 48) = 7.33$, $p < .001$, with $R^2 = .31$, and CI 95% [.12, .50]. Unstandardized coefficients for all significant paths in this model appear in Figure 9 and measures of total, direct, and mediation effects appear in Table 6. Results indicate that the anxiety ($b = -.33$, $p = .001$) and vicarious experience ($b =$

.12, *p* = .017) significantly predict self-efficacy, self-efficacy significantly predicts subject area preference (*b* = .83, *p* = .013), but anxiety (*b* = -.44, *p* = 0.059) and vicarious experience (*b* = .05, *p* = 0.658) do not significantly predict the outcome with the mediator in the model. Thus, self-efficacy appears to mediate the relationship between anxiety, vicarious experience, and subject area preference. The indirect effect of mathematics teaching anxiety on subject area preference is -.27 (Boot 95% CI [-.64, -.08]), and the indirect effect of vicarious experience on subject area preference through self-efficacy is .10 (Boot 95% CI [.02, .25]). The bootstrap samples for bias corrected confidence intervals included 1000 samples.

Analysis of Learning Block Participation

Selection into Learning Block Participation

An exploratory analysis of variance was run to determine if there were any variables of interest that could help explain which teacher education students selected into participation in the learning blocks. Given the small sample size of students who elected to complete the learning blocks and concomitant lack of power, Cohen's *d* (Cohen, 1988) is reported in addition to significance levels. Surprisingly, there were no significant differences between the 22 teacher education students who chose to complete and the 30 teacher education students who chose not to complete the learning blocks on any of the variables in this study: anxiety to teach (*p* = 0.647, *d* = .13) or learn math (*p* = 0.644, *d* = .13), mastery (*p* = 0.725, *d* = .10) or vicarious experiences (*p* = 0.962, *d* = .01), self-efficacy to teach (*p* = 0.199, *d* = .36) or learn math (*p* = 0.346, *d* = .27), preference for teaching mathematics as a core subject (*p* = 0.557, *d* = .17), or preferred grade level to teach (*p* = 0.554, *d* = .17). Thus, there were small effect size differences between the groups on self-efficacy to teach mathematics, and self-efficacy to learn mathematics. As would be expected from theory, in both cases the teacher education students with higher self-efficacy chose to participate in the learning blocks.

Experience with Learning Blocks

The analyses presented above suggest that mathematics teaching anxiety (MAT) and self-efficacy for teaching mathematics (SETM) hold promise for explaining teacher education students' attitudes toward their professional work as mathematics teachers. Additionally, self-efficacy for learning mathematics (SELM) may also contribute to teacher education students' willingness to participate in educational experiences before they enter the classroom. Finally, although outcome expectancy dropped from the model, the initial hypothesis was that outcome expectancies could be influenced via social persuasion, which in addition to the vicarious experience of watching expert teachers provided in the learning blocks, may be an effect of the professional development materials. It was therefore important to consider whether experiences with the professional development materials were able to make changes in any of these variables. Dependent *t* tests were conducted to determine if change occurred in any of these variables. Given the small sample size, *d* is again reported in addition statistical significance in Table 7.

Table 7

Mean Differences from Time 1 to Time 2 in Self-Efficacy, Mathematics Anxiety, and Outcome Expectancy Variables with Participation in Learning Blocks

Variable	M_D	SD_D	*p*	*d*
Self-Efficacy to Teach Mathematics (SETM)	-1.36	6.58	.342	-.27
Self-Efficacy to Learn Mathematics (SELM)	.91	7.66	.584	.16
Mathematics Teaching Anxiety (MAT)	-3.06	12.87	.278	-.32
Outcome Expectancies for Teachers (OET)	1.82	9.92	.399	.24

Results indicated that participating teacher education students did not make significant gains with participation in the learning blocks; however, effect size measures suggest several interesting findings to consider in future work. In terms of self-efficacy, participating teachers felt more efficacious in learning mathematics knowledge necessary to be successful teachers (d = .16), but the experience made them less confident in their ability to teach (d = .27). The largest effect was for reducing anxiety for teaching mathematics (d = .32). Outcome expectancies did show a small effect (d = .24) for increasing in positivity of beliefs that teachers in general can be successful in making changes to student achievement outcomes.

Response to Learning Blocks

Teacher education students reviewed two learning blocks that were also reviewed by Noyce teachers. Table 8 depicts the results of general feedback survey questions for both groups. In general, both groups responded extremely positively to the learning blocks, judging them to be useful for in-service teachers with experience, new teachers, and pre-service teachers. However, both groups rated the materials as most useful to new teachers.

In terms of the content, both groups felt that the *Key Ideas* learning block focused on review of material that was available to them in other places. Likewise, both groups felt that the *Absolute and Relative Thinking* learning block was a combination of new and review material, perhaps indicating that it builds on previously-learned content. Unsurprisingly, the Noyce teachers, who have many opportunities to participate in mathematics-focused professional development, were more likely to rate the materials as overlapping other professional development experiences they have had. For the teacher education students, this experience was wholly new.

Table 8

Mean, Standard Deviation, and Mode of Teacher Education Student and In-Service Teacher Responses to Learning Blocks

Feedback		*Absolute and Relative Thinking*		*Key Ideas*	
		Students	Teachers	Students	Teachers
Overall	*M* (*SD*)	3.95 (.90)	4.5 (.5)	4.11 (.74)	3.67 (.47)
	Mode	Useful	Very	Useful	Useful
In-Service	*M* (*SD*)	3.85 (.89)	4 (0)	4.26 (.71)	4 (.82)
	Mode	Useful	Useful	Very	Useful
New Teachers	*M* (*SD*)	4.5 (.58)	4.5 (.5)	4.58 (.59)	5 (0)
	Mode	Very	Very	Very	Very
Pre-Service	*M* (*SD*)	4.45 (.72)	4 (1)	4.53 (.60)	4.67 (.47)
	Mode	Very	Useful	Very	Very
Newness	*M* (*SD*)	2 (.44)	1.5 (.5)	1.42 (.59)	1 (0)
	Mode	Combination	Combination	Review	Review
Overlap	*M* (*SD*)	1.85 (1.08)	2.5 (.5)	2.11 (1.33)	2.67 (1.25)
	Mode	No	Some	No	Some

Another goal of this work was to investigate whether teacher education students would request different additional materials, clarifications, or improvements than previously studied in-service teachers when reviewing the learning blocks. Teacher education students, Noyce teachers, and a larger group of in-service teachers not associated with the Noyce program provided qualitative feedback after reviewing the two learning blocks. As can be seen in Table 9, students and teachers shared many of the same themes in their feedback. For example, both groups particularly liked many of the same aspects of the learning blocks, including example videos of teacher-student interactions, example problems and activities that could be readily incorporated in ongoing instruction or lesson planning, and clarity of explanations of terms (e.g., "absolute" and "relative").

The feedback indicated that teachers and students were able to distinguish the major objectives of each block, and their responses further indicated that they will use this content in the current or future classrooms. For example, a major objective of the *Absolute and Relative Reasoning* learning block was to help clarify the distinction between absolute and relative reasoning, and provide support for teachers to use more relative reasoning in their classrooms. Responses indicated that both groups intended to engage students in relative reasoning, create new questions to elicit relative reasoning, adapt their existing materials to incorporate more opportunities for students to engage in relative reasoning, and be more aware of the questions they write and whether they support absolute, relative, or both types of student thinking. Similarly, the two goals of the *Key Ideas* learning block were to help support the use of multiple representations of rational numbers in the classroom and to help teachers better utilize practice around these difficult concepts. Both groups indicated strategies they would use to incorporate the key ideas and improve their practice activities.

In some cases, there were no responses that were unique to either the teacher education students or the in-service teachers. For example, teachers did not identify unique strengths in the *Absolute and Relative Reasoning* learning block. Similarly, students did not identify unique implications for practice in the *Key Ideas* learning block. Further, the groups identified all the same strengths in the *Key Ideas* block (i.e., videos, activities, examples).

