ABSTRACT

Despite the effort of teacher education programs, early childhood, and elementary preservice teachers often fear mathematics, have high mathematics anxiety, hold negative self-perceptions in relation to mathematics, find mathematics irrelevant, and have low mathematics achievement. The aim of this study was to implement and investigate the influence of an identity exploration intervention on preservice teachers’ identities in mathematics during a required mathematics content course of a teacher education program to provide insight into the patterns of change in identity and motivation towards mathematics. Twenty-four preservice teachers focusing on either early childhood education or non-mathematics secondary education were included in this study from a college algebra course specifically designed for education majors. Data collection included surveys, identity-related worksheets, identity exploration tasks, reflective writing assignments, interviews, and observations. Data was analyzed using the Dynamics Systems Model of Role-Identity and the principles for promoting identity exploration (Kaplan, 2014). This model highlights the interaction between self-perceptions, beliefs, purposes and goals, and actions. Analysis led to identification of patterns of change in student role identities and themes across cases that highlight the differences in change between the early childhood participants and secondary education participants, the influence of initial identity, and the impact of perceived relevance on identity exploration. This study contributes to the understanding of identity exploration in a mathematical setting and discusses future directions of research in promotion of identity exploration in preservice teachers.
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CHAPTER 1
INTRODUCTION TO STUDY

Mathematics has been a subject widely recognized to cause fear and anxiety in both children and adults, and early childhood and elementary preservice teachers (PSTs) are no exception to these feelings (Boyd, Foster, Smith, & Boyd, 2014). It is a substantial issue that PSTs possess negative relationships with mathematics. Researchers have shown that early childhood and elementary grade teachers are often uncomfortable with content-specific teaching (Hatch, 2010). Yet, PSTs increasingly welcome teaching practices that have a focus on literacy while mathematics focused teaching practices remain an entity that PSTs fear (NRC, 2009). Although mathematics plays an integral part in children’s everyday lives, PSTs often view it as unnatural in the context of early childhood teaching (NCTM, 2000).

PSTs are in the midst of transitioning from the role of a student to the role of a teacher, but nonetheless are mathematics students for periods of time while in teacher education programs. Students’ experiences in teacher education programs shape their identities as teachers (Horn, Nolen, Ward, & Campbell, 2008), linking a PSTs’ role as a student and role as a teacher. Often, mathematics students will experience a conflict between who they feel they are and their sense of who people expect them to be in a mathematics classroom (Boaler & Greeno, 2000). These students frequently view mathematics as irrelevant to their own lives - present and/or future (Anderson, 2007), think of the subject as repetitious and senseless (Boaler & Greeno, 2000), or feel that they do not possess the “natural” talent of learning mathematics (Blackwell, Trzesniewski, & Dweck, 2007). These negative self-perceptions or self-concepts can affect student
engagement and achievement in academic study (Pajares & Schunk, 2001). PSTs’ self-perceptions in relation to mathematics, along with their attitudes towards and beliefs about mathematics, all help shape their mathematics identity – the way they view themselves in relation to the study of mathematics.

Not only can self-perceptions, beliefs, and attitudes about mathematics influence the PSTs’ engagement and achievement with the subject, holding negative attitudes and beliefs about mathematics can foster similar attitudes and beliefs in those around them, including their students. Researchers have found that having a poor attitude towards mathematics may lead to poor teaching of the material, as well as less time spent teaching mathematics in relation to other subjects (Brady & Boyd, 2006). How a teacher views himself or herself as a mathematics student can influence his or her identity as an instructor of mathematics (Bates, Latham, & Kim, 2011), making the development of a positive identity towards mathematics vital in both early childhood and elementary PSTs during the time spent in teacher education programs. A positive identity towards mathematics involves a PST viewing himself or herself in relation to mathematics in a positive way. This would include positive self-perceptions (e.g., believing they are capable of learning mathematics or are good at mathematics), positive beliefs about mathematics and learning (e.g., all students can learn mathematics), mastery goals in place of or in addition to performance goals, and perceiving additional actions as possible as a mathematics student.

Although researchers and reformers have given much attention to the issue of negative beliefs and attitudes towards mathematics in recent decades, the problem persists. Therefore, there is a need for research on how teacher education programs can
promote positive attitudes, beliefs, and self-perceptions towards mathematics in PSTs. This has the potential to shift PSTs’ negative identities to identities that are more positive and foster similar positive beliefs and attitudes towards mathematics in their future students. Having a better understanding of the identity and motivation towards mathematics as well as how to influence identity in PSTs will be valuable to teacher education programs when developing the mathematics courses for teacher education programs. Thus, the current study investigates the influence of an identity exploration intervention that applies a theoretical framework of role identity and identity exploration on PST’s identities as mathematics students and future teachers and on motivation towards mathematics. The purpose of this study was to implement an intervention on PSTs identities in mathematics and analyze its effects on their identities and motivation. In implanting an intervention, I hope to provide insight into PST’s experiences in a mathematics content course and the patterns of change in identity and motivation towards mathematics.
CHAPTER 2
LITERATURE REVIEW

This chapter begins with a discussion on preservice teachers (PSTs) mathematics content knowledge and pedagogical knowledge, identity, and mathematics identity. Second, it presents the Dynamics Systems Model of Role Identity as a theoretical framework. Next, it explores research on interventions relevant to identity and research on mathematics identity of both PST’s and in-service teachers. It then discusses mathematics methods courses versus content courses and gaps in the literature. Finally, it presents a justification for the study.

Preservice Teachers’ Content and Pedagogical Knowledge

In order for PSTs to form and maintain positive mathematical identities throughout their teacher education programs, it may be necessary for them to improve their content knowledge. Newton, Evans, Leonard, and Eastburn (2012) have shown that there is a positive relationship between mathematics content knowledge and teaching efficacy; likely, a similar relationship exists with mathematical identity and teacher identity. Although early childhood and elementary teachers teach fundamental mathematics, many researchers have argued that it is important for teachers to possess deep mathematical content knowledge (Ball, 1990; Ma, 1999). Researchers have shown that preservice early childhood and elementary teachers in the U.S. do not always hold the essential knowledge to teach mathematics (e.g. Ball, 1990; Hill, Rowan, & Ball, 2005). In education research, widely discussed are the different forms of knowledge needed for teaching a specific concentration such as mathematics (e.g., Ball, Thames, & Phelps, 2008; Morris, Hiebert, & Spitzer, 2009; Shulman, 1986). Although early
childhood and elementary teachers teach a wide range of subjects that can often span multiple contexts, they still need to exhibit the understanding of the *pedagogical knowledge* as well as the *content knowledge* for each subject. To this end, some universities have designed mathematics courses that require PSTs to examine concepts they may have originally memorized and have them make sense of the underlying principles; however, the beliefs the PSTs hold can often diminish the outcomes of the courses (Ambrose, 2004).

Along with the need for deeper content knowledge, scholars have also called for changes in the way that PSTs think about teaching current curriculum reforms in mathematics education emphasize the need to connect conceptual and procedural understanding (CCSS, 2010). While many researchers have called for a change in the teaching of mathematics to include this connection and believe there is a need to teach mathematics differently (Hodgen & Askew, 2007; NCTM, 2000; Smith, 1996), teachers need both a firm grasp of mathematics and a more positive relationship with the subject to do so (Noddings, 1992).

Shulman (1986) argued that teaching a subject requires more than knowing facts and concepts, but involves *pedagogical content knowledge*. This specific knowledge for teaching goes beyond simply *knowing* that a concept exists or is true. It includes *understanding* why, when, and where it is true, the value of knowing a concept, and knowing how it is relative to other concepts or facts. The Common Core State Standards Initiative (CCSS; 2010) emphasizes this need for a deeper understanding. When policymakers introduced the CCSS, they presented three key shifts in mathematics to show how the standards differed from previous standards, and deemed these shifts
essential for proper implementation (CCSS, 2010). The three shifts include (1) a greater focus on fewer topics, (2) coherence in linking topics and mathematical thinking across grade levels, and (3) rigor. Rigor, the third shift, calls for teachers to present mathematical content in a way that provides equal intensity towards conceptual understanding, procedural skills and fluency, and application. By narrowing the topics covered in each grade, teachers are able to spend more time on fewer topics and help students build a strong foundation of mathematics (CCSS, 2010). However, to help students build a strong foundation of mathematics, teachers need a deeper understanding of the subject. Therefore, the Common Core State Standards demand the specific knowledge for teaching espoused by Shulman (1986).

In addition to having deep levels of mathematical understanding, Shulman (1986) discussed two dimensions of curriculum knowledge—lateral and vertical—which are essential for teaching. Lateral curriculum knowledge is relating content taught in one subject to other subject areas while vertical curriculum knowledge concerns being familiar with the topics of a specific subject taught during the former and upcoming years. Lateral knowledge helps demonstrate why teachers of various subjects (e.g., mathematics, history, English, etc.) should be able to demonstrate basic knowledge in all subjects. Not only does this indicate that early childhood and elementary teachers should be able to make connections between the various subjects they teach, but also secondary teachers should be able to make connections between subjects they teach and subjects they do not teach. Vertical curriculum knowledge holds teachers accountable for knowing slightly more advanced concepts than that of which they teach in a given year. It is insufficient for early childhood and elementary PSTs to be fluent only with the
concepts and standards covered in their certified grades, or believe that being fluent with only these concepts is enough. PSTs need to have a deep understanding of middle and high school level mathematics in order to help students link mathematical topics across grade levels (Common Core State Standard Initiative, 2010).

Furthermore, early childhood and elementary school teachers build the foundation for students’ ability to thinking algebraically, making it critical for teachers to have a profound understanding of and confidence in conveying and revealing the connections between arithmetic and algebra. “Teachers with higher content knowledge are not only more apt to teach mathematics in a manner that is compatible with learning algebra but are also more inclined to hold their students to higher standards” (Darley & Leapard, 2010, p. 185). Both building a foundation and possessing a higher content knowledge underscore the need for mathematically proficient early childhood and elementary school teachers.