Table 9

Learning Block Feedback: Major Themes and Responses from In-Service Teachers and Teacher Education Students

Learning Block	Themes	Group	Responses
Absolute and Relative Reasoning	Helpful ideas to put into practice	Both groups	• Engage student in relative reasoning. • Create new relative questions. • Adapt existing questions to be more relative. • Model multiple ways to solve problems. • Make connections to specific content not covered in block (e.g., rates, negative numbers). • Make connections to real world content; personalize content for student interests. • Be more aware of how problems are framed and the kinds of thinking they will generate.
		Teachers	• Identify students as particular types of thinkers (relative versus absolute). • Explain the difference between absolute and relative thinking to students.
		Students	• Connect to research about importance of relative thinking.
	Requests for revision of material	Both groups	• Provide additional problems, activities, and resources that use relative thinking. • Demonstrate how "relative" thinking connects to higher-order thinking skills/upper levels of Bloom's taxonomy.
		Teachers	• Provide "quick" ways to engage student thinking without using much class time.
		Students	• Explain how block content relates to grade-level expectations. • Connect content to *Common Core State Standards*, especially fraction standards. • Connect to other core subjects. • Make the experience more interactive. • Improve the "cactus" problem.
	Favorite or strongest parts of learning block	Both groups	• Demonstrations of problems set in real-world contexts • Example videos

	experience		• Clarity of explanations of "relative" and "absolute"
		Teachers	*no unique responses*
		Students	• Embedded learning checkpoints • Overall organization and objectives
Key Ideas	Helpful ideas to put into practice	Both groups	• Introduce concept of "renaming" numbers. • Focus on identifying whole/unit. • Help students become accustomed to multiple representations. Connect representations across rational number forms. Ask students to report answers in multiple forms. • Use more visual representations in teaching. • Personalize example problems/incorporate real world examples. • Teach estimation and how to check for meaningfulness. • Ask students to create their own problems. • Ask students to explain their reasoning to the teacher and to each other. • Provide opportunities for in-class practice (rather than homework). Use this time to provide immediate feedback. • Be careful to distribute practice. Make sure students have adequate time for practice. Be aware that the individual needs students have for practice will vary. • Provide students with meaningful feedback (relevant to observable criteria and common errors).
		Teachers	• Teach students to ask questions and seek clarification. • Accept multiple solutions as correct. • Minimize homework assignments and grading. • Incentivize homework. • Practice being clear and explicit in explaining concepts.
		Students	*no unique responses*
	Requests for revision of material	Both groups	*no overlap in responses*
		Teachers	• Provide interactive websites where students can explore multiple

			representations of numbers. • Clarify order in which key ideas should be taught.
		Students	• Provide more examples of real-world fraction use (not pizzas or pies). • Provide "best language" for explaining key ideas to students. • Provide more support for teaching place value. • Provide examples of meaningful feedback. • Provide ideas for motivating students to engage in practice. • Connect to *Common Core State Standards.* • Include more visuals and interactivity in the learning block. • Subtitle videos.
	Favorite or strongest parts of learning block experience	Both groups	• Example videos • Example activities (e.g., renaming, place value) • Example questions to ask students
		Teachers	*no unique response*
		Students	*no unique responses*

In contrast, there were no overlapping comments in the requests for revision for the *Key Ideas* learning block. Teachers' responses focused on the activities they would use as part of their instruction around the key ideas. They requested additional support via interactive websites and more help in organizing order and sequence of concepts. In contrast, students' responses focused on increased need for structure and examples of how to *do* the suggested practice (e.g., more detail on how to provide meaningful feedback, specific language to use when engaging in instruction on key ideas, more about how to teach place value).

Some of the differences in response patterns came from teachers and students have differing needs in the immediate future. For example, students were more often concerned about broader issues of adapting the material to a variety of grade levels and types of learners. Teachers, in contrast, were better able to connect the suggestions to specific content they needed to teach (e.g., fractions, decimals, percents, negative numbers, number lines. Unsurprisingly given the needs of each group, students were more likely to respond that they would use the materials presented in the learning blocks to create lesson plans while teachers were more focused on activities they could immediately use in their classrooms.

One unexpected difference in the responses was that students were more concerned about bridging the learning block content to the *Common Core State Standards.* The in-service teachers were more likely to want support in connecting the content to more general organizational systems, such as Bloom's Taxonomy and the related Higher-Order Thinking Skills (HOTS).

Another unexpected difference in the responses was related to the *Key Ideas* material on providing review opportunities for students. Both groups indicated that they had learned about the need to provide meaningful and timely feedback to students and to provide time in class for students to review so that teachers can detect misconceptions and common errors quickly "in the moment" of the lesson. Thus, the major objectives were met for both groups. However, in-service teachers also provided feedback that indicated they interpreted the review section as suggesting that they minimize review problems, incentivize review and homework, and minimize their grading of review problems (i.e., by grading only a few of the assigned items, grading as a whole class, or having peers grade or provide feedback). It is interesting, and somewhat discouraging, that in-service teachers interpreted the ideas presented about being thoughtful in assigning review and practice such that students receive adequate practice without review becoming "busy work" to mean they should minimize the review work both for students and for themselves.

There were a few aberrant negative comments (e.g., a teacher disliked the idea of using multiple representations and thought it would be confusing for her students, a student disliked the "cactus" problem and felt that the ambiguity intended to provide opportunities for students to explain their reasoning was not worth the confusion students experienced), but overall, the responses to the learning blocks were exceptionally positive for both groups. For example, students wrote final comments that indicated how useful the experience of in-service professional development was for them while still in their teacher education programs. One student commented, "This was very helpful! I especially thought the video of how to model these problems was helpful to see students' thinking." Another wrote, "The explanations were very clear, and I appreciated the practice problems throughout the slides in order to see how these concepts could actually be used in classrooms." In general, feedback indicated that the utility of the blocks for students was in seeing how teachers incorporated content in real classrooms.

Teacher responses were also quite positive. Teachers indicated that the learning blocks were not only helpful, but made them think about their practice. For example, one teacher wrote, "The more I thought about relative thinking, the more I realized that by doing problems like these, that we are asking students to depend upon their prior knowledge in order to figure out the answer. They are having to combine multiple math skills which keeps the math concepts fresh in their minds and they are showing that they really understand the concept by apply it in out of the box ways." This theme of thinking through content in new ways was evident in other teacher responses, such as "Great module. I never really took time to dissect these two concepts," and "I really liked this block! It sort of 'clicked' in my mind and helped me to think on how to teach more 'rationally'". Thus, the utility of the experience differs slightly by group (i.e., opportunity to observe how concepts can be implemented in classrooms versus opportunity to think more deeply about content), but both groups found the materials helpful.

CHAPTER 5: DISCUSSION

Summary of Findings

Self-Efficacy

Based on the literature, it was hypothesized that teacher educations students would respond with relatively low levels of self-efficacy for teaching mathematics as has been demonstrated in multiple samples of pre-service teachers (Bursal & Paznokas, 2006; Gresham, 2008; Swars, Daane, & Giesen, 2006; Tooke & Lindstrom, 1998; Vinson, 2001). For example, Bursal and Paznokas (2006) and Swars, Daane, and Giesen (2006) both found that pre-service teachers responded with efficacy to 75% of the MTEBI items. The teacher education students in this study indicated that they felt more confident than was expected about their abilities not only to learn the content necessary to teach mathematics in elementary school classrooms (80%), but that they also felt confident about their abilities to teach (77%), use appropriate instructional strategies (80%), and even engage their students in the content (77%).

Perhaps unsurprisingly, the students in this sample felt more efficacious about their ability to learn the content than to teach the content. Further, these students indicated strong agreement that by the time they left the program, they would understand the mathematical concepts well enough to be "effective" teachers. It is especially encouraging that students indicated strong positive responses to items that assessed whether they saw themselves as continuing to learn once they leave the program and enter the profession. For example, "I will continually find better ways to teach math" was one of the items that students agreed with most strongly. These findings indicate that students not only feel that their methods classes are preparing them with adequate content knowledge, but that they understand that they will need to continue to learn when they enter the profession.

While their efficacy scores were lower on items measuring teaching, the students seemed at worst "uncertain" of their abilities in the classroom. This supposition is supported by the lower ratings students gave items that ask about their certainty that they "have the skills necessary to teach math" and the relative skill they have with have in mathematics as compared to other core subject areas. Given the relatively low level of real classroom experience these students have, uncertainty is probably a healthy response and is certainly consistent with self-efficacy theory, which asserts that the self-efficacy of novices remains fluid until such time as individuals have had successful (or unsuccessful) mastery experiences upon which to base their forward-looking judgments.