The issue of how much content to expose PSTs to is not a new debate. Some researchers and reformers have suggested increasing the number of mathematics content courses or requiring a subject-matter focus for early childhood and elementary PSTs (e.g., Burkhouse, 2002). Others have suggested redesigning methods courses and/or requiring PSTs to demonstrate subject-matter competency through high-stakes tests (e.g., NCLB). Regardless of whether teacher education programs focus more on mathematical content or more on pedagogical practices, PSTs preparing to teach early grades may still hold negative beliefs and attitudes towards mathematics. If PSTs hold these beliefs throughout their time as students, the beliefs will potentially carry over into the initial years of teaching. In addition, these negative beliefs and attitudes may have the potential
to damper the knowledge PSTs gain from their college mathematics courses. Therefore, increasing the mathematical content required of PSTs alone will not fix the problem; rather, it is a symptom of a much deeper problem perhaps better addressed with a focus on identity. Helping PSTs form a more positive identity in relation to mathematics may motivate them to increase their content knowledge by either engaging more in their required mathematics courses or potentially electing to take additional mathematics courses throughout their program.

Identity and Mathematical Identity

What is Identity?

Researchers have defined and theorized identity in different ways over the past several decades. Many perspectives on identity build on the work of Erikson (1963, 1968, 1982). While Erikson never provided a clear definition of identity, perhaps believing it was too broad of a concept, he described it as the process of achieving a sense of self, followed by continuous reformations of this self throughout the person’s lifetime (Kaplan & Flum, 2010). Erikson’s definition – or lack thereof – made it challenging to investigate identity empirically (Waterman, 1999). Thus, other researchers extended Erikson’s work to construct precise definitions of identity. For example, Waterman (1984) defined identity as “a clearly delineated self-definition comprised of those goals, values, and beliefs to which the person is unequivocally committed” (p. 331). Another highly regarded identity researcher, James Marcia, defined identity as “an internal, self-constructed organization of drives, abilities, beliefs, and individual history” (Marcia, 1980, p. 159). Gee (2001) defined identity as simply meaning the kind of person someone is considered as being at a particular point in time or a particular place. In other
words, identity – which makes up who we are – is the way we define ourselves along with the way others define us.

Although differences exist among the various definitions of identity, there are similarities. Kaplan and Flum (2010) noted some common characteristics among the definitions. These included the involvement of a combined configuration of personal attributes, values, and goals, agency in the self-construction of this combined configuration, the importance of the social-cultural environment on the self-construction of identity, and the idea that an individual is more adjusted when an identity structure is more unified and consistent. Moreover, many definitions have in common the idea that identity can change from setting to setting or can be unstable at any given moment. This ability to change makes identity a relational phenomenon rather than a fixed attribute (Oruç, 2012).

For PSTs, experiences with K-12 education, experiences as college students, studying to become a teacher, practicum settings, thoughts of being a future teacher, and even relatives who are teachers can all help shape various identities. Often PSTs must reconcile these identities (Kasten, Austin, & Jackson, 2014). One particular aspect of identity reported in education research with PSTs is teacher identity. Teacher identity is a professional identity that all PSTs are in the process of building and will continue to build throughout their futures as educators. Duru (2006) defined teacher identity as how educators interpret themselves as teachers and discussed factors that influence teacher identity. These factors include popular culture, school experiences, workplace conditions, and teacher education programs. Various researchers have expressed that teacher preparation programs are crucial in the formation of teacher identity and that
these programs need to provide opportunities for positive teacher identity formation (Beauchamp & Thomas, 2009; Chong & Low, 2009). Research in teacher identity has been growing (e.g., Beijaard, Meijer, & Verloop, 2004; Flores & Day, 2006; Mockler, 2011; Buchanan, 2015), which is important because teacher education programs facilitate teacher identity formation (Horn, Nolen, Ward, & Campbell, 2008).

Professional identity, however, should not be the only identity related focus in teacher education programs. Educators in early grades may identify with more than simply being a teacher. They may consider themselves as teachers of particular subjects (e.g., history, English, mathematics, science, and so on). As a result, for early childhood PSTs as well as elementary PSTs and secondary mathematics teachers, education programs should also consider the construction and negotiation of mathematical identities.

Mathematics Identity

Recently, researchers have used the concept of identity when trying to understand the level of student participation in mathematics (e.g., Boaler, 2002; Boaler & Greeno, 2000; Sfard & Prusak, 2005). Researchers have described mathematical identity in various ways, which range from a pure personality trait (e.g., Bikner-Ahsbahs, 2003) to something that students form and shape in mathematics classrooms (e.g., Anderson, 2007). Mathematical identity has been described as simply the relationship one has with mathematics and, like all identities, can change or be (re)constructed at any time (Bikner-Ahsbahs, 2003). Cobb, Gresalfi, and Hodge (2008) took the idea of mathematical identity further by categorizing identity into two constructs: normative and personal. Normative identity is defined as “compris[ing] both the general and the specifically
mathematical obligations that delineate the role of an effective student in a particular classroom” (p. 43), while personal identity concerns “the extent to which individual students identify with, merely comply with, or resist their classroom obligations, and thus with what it means to know and do mathematics in their classroom” (p. 44). Therefore, the normative identity established in a classroom will shape a student’s personal mathematical identity. However, students who are engaged in the same classroom activities and who follow the same classroom norms can hold different mathematics identities (Bishop, 2012). One advantage of incorporating identity into mathematics education and research is that it helps focus on a student as a whole person and on how he or she learns mathematics rather than simply compressing learning to performance, achievement, or cognition (Darragh, 2013).