One content area in which students were less certain that they would be able to learn what they need to know to be successful teachers is how to inspire students in mathematics. Both the item in the self-efficacy to learn mathematics content and two of the four items in the self-efficacy for student engagement scales were rated with relatively low efficacy. In particular, teacher education students reported lower self-efficacy for helping their students become interested in mathematics, motivating them when they lost interest, and helping build connections with families to improve student achievement in mathematics. Clearly, students need more support to develop skills and confidence in teacher-student and teacher-family relationships, particularly as these relate to motivating and inspiring students to remain involved in mathematics.

Mathematics Anxiety

It was hypothesized based on the literature that teacher education students would experience high levels of mathematics anxiety. Their responses did not indicate an extremely high level of anxiety (i.e., they scored slightly below 50% anxiety on both scales). However, these findings still indicate that about half of the time, these students feel measurable anxiety (i.e., between "a little" and "a fair amount") when they come into contact with mathematics generally or are asked to engage in mathematics teaching. These findings suggest that these students are actually equally or more anxious than other populations of pre-service teachers that have been evaluated. For example, while some researchers have reported similar anxiety ratings with this population (e.g., Bursal & Paznokas, 2006; Gresham, 2008), Hadley and Dorward (2011) found that only 36% anxiety score on the same mathematics teaching anxiety used in this study and researchers using more general measures of anxiety have found pre-service teachers to respond with anxiety to as low as 38% of the scale (Swars, Daane, & Giesen, 2006). Further, the students in this study are approximately equally anxious in learning and teaching. This suggests an opportunity still exists to improve their experience of mathematics anxiety.

Further, improvement in mathematics anxiety may well be possible with experience in the teacher education program. Both the learning ($r = -.47$, $p = .010$) and teaching ($r = -.47$, $p = .010$) anxiety scales were significantly negatively correlated with years in the program. Thus, the higher ratings of anxiety found in this study may be due to the relatively younger population of students in the sample. Although the data are cross-sectional, and thus not causal, these findings also suggest the potential to reduce mathematics anxiety across teacher education coursework. Future research should investigate this potential longitudinally as well as attempt to determine what aspects of the program experience best impact anxiety. The lack of relationship between anxiety and measures of vicarious and mastery experience suggests that observation and opportunity to practice skills are not the most important experiences for reducing anxiety.

A clear finding is that teacher education students felt the highest levels of anxiety in evaluation settings. These included both evaluations of their own mathematics teaching and learning (e.g., observation by an administrator, taking a math test) and evaluation of their future students (e.g., preparing students for year-end tests and waiting for the results of their students' year-end tests).

Outcome Expectancies

As expected teacher education students held more positive expectations related to teachers (71%) and students (65%) than they did about the mathematical content (57%). Students felt positive about the general ability of teachers to impact student achievement and also believed teachers should take responsibility when students are not achieving, which is encouraging given their professional plans. However, it was hypothesized that expectations shift with social messages they receive in the program, and hoped that those messages become more positive within a program than they may be in other venues. In contrast, no significant relationships were found between the teaching outcome expectancy variable and experience in the programs.

Model 1

The first model attempted to predict grade-level preference from mathematics anxiety and self-efficacy for learning mathematics. Based on the literature, it was expected that higher levels of mathematics anxiety would negatively impact pre-service teachers' experience of self-efficacy for learning the content and pedagogical content knowledge necessary to teach mathematics effectively, which would in turn result in preference for teaching earlier grade levels in which the mathematics content was perceived to be less difficult to master. However, there was no support for this hypothesis. It is possible that the lack of support comes in part from the restricted range of grades students wanted to teach in this study (primarily early and upper elementary grades, with few students interested in teaching middle school or high school). However, it is also possible that the constructs of mathematics anxiety and self-efficacy better predict selection into the education field as a whole rather than to particular grade levels (i.e., that experiences of high mathematics anxiety and low self-efficacy predict choice of majors that require fewer or lower level mathematics courses). This is consistent with Hembree's (1990) analysis and assertions made by Beilock et al. (2010). Future work should more closely examine this possibility by modeling the relationship between mathematics anxiety, self-efficacy for learning mathematics, and major choice.

Model 2

In analysis of Model 2, there was support for the relationship between vicarious experience, mathematics teaching anxiety, self-efficacy for teaching mathematics, and preference for teaching mathematics. Outcome expectancies failed to predict self-efficacy and preference, causing them to be removed from the model. Further, given the low level of mastery experiences in this group of novice teacher education students, it is not surprising that mastery experience failed to predict self-efficacy or preference. However, these findings lend support to the argument that in the absence of mastery experience, the other developmental pathways for efficacy beliefs become more predictive of outcomes.

As expected from theory, self-efficacy beliefs were a strong predictor of mathematics subject area preference. Further, the physiological arousal pathway (anxiety for teaching mathematics) was a stronger predictor of self-efficacy than the vicarious experience pathway.

Thus, it may be especially useful to explore reducing anxiety in order to improve the self-efficacy of low efficacy students before they enter the field.

Experience with Professional Development

Consistent with expectations from theory, there were small effect size (though non-significant) differences between students who chose to complete learning blocks and those who did not in terms of both self-efficacy for teaching and self-efficacy for learning content. If these effects are replicated with a larger sample, they will provide support for the idea that task choice (i.e., participation in professional development) can be predicted from experiences of self-efficacy.

Experience with the learning blocks did not result in significant pre to post changes in measures of anxiety, self-efficacy, or outcome expectancies. It is possible that the small sample did not allow the power to fully investigate these effects. It is also possible that the dosage of the learning block treatment simply was not great enough to elicit large effects. However, small, non-significant effects were detected for both reducing mathematics teaching anxiety and self-efficacy for teaching mathematics and increasing teacher outcome expectancies. Future work should attempt to replicate these effects with a larger sample and/or more exposure to learning blocks. If they are replicated, evidence will exist that professional development intended for in-service teachers has the potential to reduce mathematics anxiety and increase teacher outcome expectancies for teacher education students while they are still in their education programs.

The potential to reduce self-efficacy is interesting and unexpected. Given the relatively high levels of self-efficacy exhibited by the students in this study, it is possible that students have unrealistically high efficacy beliefs at this point in their careers. Bandura (1997) cautions against unrealistic beliefs in that they can set the individual up for frustration when actual experiences do not match beliefs. If their beliefs are unrealistically high, it is possible that future mastery and vicarious experiences will initially lower self-efficacy for these students. If this is the case, vicarious experiences and social persuasion embedded in professional development like that presented in this study may help lower efficacy to more realistic levels without exposing students to potentially damaging failure experiences. Moreover, access to experience like this when students are still in a teacher education program provides a "safe" environment to participate in new experiences.

Further, the results of learning block feedback indicate that the materials are appropriate for pre-service as well as in-service teachers. Students indicated that they understood the same key objectives as in-service teachers and both groups indicated they would utilize those objectives in their (future) classrooms. Where the two groups differed tended to be in the lack of experience that teacher education students have. Students wanted additional structure and specific ways of teaching material to their students (even including specific language to introduce concepts or use when providing feedback), whereas in-service teachers were more comfortable with the instructional aspects and wanted instead additional activities to support their instruction. Additionally structuring of examples may be necessary to fully meet the needs of a pre-service population.

Interestingly, teacher education students were more critical of the online nature of the learning blocks than in-service teachers. They were more likely to indicate that the learning blocks were not interactive enough and to suggest technical fixes for problems (e.g., captioning video to make student talk clearer to the listener). It is possible that students have more experience with online learning and thus, are more critical of the products created by the *Algebra Ready* team. In contrast, given that these students have little experience with teacher professional development, it is also possible that they do not have an adequate sample of typical professional development with which to compare *Algebra Ready* content, resulting in less positive estimations than teachers with a good deal of experience with the types of professional development regularly available in the field. Regardless of the source of the difference between in-service teachers and teacher education students, these findings indicate that a greater level of interaction may be needed to engage students in pre-service programs.