Regardless of the various definitions of identity and mathematical identity presented in the literature, identity is “underdeveloped as an explanatory construct in mathematics education” (Cobb, 2004, p. 333) and more research is needed on this topic. Along with other factors such as achievement, researchers suggest that identity predicts the continuation in studying mathematics (Boaler & Greeno, 2000). However, little research illustrates how teachers can cultivate positive identities in relation to mathematics in students (Darragh, 2013); let alone help transition a student’s identity in relation to mathematics from negative to positive. Regardless of the definition, positive identity in relation to mathematics requires more than just mathematical ability; it requires participating in authentic activities (Boaler, 1999) and imagining one’s self as a mathematics learner (Boaler & Greeno, 2000, cited in Graue et al., 2015).

Identity Formation
A discussion on identity formation warrants a better understanding of how teachers can cultivate positive identities in relation to mathematics in students. Identity formation involves both exploration and commitment (Marcia, 1966, 1980, 1993). The psychosocial perspective on identity describes identity formation as the process of identification, exploration, and commitment, and it stresses individual agency. In identity exploration, a person gathers information, questions, experiments, and reflects on their beliefs, abilities, and roles. Commitment involves the selection and incorporation of the set of values and goals that a person holds. This commitment, or the degree to which a person invests in an idea or action (e.g., profession, social relationships, political beliefs), make up a person’s core identity when integrated. Thus, “[i]t is the engagement in exploration that leads to the synthesis and integration of prior identifications, self-perceived abilities, and experiences, which in turn lead to commitments to beliefs, values, roles, and goals that comprise the core of the person’s identity” (Kaplan & Flum, 2010).

Erikson’s identity theory provides a key focus on the importance of the social contexts and the role that such contexts play in the formation of identity. One such important context is schools, where students spend a great deal of time. The engagement in social activities with adults and other students as well as the experience and exposure to new activities and ideas all occur within the social environment of schools and all contribute to identity exploration (Erikson, 1968). These activities as well as the type of people encountered in schools all help build and shape the experiences that make up the construct for a student’s identity exploration and formation (Roeser & Lau, 2002). Thus, the sociocultural and psychosocial perspectives on identity both give insight into identity formation (Kaplan, Sinai, & Flum, 2014). Not only is this important for PSTs because
they are students, but also because they will one day be the adult or role model who help build and shape the experiences and identities of their own students.

Horn, Nolen, Ward, and Campbell (2008) use Holland et al.’s (1998) idea of “figured worlds” when discussing the development of identity for novice teachers. They discuss how individual forms identities culturally through the context around them. Thus, when operating in various figured worlds, individuals assert and receive different identities. A PST’s identity as a student and his or her identity as a prospective teacher shapes the way he or she engages in coursework during their teacher education program, influencing his or her learning and later, his or her teaching. Horn et al.’s findings indicated that PSTs’ often enter teaching programs with certain beliefs and identities, but teacher education programs can help PSTs’ modify or shift their identities. Through participation in various figured worlds (e.g., courses in teacher education programs or fieldwork), PSTs are able to negotiate identities, begin to understand themselves as teachers, and change learning agendas.

In relation to mathematics, a person forms an identity with the subject when he or she negotiates his or her relationship with mathematics, taking into account their core identity (Black et al., 2010). The construction of identity in relation to mathematics comes from many contexts or “figured worlds” including mathematics courses, teacher education programs, real world mathematical interactions, and mathematics teachers (Kasten, Austin, & Jackson, 2014). This dissertation research sought to study PSTs’ identity formation and reconstruction both as mathematics students and as future teachers within the context of a mathematical content course involving an intervention and the
effects of the intervention on student motivation to increase mathematics content knowledge.

**Theoretical Framework**

Preservice teachers enter into teacher education programs with identities already formed that include different perceptions, goals, beliefs, and knowledge. These identities act as a lens for how the PSTs’ view and partake in particular classes and subjects. By better understanding PSTs’ identities not only can we better understand how they negotiate the experiences of being in a mathematics classroom but we can also help to motivate and alter negative identities using identity exploration. The Dynamic Systems Model of Role Identity offers a framework to better understand and be able to study the content of role identities. Unlike other motivational models that treat motivational constructs and their influence on action as mechanistic, the Dynamic Systems Model of Role Identity (Kaplan, 2014) treats motivation and action as a dynamic system. Treating motivation and action as a dynamic system is more in line with the idea that identity is a holistic and contextual (Kaplan, 2014).

**Personal Investment Theory**

The Dynamics Systems Model of Role-Identity (DSMRI) – the model used in this study for examining PSTs identity in relation to mathematics – stems from Maehr and Braskamp’s (1986) Personal Investment Theory (PIT). PIT centers on achievement motivation and the choices a person makes on how to invest his or her time and energy in certain tasks. It underlines the roles that social and cultural contexts play in motivation. PIT proposes that how people invest in activities or courses of action depends on their subjective meaning of those activities or courses of actions. That is, “people exhibit
different patterns of personal investment because they understand the investment situation differently” (Maehr & Braskamp, 1986, p. 48). These meanings lead to a person’s investment or avoidance of particular tasks. PIT also proposes three connected facets of meaning: (1) sense of self, (2) perceived purposes and goals, and (3) perceived action possibilities.

Sense of self – closely linked to identity-relevant processes – refers to the collection of perceptions, beliefs, and feelings about one’s self. This includes identifications, self-reliance, sense of competence, and goal-directedness (Maehr & Braskamp, 1986). Perceived purposes and goals, the second facet, refers to the different reasons people advocate for carrying out certain activities. This sense of purpose denotes goals that can be broken down into categories which include task or mastery goals (wanting to increase one’s competence or knowledge), ego goals (wanting to outperform others), social solidarity goals (wanting to receive social acceptance from others), and extrinsic rewards goals (wanting praise or a reward). Finally, action possibilities pertain to “behavioral alternatives or options that a person perceives to be available to him or her in any given situation” (Maehr, 1984, p. 124). Sociocultural norms along with perceived barriers influence what a person sees as action possibilities.

Maehr and Braskamp (1986) stressed that researchers should study personal investment in context. This is because meaning making is endless, dynamic, and closely linked to social cultural contexts, making personal investment adjustable. While PIT has been applied and studied in various contexts (e.g., Fyans, Salili, Maehr, & Desai, 1983; McInerney, 2012; Lindholm, 1997), it has been tailored recently to use for developing a model of professional identity (Kaplan, 2014).
The Dynamic System Model of Role Identity

Kaplan and his colleagues (2014) have begun creating a conceptual model of teacher’s professional identity based on Maehr and Braskamp’s (1986) PIT. This conceptual model includes how a teacher develops and sustains his or her professional self. It encompasses the three facets of PIT; however, a fourth element is included in the model that captures epistemological and ontological beliefs. This fourth element involves a person’s collective beliefs about knowledge, teaching, and learning. The model strays from treating motivational constructs and their relation to action as mechanistic and linear to depicting motivation and action as a nonlinear dynamic system (Guastello & Gregson, 2011). This dynamic system model looks at role identity in the social context, including the subject domain, culture, and personal dispositions, to include four facets: (1) ontological and epistemological beliefs, (2) purposes and goals, (3) self-perceptions and definitions, and (4) perceived action possibilities. Figure 2 gives a visual display of the model.

Figure 1. The dynamic systems model of role identity (Kaplan, 2014).
A model such as the DSMRI conceptualizes a teacher’s professional identity formation, including both the identity structure and process, as a complex dynamic system. Thus, in relation to teachers’ professional identity researchers can use the model to study changing structures of professional identity over time. Although Kaplan’s model pertains particularly to teacher’s professional identity formation, the role-identity phenomenon is part of a larger dynamic system that includes many roles (Kaplan, 2014). For PSTs, two salient roles that play a part in their lives during the years in a teacher education program are the roles of student and future teacher. PSTs are in the process of forming their teacher role identities when partaking in a teacher education program (Beauchamp & Thomas, 2009; Kaasila, 2011) and even enter into teacher education programs with an internalized recollection of teachers and experiences that influence their own teacher role identities (Knowles, 1992). They are also continuing the formation and fluctuations of their student identities because identity formation is an ongoing process (Beauchamp & Thomas, 2009; Gee, 2001). “Preservice teachers must often reconcile identities associated with their experiences as K-12 students, as university students studying to become teachers, as temporary teachers in their practicum settings, as future teachers in their own classrooms, and sometimes as the relative or close friend of a student or teacher” (Kasten, Austin, & Jackson, 2014, p.129). As previously mentioned, a person’s sense of self as a student of mathematics can strongly affect his or her continued engagement with the subject (Boaler & Greeno, 2000). Thus, if done in a supportive environment, exploring one’s identity in relation to mathematics as a student in the early years of a teacher education program may help to shape a teacher’s identity in
a positive way while also increasing the motivation to further his or her knowledge of the subject.

Identity Exploration

Kaplan, Sinai, and Flum (2014) describe a conceptual framework that includes four principles for interventions that promote identity exploration. Using such principles and interventions, educators can promote a PST’s agency in relation to investigating who he or she is and who he or she wants to become with respect to mathematics in his or her future teaching career. Such identity exploration then is likely to influence motivation, development, and learning. The four interrelated principles integrated in the framework include promoting relevance, triggering exploration, facilitating a sense of safety, and scaffolding exploration.

Promoting Relevance

An issue that often arises in educational settings is that students do not view the content presented as relevant to their own lives. This is often the case for early childhood and elementary PSTs when presented with higher-level mathematics such as college algebra (Hart, Oesterle, & Swars, 2013). Accordingly, to promote identity exploration in relation to mathematics for PSTs, the first principle of promoting self-relevance must be the starting point. Teachers (or curriculum) often decide on instructional examples, and they often choose what they believe to be relevant to the students (e.g., Kwiek, Halpin, Reiter, Hoeffler, & Schwartz-Bloom, 2007). However, in today’s extremely diverse classrooms, finding examples that are relevant to all students may often feel like an impossible task. Thus, educators need to promote student agency because students’ perceived self-relevance is subjective. Rather than the teacher making a connection
between the content and the students’ lives, he or she can ask the students to bridge the connection in order to create this relevance (Sinai, Elgad, & Manor, 2013). Some students, however, may still require scaffolding in this process.

Triggering Exploration

While promoting self-relevance of academic content contributes to the foundation of identity exploration, identity exploration involves active examination and questioning of the self-aspects that become salient through experiencing self-relevance. This questioning is in response to exploration triggers, the second principle. Exploration triggers occur when there are personal experiences of discrepancy with a current identification such as a goal or self-perception one may hold of him or herself (Kaplan, Sinai, & Flum, 2014). When such a discrepancy occurs, a person will seek new information about one’s self and the environment in order to construct a new self-aspect. This can trigger ambiguity or confusion, which can then provide motivation for exploration (Flum & Kaplan, 2003). However, along with the motivation for exploration, identity exploration triggers can lead to anxiety.