Another interesting difference between teacher education students and in-service teachers was that the students were also much more concerned about the relationship between concepts presented in the blocks and the *Common Core State Standards.* Several explanations could account for this difference. Teachers in this state may not have fully implemented *Common Core*; despite the state timelines for full implementation, *Common Core* assessment is only being piloted this year and thus teachers' evaluation may depend more on past sets of standards. In-service teachers may also have had sufficient *Common Core* professional development through other opportunities provided by their districts and the state. It is also possible there is more pushback against the new standards in the schools than there is in the teacher education program. Clearly, students in the program are aware of the new standards and concerned with matching their content learning to the expectations outlined in the *Common Core.*

Overall, both the in-service teachers and teacher-education students were strongly supportive of the utility of the materials for both pre-service and in-service professional development. Both groups commented that the conceptual content made them consider aspects of the mathematical content standards and their instruction that they had not previously considered and that they felt the materials would improve their instruction. These findings are similar to feedback received from previous iterations of the project (Good et al., 2013) and given that four iterations of teachers (and now students) have responded positively to the blocks, there is a good deal of support for their continued use.

Theoretical Implications

Self-Efficacy Theory

It was argued in this paper that self-efficacy can be predicted from mastery experience, vicarious experience, social persuasion via the social transmission of outcome expectancies, and physiological arousal via mathematics teaching anxiety. Further, it was argued that vicarious experience, social persuasion, and physiological arousal would have greater impacts on the development of self-efficacy for novices such as the teacher education students in this study. As expected, students had relatively few mastery experiences and indeed mastery experience was removed from the models predicting self-efficacy. There was support for the role of vicarious experiences and anxiety in forming students' self-efficacy. However, there was little support for the argument that teacher outcome expectancies contribute to self-efficacy, and in fact, these were removed from the model as well. Future work should investigate other forms of social persuasion that students receive in their programs as well as how social persuasion relates to collective efficacy of high- and low-performing schools and related shifts in outcome expectancies when teachers enter the field.

Further, the modeling hypotheses indicated that not only did vicarious experience and mathematics teaching anxiety predict students' self-efficacy, but that their effect on the outcome was perfectly mediated by the self-efficacy measure (i.e., the relationship between vicarious experience, mathematics teaching anxiety, and the outcome ceased to be significant when the mediating variable was entered in the model). This finding lends strong support to the causal model theorized in self-efficacy approaches, as well as helps further explain the development of self-efficacy for novices (i.e., prior to mastery experience).

Additionally, evidence from this study supports the assertion that self-efficacy predicts task choice (both willingness to participate in professional development and preference for teaching mathematics). It is not evident from this study whether the predictive nature of self-efficacy functions similarly in actual teaching behavior and resilience to setbacks in the classroom, although the evidence from the literature indicates this is likely the case (Friedman, 2000; Skaalvik & Skaalvik, 2007). Given these sources of evidence, self-efficacy appears to be a useful point of intervention in order to ensure both good learning experiences in teacher education programs and positive teaching behaviors as students transition to the profession.

Mathematics Anxiety Construct

Measures of mathematics anxiety indicated that students in the teacher education program have more anxiety than would be expected from the results of other samples of pre-service teachers in the literature. Mastery experience and vicarious experience were not related to anxiety, but the length of time the student had been in the teacher education program was. This suggests the potential importance of coursework to ameliorating anxiety in a population expected to be highly anxious. Similarly, there were also indications that experiences with professional development could also reduce anxiety for teacher education students. Thus, it is important that future research investigate the characteristics of coursework and professional development experiences that most positively impact anxiety.

The mathematics anxiety findings indicate strong anxiety for evaluation and weaker anxiety for all other indicators. The evaluative component is not present in all situations in which individuals engage in mathematics, but it is highly relevant to the research about how mathematics anxiety develops. Studies suggest that students develop anxiety when they feel humiliated or exceptionally concerned about failure and when they are provided with feedback that the failure is unexpected, as in for example, experiences with teachers who did not understand why they weren't "getting it" (Brady & Bowd, 2005; Brown, McNamara, Hanley, & Jones, 1999; Jackson & Leffingwell, 1999; Stoehr, Carter, & Sugimoto, 2013; Trujillo & Hadfield, 1999; Uusimaki & Nason, 2004). It seems that it is not the mathematics that makes people anxious, but rather the fear of failing, particularly failing in front of valued peers and teachers. This has strong implications for how teachers are trained to interact with students, and how to manage their own frustration when students have difficulty despite teachers' best efforts. Further, the findings also indicate a need to develop teachers' depth of understanding so that they have improved flexibility in how they explain content to students and greater understanding of the potential misconceptions and indicators that suggest that the teacher's instruction is not effective.

Practical Implications

Self-Efficacy

Despite the use of scales designed by different authors, students scored similarly on all three self-efficacy for teaching scales, thus, providing some evidence of the construct validity of these scales (i.e., that all three scales measure the same construct). Unlike the items drawn from the Mathematics Teacher Efficacy and Belief Instrument (Enochs, Smith, & Huinker, 2000), the Teacher Self-Efficacy Scale (Tschannen-Moran & Woolfolk Hoy, 2001) was initially designed to be a general, rather than subject-specific, measure. With minor edits to focus more specifically on mathematics, (i.e., changing "school work" to "math"), the self-efficacy for student engagement and self-efficacy for instructional strategies scales correlate significantly with the scale designed to be subject specific ($r_{SESE\text{-}SETM} = .426$, $p = .001$, $r_{SEIS\text{-}SETM} = .513$, $p < .001$). Thus, the evidence presented here suggests that researchers interested in measuring subject-specific efficacies can adapt the widely-used Teacher Self-Efficacy Scale rather than rely on less well-known and less tested subject-specific scales, providing opportunities to link results more widely across the study of teacher efficacy.

Mathematics Anxiety

The evaluation component of mathematics anxiety is particularly troubling when considering practical implications of these findings. Teachers and students are both increasingly evaluated and those evaluations carry higher stakes than ever before. Given the research that suggests teachers are modeling their anxiety and that their students are learning from this modeling (e.g., Beilock et al., 2010), the modeling of evaluation anxiety has the potential to be detrimental not just in mathematics, but in other areas of assessment. Teacher education programs need to consider how to incorporate instruction around evaluation and evaluation anxiety into coursework. In doing research on their own practice, mathematics methods teachers have demonstrated that mathematics content anxiety can be reduced when teachers are mindful about how they present material in their courses (e.g., McGlynn-Stewart, 2010; Vinson, 2001); perhaps assessment teachers should begin to consider how they can similarly be mindful of their own teaching in order to reduce student anxiety and begin to build a research literature around most effective methods of reducing evaluation anxiety.

Outcome Expectancies

The lack of reliability of the student and mathematics expectancy scales is interesting in that a lack of internal consistency in these scales suggests that either a) the items within a scale measure very different constructs or b) the students are not consistent in how they feel about the content of the scales. For the student scale, it appears that teacher education students are inconsistent about what effects they expect the relationship between teachers and students to have on student achievement. For example, they believe students have control of their own motivation as it relates to their achievement, but they also believe that teachers are responsible for students' achievement *even when low achievement reflects motivational issues.* Perhaps this scale will become more consistent once these students have experiences with their own students in classrooms (i.e., mastery experiences), but it may be a very real finding that teachers and teacher education students are ambivalent about when achievement is under their control and when it is under student control. There are likely aspects of individual teacher-student relationships that could help explain this lack of consistency and should be studied further in other research.

Both scales also decrease in internal consistency following exposure to the learning blocks (as opposed to other scales which became more consistent). This is an interesting finding in that aspects of the learning blocks may affect some beliefs about student and content more than others for some students. The lack of consistency makes interpreting any changes difficult (i.e., the scales do not function as intended). Thus, it may be useful to explore student and content expectations more thoroughly in a qualitative way in order to better craft scales that can capture general beliefs and change in these variables across time.

In terms of mathematics, the expectations for mathematics were inconsistent, but also interesting for this population of students. Recall that these students were primarily interested in teaching science, and thus, were more likely to have at least some mathematics background in comparison to the full population of elementary teacher education students. They may value their own past success (or at least lack of failure) in mathematics as being due to high levels of effort in a subject that is perceived to be more difficult, but ultimately more logical than other subjects, and at the same time they feel students generally dislike and worry about mathematics, which will put pressure on them as teachers to maintain and improve student engagement in content.