Facilitating a Sense of Safety

This harvested anxiety, sense of conflict, or threatening feeling that can surface during this process may lead to resistance to identity exploration. Hence, it is important to include the third principle, facilitating a sense of safety, to avoid having students resist identity exploration due to conflict or threat. Especially in a situation where anxiety levels may already be high, it is important that teachers promote a sense of safety in the classroom. Although sense of safety is subjective, there are general principles such as acknowledging and validating feeling and perceptions, promoting mutual respect, and
supporting basic psychological needs that teachers can use for promoting a sense of safety (Sinai, et al., 2013).

Scaffolding Exploration

Students may lack the knowledge needed to explore their identity effectively (Kaplan, Sinai, & Flum, 2014). As a result, teachers should take the time to scaffold identity exploration for students, which is the fourth principle in the model. This scaffolding can be done using a variety of tasks including discussions, writing assignments, exercises, and peer modeling. It is important to keep in mind that each of the four principles is subjective. One student may find an activity relevant while another may not. A particular group of students may experience an event as an exploration trigger while others may not see it as such. What one student may see as a safe environment, others may not see as safe. Scaffolds also may differ from student to student. All four principles work together to create a balance that allows students to partake in identity exploration (See figure 1).

Figure 2. The principles for promoting identity exploration (Kaplan, Sinai, & Flum, 2014).
Some of the key reasons for studying identity in relation to mathematics in PSTs are the potential to increase motivation and efficacy in learning mathematics and potentially lower anxiety. As illustrated in Figure 1, it is important to have a balance between exploration triggers, sense of safety, and scaffolding identity exploration. Having a high level of exploration triggers while not fostering a sense of safety can lead to anxiety or paralysis.

Interventions Relevant to Identity

While literature that provides insight into how teachers can cultivate positive mathematical identities in students is scarce (Darragh, 2013), there has been identity-relevant research that looks at interventions specifically focusing on a particular facet of identity (e.g., perceived ability). These studies demonstrate the potential for affecting students’ view of themselves in relation to mathematics in a positive way as well as having positive effects on academic performance. Such studies are included in this literature review under the identity facet they specifically target.

Epistemological and Ontological Beliefs

As mentioned above, the epistemological and ontological beliefs aspect of the DSMRI model involves a person’s collective beliefs about knowledge, teaching, and learning. Students’ hold various beliefs about the nature of mathematics, the nature of intelligence, and of mathematical ability, all of which influence their behavior, self-efficacy, and acknowledgements of their achievements and failures. Several researchers have emphasized the importance of students’ beliefs about mathematical learning and problem solving (e.g., Greeno, 1991; McLeod, 1992; Kloosterman, 1996). Schoenfeld (1992) provides a list of beliefs students typically have in relation to the nature of
mathematics. These beliefs include but are not limited to: there is only one correct answer to a mathematics problem, there is only one correct way of solving a mathematics problem, mathematics is a solitary activity for which individuals complete in isolation, ordinary students are not expected to understand mathematics but rather memorize it, and the mathematics learned in school has little to no relation to the real world. When students hold such beliefs, their engagement and goals for learning, mathematics on a higher-level may be negatively impacted.

In society, there is a belief that a person is either naturally good or naturally bad at mathematics. The extent to which a person views personal attributes (e.g., ability) as fixed or malleable can influence motivation and learning (Dweck, 1999). When a person views attributes as malleable or impressionable (hold an incremental theory), he or she is more likely to adopt mastery goals, whereas when a person views attributes as unchangeable (hold an entity theory), he, or she is more likely to adopt performance goals (Dweck, 1999; Dweck et al., 1995; Dweck & Leggett, 1988). Thus, theories of intelligence influence achievement goals. Myers, Nichols, and White (2003) suggest that entity theories are more frequent in subjects such as mathematics and incremental theories are more frequent in subjects such as social studies. Similarly, Calderhead (1996) suggested that different academic disciplines hold different epistemological beliefs.

Beliefs regarding the nature of mathematics and mathematical learning are also a part of the competence needed for teaching mathematics. PSTs enter teacher education programs with the preconceived beliefs about mathematics and mathematical learning which they formed as students (Goodman, 1988; Lubinski & Otto, 2004). Many of these
beliefs, some held since elementary grades, can be challenging to change, however; beliefs can be indicative to actions, making beliefs a critical topic to study in teacher education (Pajares, 1992). “There is substantial evidence that teachers’ beliefs about mathematics impact their teaching of mathematics” (Hart, 2002, p. 4). For example, if a teacher has the belief that their students cannot construct knowledge independent of the teacher, he or she may keep a more teacher-centered classroom (Beswick, 2005). Thus, it is important for teacher’s beliefs regarding the nature of mathematics to be challenged to make changing teacher practices easier (Nisbet & Warren, 2000), and it is often up to teacher education programs to break the cycle of negative beliefs in prospective teachers.