Limitations

Several important limitations exist in this study. First, recruitment resulted in a fairly homogenous sample, with primarily teacher education students interested in teaching early and upper elementary grades. This led to difficulty in assessing hypotheses about grade level preference, and limited the generalizability of findings to elementary education majors. Moreover, the target audience of *Algebra Ready* materials is upper elementary and middle school teachers. While students in this study found the materials useful, further research needs to be done to assess the utility of materials for students interested in teaching middle school. Some amelioration to the threat to the generalizability of learning block feedback may exist in that the specific learning blocks chosen for students to review focused on development of conceptual understandings important for teachers across elementary and middle school grades.

A second limitation is the design, which allowed for selection bias. Students chose whether to respond to recruitment ads, leading to the theoretically-grounded possibility that students with the highest self-efficacy around mathematics and the lowest anxiety for mathematics were most likely to agree to participate. Attempts were made to decrease this possibility by ensuring that recruitment materials made clear that there would be no evaluation of actual mathematics skill as part of this project. However, the extent to which this was successful is suspect given that nothing is known about the students who chose not to participate.

Further, of those agreeing to participate in the initial survey, only 42% agreed to continue on to the learning blocks. Selection bias both into the study and into the learning blocks would be hypothesized from self-efficacy theory, which asserts that task choice is a function of self-efficacy. Further, the small effect size differences in self-efficacy to learn mathematics and self-efficacy to teach mathematics between those students who chose to participate in the learning blocks and those who did not supports this assertion.

The choice to focus on two learning blocks, both more conceptual in nature, is also a limitation. Conceptual learning blocks were used in hopes that they would provide teacher education students with content knowledge helpful for their mathematics methods courses, and with the belief that learning blocks that focus more heavily on instructional activities may not be useful for this population because they are not yet in classrooms. However, it is possible that greater effects would have been found with one of the more practical learning blocks. Future research should examine this possibility.

Additionally, this study focuses exclusively on self-report data, and thus, is open to reporting biases and concomitant threats to validity. Students may have reported higher self-efficacy and lower anxiety because of social desirability or demand characteristics that elicited "good participant" behavior. For example, the support from faculty to recruit in their classrooms as well as the generally helpful dispositions of the teacher education students may have unintentionally biased students to respond in ways consistent with their beliefs about the desired outcomes of this study.

Part of the study was to investigate evidence for future causal modeling approaches. Given that the lack of experimental design, it is impossible to make causal conclusions. Modeling approaches investigate prediction, but the directionality of any existing causality is suspect and alternative models must be hypothesized and evaluated. Future work should attempt to strengthen the causal argument to the extent that it is possible to randomly assign teachers and students to voluntary professional development opportunities (not an easy task) or to create quasi-experimental matched groups to investigate effects.

Finally, the greatest limitation of this study was the inability to determine the relationship between self-efficacy and actual teaching behaviors. Given that these students are not yet in the classroom, the outcome variable measured their interest and preference for teaching mathematics content. While preference is indicative of task choice and motivation, it does not indicate how effective these teachers will be in the classroom. It is entirely possible that teachers who strongly dislike particular content areas do well in teaching them and that teachers who express much enthusiasm for particular content fail to teach it well. Thus, future longitudinal work needs to assess the impacts of efficacy beliefs as teachers move into classrooms, perhaps via observation of in-class behaviors and measures of student motivational and achievement outcomes.

Future Directions

The results of this study open several avenues to future work. First, in terms of mathematics anxiety, it is important to evaluate the extent to which mathematics anxiety can be distinguished from evaluation anxiety. It may be that some students are simply more sensitive to failure feedback and that little of the phenomenon of mathematics anxiety (at least in the population of pre-service teachers) has to do with mathematics. If this is the case, it may be more effective to support the resiliency of students in general than to target mathematics specifically.

Teachers are increasingly expected to make data-driven decisions about their instruction. This includes not only use of assessment data gathered by large-scale tests, but also appropriate use of teacher-designed classroom assessment. Unfortunately, the anxiety measures in this study did not include reference to use of student data, which is conceptually related to learning and using mathematics. However, the statistics coursework item did elicit relatively high levels of anxiety, suggesting a need to address teacher education students' level of comfort with statistics and use of statistics in their classrooms. Future research should explore teachers' anxiety around the use of assessment and student data.

Second, longitudinal work needs to be undertaken to better understand the developmental trajectory of self-efficacy throughout teacher education and into the professional fields. Evidence presented here suggests links between what teachers are most interested in teaching and their efficacies, but work needs to be done to link preferences with actual teaching behaviors. Further, results are suggestive that the students may have overly high efficacy beliefs during their education programs. While it is important to help students feel efficacious, unrealistic goals may lead to burnout once they enter the field. More needs to be done to understand what appropriate levels of efficacy are at various times in the career.

Lastly, this study does not provide enough information about outcome expectancies teachers may hold about themselves, their students, and the content they will be teaching. The evidence presented from this study suggests the interaction between expectations is more complex than could be captured by the instruments used here. Further review of the expectation literature and qualitative work with teacher education students and in-service teachers is needed.

Conclusion

Although more must be done to fully model the relationships, this study provides evidence of the predictive capacities of teacher efficacy models that incorporate student experiences and feelings of anxiety to better understand task choice. Additionally, experience in teacher education coursework has the potential to reduce anxiety for teaching. Finally, evidence is provided that teacher professional development is not only perceived as useful to teacher educations students, but has the potential to improve self-efficacy and reduce anxiety for teaching. Given these findings, it makes sense to further evaluate the ways in which the strengths of pre-service coursework and in-service professional development can be leveraged to best prepare future teachers for their professional roles.

APPENDIX A: RECRUITMENT AND CONSENT DOCUMENTS

Initial Recruitment Email

Hello,

As a student interested in becoming a teacher, I am contacting you to ask if you are willing to help evaluate *Algebra Ready* professional development intended to help teachers improve their math instruction. We believe the feedback that teacher education students provide can help improve the professional development for pre-service and early career teachers.

You will be asked to complete two surveys about your feelings about math and review two online math lessons (learning blocks). Your math skills will not be tested. The surveys and learning blocks should take you less than 3 hours; you will be paid for your time and thoughtful feedback. You may also find the materials helpful as you complete math methods coursework and start designing your own lessons.

If you are interested in participating, please follow the link below to consent and complete the first survey.

https://uarizona.co1.qualtrics.com/SE/?SID=SV_55xmX7ZlkP6SqJ7
(If this link fails to open, you may also copy and paste it into your browser.)

You may email Amy Olson (**aowen@email.arizona.edu**) or call 520-603-3956 with any questions or concerns. Please also contact Amy if you would like a copy of the final report.

Thank you,
Amy Olson, M.A.
Algebra Ready Project

An Institutional Review Board responsible for human subjects research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Follow-Up Recruitment Email

Hello again,

If you have not yet had a chance, this is a reminder of an opportunity for teacher education students to participate in evaluation of real teacher professional development.

We value the input of teacher education students in improving our lessons. If you choose to participate, you will be asked to complete two surveys and review two online math lessons (learning blocks). The surveys will ask about your feelings about math. Your math skills will not be tested, and you may find the lessons helpful as you take math methods courses and begin writing your own math lessons plans. Altogether, the tasks should take less than 3 hours, and you will be paid for your time.

If you are interested in participating, please follow the link below to consent and complete the first survey.

https://uarizona.co1.qualtrics.com/SE/?SID=SV_55xmX7ZlkP6SqJ7
(If this link fails to open, you may also copy and paste it into your browser.)

You may email Amy Olson (aowen@email.arizona.edu) or call 520-603-3956 with any questions or concerns. Please also contact Amy if you would like a copy of the final report.

Thank you,
Amy Olson. M.A.
Algebra Ready Project

An Institutional Review Board responsible for human subjects research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Teacher Education Student Consent Form

Project Title: Algebra Ready: Transitioning to Academic Success
Study Investigator: Amy Olson, M.A.
Project Principal Investigator: Thomas Good, Ph.D.

This is a consent form for research participation. Please consider the information about this study carefully. Feel free to discuss the study with others and to ask questions before making your decision whether or not to participate.

Why is this study being done? The purpose of this study is to improve online professional development content for the instruction of rational numbers and early algebra concepts and to learn more about how teacher education students view math.

What will happen if I take part in this study? You will be asked to take two surveys about how you feel about math and math instruction. You will be asked to review two online professional development lessons (learning blocks). You will be asked to give your feedback about your experience with the learning blocks.

Participation is voluntary. You may choose not to participate without penalty or loss of benefits to which you are otherwise entitled. You may discontinue participation at any time without penalty or loss of benefits. By agreeing to participate, you do not give up any personal legal rights you may have.

What benefits can I expect from being in the study? You will potentially benefit from learning more pedagogical and content knowledge from the professional development.

What risks can I expect from being in the study? The risks are minimal. You may be challenged to think about teaching and learning math in new ways.

What are the costs of taking part in this study? You will spend approximately 3 hours participating in this study. Aside from your time, there are no costs for taking part.

Will I be paid for taking part in this study? You will be compensated $50 for your 3 hours of participation. By law, payments to subjects may be considered taxable income.

Your privacy will be protected. You will not be identified in any reports that result from this study. However, representatives of regulatory agencies, including the University of Arizona Human Subjects Protection Program, may review your records.

Who can answer my questions about the study? For questions, concerns, complaints, or to be removed from this study at any time, you may contact Amy Olson (aowen@email.arizona.edu) and 520-621-7828.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact the Human Subjects Protection Program at 520-626-6721 or online at http://orcr.arizona.edu/hspp.

Signing the consent form

By electronically signing this form (typing my name), I affirm that I have read this form, and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study. I do not give up any legal rights by signing this form.

____

Student's Name (typed)

An Institutional Review Board responsible for human subjects research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

APPENDIX B: COMPLETE INSTRUMENTATION

Learning Block Review Items

The following previously approved items are embedded in the learning blocks. Teacher education students will have the opportunity to complete them as they complete the blocks.

A. In your opinion, what were the two or three most helpful ideas that were presented in this learning block?

B. What are one or two things you will do with this information?

C. Is there anything else you would like to know?

D. Additional comments or suggestions?

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1. Is the material presented in this learning block useful to you?
Not useful
Rarely useful
Somewhat useful
Useful
Very useful

2. Does this material provide content that would be useful to experienced in-service teachers (with more than five years of experience)?
Not useful
Rarely useful
Somewhat useful
Useful
Very useful

3. Does this learning block provide content that would be useful to new teachers in their first 1-3 years of teaching?
Not useful
Rarely useful
Somewhat useful
Useful
Very useful

4. Does this learning block provide content that would be useful to pre-service teachers?
Not useful
Rarely useful
Somewhat useful
Useful
Very useful

5. Would you classify the material in this learning block as:
Review of material you have learned in other formats?
New material you are just now learning?
A combination of new and review material?

6. To what extent do these materials overlap with other professional development opportunities you have had?
No overlap
Very little overlap
Some overlap
A lot of overlap
Completely overlaps other professional development

7. If you answered that this learning block overlaps other professional development programs, please list those programs here:

Survey

Please provide your preferred email address so that we can contact you to give you access to the learning blocks and arrange payment.

Preferred Email Address: ________________________________

This questionnaire is designed to help us gain a better understanding of the kinds of things that create difficulties for teachers in their school activities. Please indicate your opinion about each of the statements below. Your answers are confidential.

	Nothing		Very little		Some influence		Quite a bit		A great deal
1. How much will you be able to do to motivate students who show low interest in math schoolwork?	☐	☐	☐	☐	☐	☐	☐	☐	☐
2. How much will you be able to do to get students to believe they can do well in math schoolwork?	☐	☐	☐	☐	☐	☐	☐	☐	☐
3. How much will you be able to do to help your students value math learning?	☐	☐	☐	☐	☐	☐	☐	☐	☐
4. To what extent will you be able to craft good math questions for your students?	☐	☐	☐	☐	☐	☐	☐	☐	☐

	Nothing		Very little		Some influence		Quite a bit		A great deal
5. How much will you be able to use a variety of assessment strategies in math?	☐	☐	☐	☐	☐	☐	☐	☐	☐
6. To what extent will you be able to provide an alternative explanation or example when students are confused about math?	☐	☐	☐	☐	☐	☐	☐	☐	☐
7. How much will you be able to assist families in helping their children do well in math?	☐	☐	☐	☐	☐	☐	☐	☐	☐
8. How well will you be able to implement alternative math strategies in your classroom?	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please indicate the degree to which you agree or disagree with each statement.

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
1. When a student does better than usual in math, it is often because the teacher exerted a little extra effort.	☐	☐	☐	☐	☐
2. I will continually find better ways to teach math.	☐	☐	☐	☐	☐
3. Even if I try very hard, I will not teach math as well as I will most subjects.	☐	☐	☐	☐	☐
4. When the math grades of students improve, it is often due to their teacher having found a more effective teaching approach.	☐	☐	☐	☐	☐

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
5. Math requires more effort than other subjects.	☐	☐	☐	☐	☐
6. I will know the steps necessary to teach math concepts effectively.	☐	☐	☐	☐	☐
7. I will not be very effective in monitoring math activities.	☐	☐	☐	☐	☐
8. If students are underachieving in math, it is most likely due to ineffective math teaching.	☐	☐	☐	☐	☐
9. I will generally teach math ineffectively.	☐	☐	☐	☐	☐
10. Math makes more sense than other subjects.	☐	☐	☐	☐	☐
11. The inadequacy of a student's math background can be overcome by good teaching.	☐	☐	☐	☐	☐
12. The low math achievement of some students cannot generally be blamed on their teachers.	☐	☐	☐	☐	☐
13. When a low-achieving child progresses in math, it is usually due to extra attention given by the teacher.	☐	☐	☐	☐	☐
14. I will understand math concepts well enough to be effective in teaching elementary math.	☐	☐	☐	☐	☐
15. It is more difficult to improve in math than in other subjects.	☐	☐	☐	☐	☐
16. Increased effort in math teaching produces little change in some students' math achievement.	☐	☐	☐	☐	☐
17. The teacher is generally responsible for the achievement of students in math.	☐	☐	☐	☐	☐

	Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
18. Students' achievement in math is directly related to their teachers' effectiveness in math teaching.	☐	☐	☐	☐	☐
19. If parents comment that their child is showing more interest in math at school, it is probably due to the performance of the child's teacher.	☐	☐	☐	☐	☐
20. In general, people worry more about being successful in math than they do in other subjects.	☐	☐	☐	☐	☐
21. I will find it difficult to use manipulatives to explain to students why math works.	☐	☐	☐	☐	☐
22. I will typically be able to answer students' math questions.	☐	☐	☐	☐	☐
23. I wonder if I have the necessary skills to teach math.	☐	☐	☐	☐	☐
24. Effectiveness in math teaching has little influence on the achievement of students with low motivation.	☐	☐	☐	☐	☐
25. In general, people like taking math more than other subjects.	☐	☐	☐	☐	☐
26. Given a choice, I will not invite the principal to evaluate my math teaching.	☐	☐	☐	☐	☐
27. When a student has difficulty understanding a math concept, I will usually be at a loss as to how to help the student understand it better.	☐	☐	☐	☐	☐
28. When teaching math, I will usually welcome student questions.	☐	☐	☐	☐	☐
29. I will not know what to do to turn students onto math.	☐	☐	☐	☐	☐
30. Even teachers with good math teaching abilities cannot help some kids learn.	☐	☐	☐	☐	☐

Please indicate your level of anxiety in the following situations.

	Not at all	A little	A fair amount	Much	Very much
1. Looking through the pages in a math text	☐	☐	☐	☐	☐
2. Having to use the tables in the back of a math book	☐	☐	☐	☐	☐
3. Thinking about an upcoming math test one day before	☐	☐	☐	☐	☐
4. Watching a teacher work an algebraic equation on the blackboard	☐	☐	☐	☐	☐
5. Being told how to interpret probability statements	☐	☐	☐	☐	☐
6. Picking up a math textbook to begin working on a homework assignment	☐	☐	☐	☐	☐
7. Taking an examination (quiz) in a math course	☐	☐	☐	☐	☐
8. Reading or interpreting graphs or charts	☐	☐	☐	☐	☐
9. Signing up for a course in statistics	☐	☐	☐	☐	☐
10. Waiting to get a math test returned in which you expected to do well	☐	☐	☐	☐	☐
11. Being given a "pop" quiz in math class	☐	☐	☐	☐	☐
12. Walking on campus and thinking about a math course	☐	☐	☐	☐	☐
13. Looking through the pages in your math series teachers' manual	☐	☐	☐	☐	☐
14. Teaching students how to use and interpret tables, graphs, and charts	☐	☐	☐	☐	☐
15. Preparing students for a "standardized" math test throughout the week before	☐	☐	☐	☐	☐

	Not at all	A little	A fair amount	Much	Very much
16. Working out math equations on the board in front of a class of students	☐	☐	☐	☐	☐
17. Preparing to teach students a new math concept that will be challenging for them	☐	☐	☐	☐	☐
18. Explaining the rationale for the math curriculum to a parent who stopped by your classroom after school	☐	☐	☐	☐	☐
19. Talking to a student who wanted to use a different way to solve a math problem than the way you taught in class	☐	☐	☐	☐	☐
20. Writing a lesson plan for teaching a new math concept	☐	☐	☐	☐	☐
21. Waiting for results of your students' year-end math tests	☐	☐	☐	☐	☐
22. Having a surprise evaluation by an administrator during a math lesson you are teaching	☐	☐	☐	☐	☐
23. Walking into school and thinking about teaching a math lesson	☐	☐	☐	☐	☐

Please rank the following core subject areas in the order you are most confident (least worried) about teaching them (1 = most confident, 4 = least confident).