Many times, early childhood and elementary PSTs enter into teacher education programs with optimistic bias – believing they already hold the knowledge they need to know to be able to teach children (Weinstein, 1989). These beliefs then lead teachers to underestimate the difficulty of teaching and the need for content knowledge (Ambrose, 2004). One way to change teachers’ beliefs about mathematical learning is through students’ mathematical thinking. Ambrose (2004) studied just that by having PSTs work in an elementary school with children during their initial mathematics content course for teachers. For PSTs who focused on children’s mathematical thinking, the project helped them to understand the importance of content knowledge as well as reconsider their assumptions of mathematics teaching. During the project however, many of the elementary students had trouble with manipulatives and story problems, making the PSTs focus more on the students’ failures as opposed to their successes.

Many PSTs hold beliefs about mathematics and mathematical learning based on procedural knowledge and need experiences to change these beliefs and to help focus
more on conceptual understanding (Stohlmann, Cramer, Moore, & Maiorca, 2014). One such intervention focused on building conceptual understanding through multiple representations. Stohlmann and colleagues used teaching procedurally, example videos and building conceptual understanding of fraction division as different representations. By the end of the course, the PSTs placed greater value on the use of multiple representation to measure understanding. This study, along with other studies that implement interventions on PSTs’ and in-service teacher’s beliefs (e.g., Swan, 2007; Grootenboer, 2008), help to demonstrate how it is possible to change PSTs’ beliefs about mathematics and about mathematics learning. Although these researchers argue that making said changes could be extremely difficult, appropriate interventions can initiate change.

Changing beliefs alone may not be enough to change teacher practices. Although many researchers state that it is possible to change beliefs, they often follow these statements with suggesting that the change may not significantly affect teacher practices (Raymond, 1997; Vacc & Bright, 1999). For example, Grootenboer (2008) hypothesized that beliefs would remain stable for PSTs partaking in an initial education course. While the results showed that PSTs beliefs remained stable, the researchers found slight changes in the formation of new beliefs; however, Grootenboer was skeptical that the changes in belief would lead to initiating change in practice.

Self-Perceptions and Self-Definitions

The self-perceptions and self-definitions aspect of the DSMRI model includes how a person defines themselves (e.g., a female, a student, a teacher, Asian), his or her self-beliefs and self-efficacy (e.g., good at math, unmotivated, outgoing), and his or her
values. In mathematics, anxiety is a substantial issue (Ashcraft, 2002). A large number of children and adults suffer from mathematics anxiety. Mathematics anxiety has been a subject widely studied in research for the past thirty years. Although the definition of mathematics anxiety has varied over the years, a common definition is “a feeling of tension, apprehension, or fear that interferes with mathematics performance” (Ashcraft, 2002). Having anxiety towards mathematics can lead to unfortunate consequences such as avoidance, low motivation, and low self-perceptions about abilities. Researchers have also found a difference in mathematics anxiety based on gender (Hembree, 1990; Kelly & Tomhave, 1985), which suggests that females have more anxiety than males. This higher level of anxiety encompasses portions of working memory leading to poorer mathematical performances for females (Ganley & Vasilyeva, 2014). With reports of 87% of all early childhood education teachers in the United States being female (The World Bank, 2012), mathematics anxiety is a concern for teacher education.

Researchers have found that there is a negative relationship between mathematics anxiety and self-confidence in the subject, as well as enjoyment of the subject (Hembree, 1990). When comparing mathematics anxiety among various college majors and courses by using meta-analysis, Hembree found that students preparing to be elementary school teachers held the highest levels of mathematics anxiety compared to other majors such as business, social sciences, health sciences, physical sciences, and humanities. Predictably, mathematics and science majors held the lowest mathematics anxiety levels. Furthermore, students with high mathematics anxiety were less motivated to take additional mathematics courses beyond what their programs require. Hembree concluded that the PSTs with weak mathematics backgrounds and negative mathematical views
were not prepared to lead their students. Similarly, from surveys given during the beginning of an introductory mathematics class, Perry (2004) found that 85% of the participating PSTs experienced some form of mathematics anxiety. This is a serious issue for teacher education because not only does mathematics anxiety negatively correlate with self-confidence, but many researchers believe that teachers pass their fears and mathematics anxiety onto their students (e.g., Hembree, 1990; Kelly & Tomhave, 1985; Sloan, Daane, & Giesen, 2002), perpetuating fear of the subject.

Elementary classes are a starting point for the formation of mathematics anxiety and specific experiences can lower a student’s self-confidence in their mathematical ability, resulting in the avoidance of mathematics (Harper & Daane, 1998). In a study conducted by Brady and Bowd (2005) on 238 elementary PSTs, findings indicated that PSTs’ confidence in teaching mathematics related to both mathematics anxiety and prior grade-school experiences. While mathematics anxiety negatively correlated with confidence to teach mathematics, enjoyment of the subject positively correlated confidence to teach. Brady and Bowd further discussed how a PSTs’ weak knowledge could limit his or her ability to present mathematical content in a variety of ways, which inhibits his or her ability to reach the diverse community of learners in today’s classrooms. Their study is consistent with studies such as Hembree’s (1990) that demonstrate how students with high mathematics anxiety take fewer college level mathematics courses, further validating why the various facets of mathematical identity are key constructs to study in teacher education programs.