_________ English Language Arts

_________ Math

_________ Science

_________ Social Studies

What classroom experiences have you had? (Select all that apply.)

☐ I have taken math classes like the ones I expect to teach.

☐ I have observed classroom teachers give math lessons in the grade(s) I want to teach.

☐ I have observed teacher education faculty give math lessons similar to the ones I expect to teach.

☐ I have participated in workshops or professional development about teaching math.

☐ I have designed math lessons.

☐ I have student teacher experience assisting a mentor teacher with math lessons.

☐ I have student teaching experience giving my own math lessons.

What grade level do you most wish to teach?

☐ Pre-Kindergarten or Kindergarten

☐ Grades 1 – 2

☐ Grades 3 – 4

☐ Grades 5 – 6

☐ Grades 7 – 8

☐ High School

Thank you for your interest in the project!

If you provided your email address, you will receive a follow up invite to evaluate the Algebra Ready lessons and to arrange payment.

If you have chosen not to participate, thank you for considering this opportunity. If you change your mind, please do not hesitate to contact Amy Olson (aowen@email.arizona.edu)

REFERENCES

Alexander, L., & Martray, C. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale. *Measurement and Evaluation in Counseling and Development, 22,* 143-150.

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher Education and Special Education, 17,* 86-95.

Anderson, R., Greene, M., & Loewen P. (1988). Relationships among teachers' and students' thinking skills, sense of efficacy, and student achievement. *Alberta Journal of Educational Research, 34,* 148-165.

Armor, D., Conry-Oseguera, P., Cox, M., King, N., McDonnell, L., Pascal, A., Pauly, E., & Zellman, G. (1976). *Analysis of the school preferred reading program in selected Los Angeles minority schools* (Rep. No. R-2007-LAUSD). Santa Monica, CA: Rand Corporation. (ERIC No. ED 140 432).

Baloğlu, M., & Zelhart, P. F. (2007). Psychometric properties of the revised mathematics anxiety rating scale. *The Psychological Record, 57,* 593-611.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A. (1993). Perceived self-efficacy in cognitive development and function. *Educational Psychologist, 28*(2), 117-148. doi: 10.1207/s15326985ep2802_3

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and

Company.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307-337). Greenwich, CT: Information Age.

Bandura, A., & Locke, E. A. (2003). Negative self-efficacy and goal effects revisited. *Journal of Applied Psychology, 88*(1), 87-99. doi: 10.1037/0021-9010.88.1.87

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America, 107*, 1860-1863.

Brady, P., & Bowd, A. (2005). Mathematics anxiety, prior experience, and confidence to teach mathematics among pre-service education students. *Teachers and Teaching: Theory and Practice, 11*(1), 37-46. doi: 10.1080/1354060042000337084

Brown, T., McNamara, O., Hanley, U., & Jones, L. (1999). Primary student teachers' understanding of mathematics and its teaching. *British Educational Research journal, 25*(3), 299-322. doi: http://dx.doi.org/10/1080/0141192990250303

Brown, A. B., Westenskow, A., & Moyer-Packenham, P. S. (2011). Elementary pre-service teachers: Can they experience mathematics teaching anxiety without having mathematics anxiety? *Issues in the Undergraduate Mathematics Preparation of School Teachers, 5,* 1-14.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 104(*6), 173-180

Bush, W. S. (1989). Mathematics anxiety in upper elementary school teachers. *School Science and Mathematics, 89*(6), 499-509. doi: 10.1111/j.1949-8594.1989.tb.11952.x

Cemen, P. B. (1987). The nature of mathematics anxiety. (Report No. SE 048 689) Stillwater, OK: Oklahoma State University. (ERIC Document Reproduction Service No. ED 287 729).

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Erlbaum.

Durbin, J., & Watson, G. S. (1951). Testing for serial correlation in least squares regression. *Biometrika, 38*(1/2), 159-177.

Enochs, L. G., Smith, P. L. & Huinker, D. (2000). Establishing factorial validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics, 100*(4), 194-202.

Friedman, I. A. (2000). Burnout in teachers: Shattered dreams of impeccable professional performance. *Journal of Clinical Psychology, 56*(5), 595-606.

Fritz, J. J., Miller-Heyl, J., Kreutzer, J. C., MacPhee, D. (1995). Fostering personal teacher efficacy through staff development and classroom activities. *Journal of Educational Research, 88*(4), 200-208.

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76,* 569-582.

Goddard, R. D. (2001). Collective efficacy: A neglected construct in the study of schools and student achievement. *Journal of Educational Psychology, 93*(3), 467-476.

Goddard, R. D., & Goddard, Y. L. (2001). A multilevel analysis of teacher and collective efficacy. *Teaching and Teacher Education, 17,* 807-818.

Goddard, R. D., Hoy, W. K., & Woolfolk, Hoy, A. (2000). Collective teacher efficacy: Its meaning, measure, and effect on student achievement. *American Educational Research Journal, 37,* 479-507.

Goddard, R. D., Hoy, W. K., & Woolfolk, Hoy, A. (2004). Collective efficacy beliefs: Theoretical developments, empirical evidence, and future directions. *Educational Researcher, 33,* 3-13.

Gold, Y. (1996). Beginning teacher support: Attrition, mentoring, and induction. In J. Sikula (Ed.), *Handbook of research on teacher education, 2nd ed.* (pp. 548-494). New York: Macmillan.

Good, T. L., Wood, M. B., Sabers, D., Olson, A. M., Lavigne, A. L., Sun, H., & Kalinec-Craig, C. (2013). Strengthening grade 3-5 students' foundational knowledge of rational numbers. *Teachers College Record, 115*(7), 1-45.

Gresham, G. (2007). A study of mathematics anxiety in pre-service teachers. *Early Childhood Education Journal 35*(2), 181-188. doi: 10.1007/s10643-007-0174-7.

Grottenboer, P. (2008). Matheamtical belief change in prospective primary teachers. *Journal of Math Teacher Education, 11,* 479-497. doi:10.1007/s10857-008-9084-x

Hadley, K. M., & Dorward, J. (2011). The relationship among elementary teachers' mathematics anxiety, mathematics instructional practices, and student mathematics achievement. *Journal of Curriculum and Instruction, 5*(2), 27-44.

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Action in Teacher Research, 19*(4), 29-38. doi: 10.1080/01626620.1998.10462889

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York: Guilford.

Hayes, A. F. (2014, February 15). *PROCESS for SPSS macro, version 2.11.* Retrieved from: http://www.afhayes.com/introduction-to-mediation-moderation-and-conditional-process-analysis.html

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46.

Henry, G. T., Bastian, K. C., & Fortner, C. K. (2011). Stayers and leavers: Early-career teacher effectiveness and attrition. *Educational Researcher, 40*(6), 271-280.

Hopko, D. R. (2003). Confirmatory factor analysis of the Math Anxiety Rating Scale – Revised. *Educational and Psychological Measurement*, *63*(2), 336-351. doi: 10.1177/0013164402251041

Jackson, C. D., & Leffingwell, R. J. (1999). The role of instructors in creating math anxiety in students from kindergarten through college. *The Mathematics Teacher*, *92*(2), 583-586.

JohnBull, R. M., & Hardiman, M. M. (2013). *Professional development effects on teacher efficacy: Exploring how knowledge of neuro- and cognitive science changes beliefs and practice.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco: CA.

Jones, W. J., Childers, T. L., & Jiang, Y. (2012). The shopping brain: Math anxiety modulates brain responses to buying decisions. *Biological Psychology*, *89*, 201-213. doi:10.1016/j.biopsycho.2011.10.011

Karp, K. S. (1991). Elementary school teachers' attitudes towards mathematics: The impact on students' autonomous learning skills. *School Science and Mathematics*, *91*(6), 265-270.

Kersting, N. B., Chen, M., & Stigler, J. W. (2012). Value-added teacher estimates as part of teacher evaluations: Exploring the effects of data and model specifications on the stability of teacher value-added scores. *Educational Policy Analysis Archives, 21*(7). Retrieved from http://epaa.asu.edu/ojs/article/view/1167.

Kirk, R. E. (2008). *Statistics: An Introduction (5th edition).* Belmont, CA: Thompson Wadsworth.

Lee, J. (2009). Universals and specifics of math self-concept, math self-efficacy, and math anxiety across 41 PISA 2003 participating countries. *Learning and Individual Differences, 19*, 355-365. doi:10.1016/j.lindif.2008.10.009

Luo, X., Wang, F., & Luo, Z. (2009). Investigation and analysis of mathematics anxiety in middle school students. *Journal of Mathematics Education*, *2*(2), 12-19.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30*(5), 520– 540.

McGlynn-Stewart, M. (2010). Listening to students, listening to myself: Addressing pre-service teachers' fears of mathematics and teaching mathematics. *Studying Teacher Education, 6*(2), 175-186.

Meijer, C. J. W., & Foster, S. F. (1998). The effect of teacher self-efficacy on referral change. *Journal of Special Education, 22,* 378-385.

Midgley, C., Feldlaufer, H., & Eccles, J. S. (1989). Change in teacher efficacy and student self- and task-related beliefs in mathematics during the transition to junior high school. *Journal of Educational Psychology, 81*, 247-258.

Muijis, D., & Reynolds, D. (2002). Teacher beliefs and behaviors: What matters. *Journal of*

Classroom Interaction, 37, 3-15.

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: Enhancing self-efficacy. *Teaching and Teacher Education, 17,* 243-261.

National Commission on Teaching and America's Future. (2007). *The cost of teacher turnover in five districts: A pilot study.* Retrieved from: http://nctaf.org/

National Commission on Teaching and America's Future (2003). *No dream denied: A pledge to America's children.* Retrieved from http://nctaf.org/

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common Core State Standards – Mathematics.* National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C. Retrieved from http://www.corestandards.org/Math

National Mathematics Advisory Panel. (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel.* Washington. D.C.: U.S. Department of Education.

National Research Council. (2001). *Adding + it up: Helping children learn mathematics.* Washington, D.C.: National Academy Press.

Newstead, K. (1998). Aspects of children's mathematics anxiety. *Educational Studies in Mathematics, 36*(1), 53-71.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578.

Peker, M. (2009). Pre-service teachers' teaching anxiety about mathematics and their learning styles. *Eurasia Journal of Mathematics, Science, & Technology Education, 5*(4), 335-345.

Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the Mathematics Anxiety Rating Scale. *Educational and Psychological Measurement, 42,* 551-557.

Rayner, V., Pitsolantis, N., & Osana, H. (2009). Mathematics anxiety in preservice teachers: Its relationship to their conceptual and procedural knowledge of fractions. *Mathematics Education Research Journal, 21*(3), 60-85.

Rech, J., Hartzell, J., & Stephens, L. (1993). Comparisons of mathematical competencies and attitudes of elementary education majors with established norms of a general college population*. School Science and Mathematics, 93*(3), 141-145.

Richardson, F., & Suinn, R. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology, 19*, 551-554.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637.

Ross, J. A., (1998). The antecedents and consequences of teacher efficacy. In J. Brophy (Ed.), *Advances in research on teaching, Vol. 7* (pp. 49-73). Greenwich, CT: JAI Press.

Ross, J., & Bruce, C. (2007). Professional development effects on teacher efficacy: A randomized field trial. *Journal of Educational Research, 101*(1), 50-60.

Schunk, D. H. (1990). Goal setting and self-efficacy during self-regulated learning. *Educational Psychologist, 25*(1), 71-86. doi: 10.1207/s15326985ep2501_6

Schunk, D. H., & Pajares, F. (2005). Competence perceptions and academic functioning. In. A.

J. Elliot and C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 85-104). New York: Guilford Press.

Skaalvik, E. M., & Skaalvik, S. (2007). Dimensions of teacher efficacy with strain factors, perceived collective teacher efficacy, and teacher burnout. *Journal of Educational Psychology, 99*(3), 611-625.

Soodak, L. C., & Podell, D. M. (1996). Teacher efficacy: Toward the understanding of a multi-faceted construct. *Teaching and Teacher Education, 12,* 401-411.

Stoehr, K., Carter, K., & Sugimoto, A. (2014). *Past experiences and present reality: How women preservice teachers view teaching mathematics*. Paper presented at the American Educational Research Association (AERA) Annual Meeting, Philadelphia, Pennsylvania.

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences (5th edition).* New York: Taylor Francis Group.

Swars, S. L., Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106*(7), 306-315. doi: 10.1111/j.1949-8594-2006.tb17921.x

Swars, S. L., Smith, S. Z., Smith, M. E., & Hart, L. C. (2009). A longitudinal study of the effects of a developmental teacher preparation program on elementary prospective teachers' mathematics beliefs. *Journal of Mathematics Teacher Education 12*(1), 47-66. doi: 10.1007/s10857-008-9092-x

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics (6th edition).* Boston, MA: Pearson.

Trujillo, K. M. , & Hadfield, O. D. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College Student Journal 33*(2), 219-

233.

Tschannen-Moran, M. & Barr, M. (2004). Fostering student achievement: The relationship between collective teacher efficacy and student achievement. *Leadership and Policy in Schools, 3,* 187-207.

Tobias, S. *Overcoming math anxiety.* New York: W. W. Norton and Company.

Tournaki, N., & Podell, D. M. (2005). The impact of student characteristics and teacher efficacy on teacher predictions of student success. *Teacher and Teacher Education, 21,* 299-314.

Tooke, D. J., & Lindstrom, L. C. (1998). Effectiveness of mathematics methods course in reducing math anxiety of preservice elementary teachers. *School Science and Mathematics, 98*(3), 136-140.

Tschannen-Moran, M. & Barr, M. (2004). Fostering student achievement: The relationship between collective teacher efficacy and student achievement. *Leadership and Policy in Schools, 3,* 187-207.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 23,* 944-956.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 17,* 783-805.

Uusimaki, L., & Nason, R. (2004). Causes underlying pre-service teacher's negative beliefs and anxieties about mathematics. In *Proceedings of the 26th Conference of the International Group for the Psychology of Mathematics Education, Vol. 4.,* 369-376.

Vinson, B. M. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *Early Childhood Education Journal, 29*(2), 89-94.

Weick, K. E. (1984). Small wins: Redefining the scale of social problems. *American Psychologist, 39*(1), 40-49.

Wilson, S. (2013). Mature age pre-service teachers' mathematics anxiety and factors impacting on university retention. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics education: Yesterday, today, and tomorrow (Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia).* Melbourne VIC: MERGA.

Wilson, S. (2012). Investigating pre-service teachers' mathematics anxiety using the Revised Mathematics Anxiety Scale (RMARS). In J. Dindyal, L. P. Cheng, & S. F. Ng (Eds.), *Mathematics education: Expanding horizons (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia).* Singapore: MERGA.

Woolfolk, A. E., Rosoff, B., & Hoy, W. K. (1990). Teachers' sense of efficacy and their beliefs about managing students. *Teaching and Teacher Education, 6,* 137-148.

Woolfolk Hoy, A., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education, 21,* 343-356.

Zambo, R. & Zambo, D. (2008). The impact of professional development in mathematics on teachers' individual and collective efficacy: The stigma of underperforming. *Teacher Education Quarterly, 35*(1), 159-168.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82-91. http://dx.doi.org/10.1006/ceps.1999.1016

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, *29*(3), 663-676. doi: 10.3102/00028312029003663