It is expected that proficient teachers have positive self-efficacy in relation to mathematics. Akay and Boz (2010) conducted an intervention with elementary PSTs
aimed at increasing their mathematics self-efficacy through problem posing instruction. By using the Mathematics Self-Efficacy Scale (MSES), the researchers were able to measure the PSTs’ self-efficacy of mathematics before and after partaking in the problem posing instruction. Results indicated that the experimental group of PSTs exposed to problem posing instruction experienced a significant positive increase in self-efficacy scores, whereas the control group exposed to traditional mathematics instruction did not experience a statistically significant difference in their self-efficacy. In fact, when looking at the mean scores, a decrease appeared for the control group. For the problem posing intervention, the researchers used various structures. In some instances, the tasks were structured or semi-structured while at other times there were “free problem posing tasks.” An example of a semi-structured problem-posing situation provided is, “You will get engaged when you graduated from the university. If you are going to design your engagement ring, how would you design the ring and determine its cost?” (Akay & Boz, 2010, p. 67). In this example, the researchers scaffold the students’ creativity to help them connect what the instructor taught to real-life; however, some students may not relate to such an example if engagement is not something they are interested in after graduating.

In another study, also providing students with the ability to form their own connection to the content, Hulleman, Godes, Hendricks, and Harackiewicz (2010) felt that an intervention encouraging students to self-discover the connections between mathematical activities and their own interests and lives rather than teachers informing the students of the relevance would be less threatening to students. Students increased in interest and utility value when asked to write about the connection between the
mathematics taught and the relevance to their own lives. These positive effects were greater for students with low performance or low expectation for performance (Hulleman et al., 2010). Because early childhood and elementary PSTs often hold high levels of mathematics anxiety and low self-perceptions in relation to mathematics, being exposed to identity triggering interventions that allow them to make their own connections and explore their own sense of value and self-perceptions of learning mathematics may help to improve their academic performance and confidence in learning and teaching mathematics.

Purpose and Goals

Perceived purpose and goals - the different reasons people advocate for carrying out certain activities - can be broken down into different types of goals. One specific theory that helps to understand student goals is achievement goal theory. Achievement goals include mastery goals and performance goals (Dweck & Elliot, 1983). When a student holds mastery goals, they seek to gain competence and actually learn the content (Ames & Archer, 1988). When a student holds performance goals, they seek an objective such as high grades over learning or seek to demonstrate competence, primarily relative to others. Further those with performance-approach goals seek for others to perceive them as competent, whereas those with performance-avoidance goals seek to avoid appearing incompetent to others.

Traditional methods of instruction found in many mathematics classrooms are performance-oriented, encouraging students to adopt performance goals as their own (Nicholls, Cobb, Wood, Yackel, & Patashnick, 1990; Anderman, Maehr, & Midgley, 1999). As mentioned, the population of elementary teachers is mostly comprised of
females. Some researchers have reported that females tend to possess more mastery-oriented goals over males (Peterson & Fennema, 1985). Perry (2011) suggests that “performance-oriented instruction coupled with an initial inclination to mastery goals may negatively affect the attitude [teachers] present toward mathematics in their own classrooms and encourage the adoption of maladaptive performance goals by students in the mathematics classes they teach” (p. 3). She further states that this cycle of negative attitudes and performance goals is never ending.

Some educational researchers have suggested that when a teacher promotes mastery goals in his or her classroom, students are more willing to adopt such mastery goals for themselves and begin to think of mathematics as more than procedures (Nolen & Haladyna, 1990; Morrone et al., 2004; Harkness et al., 2007). A majority of the studies that look at achievement goal theory in mathematics and how teachers can influence students’ goals (e.g., Turner, Meyer, Cox, Logan, DiCintio, & Thomas, 1998; Patrick, Anderman, Ryan, Edelin, & Midgley, 2001) were conducted with elementary, middle, or high school students. Far less research has focused on college students or preservice teachers. In a study where elementary PSTs were enrolled in an experimental mathematics course focused on mathematical problem solving, Morrone et al. (2004) found that instructors’ discourse patterns helped promote PSTs to adopt mastery goals. Students in the class felt that the course was mastery-goal focused. Specifically, scaffolding, pressing for understanding, and asking complex questions often resulted in students asking questions that involved higher-order thinking or asking questions that targeted the “big ideas” of mathematics.
In a follow up study, Harkness, Ambrosio, and Morrone (2007) once again worked with PSTs but focused on student voices to determine what students felt was motivating. In the beginning of the course, a third of the students expressed their dislike for mathematics and their inability to do well in mathematics; however, after partaking in a mastery-goal oriented classroom, students were able to override this perceived low ability. While students did not mention the discourse patterns emphasized in Morrone et al.’s (2004) study, they did recognize the teachers’ efforts to help them understand and work hard towards mastery goals. Given that college students place a great amount of emphasis on grades and performance in courses, it is important that there is “a balance between a focus on mastery and performance goals for college students with more emphasis on mastery goals for students who ‘dislike’ the subjects we teach and who feel that ability is a fixed trait that cannot be changed through effort” (Harkness et al., 2007, p. 252).

Perceived Action Possibilities and the Interaction between the DSMRI Components

The last facet of the DSMRI model involves perceived action possibilities. This involves a student’s perception of possible actions available that are relevant and appropriate for pursuing his or her purposes and goals (Kaplan, 2014). Students can have numerous and various options in any given situation. They may think of their options as trying to hide, asking a peer for help, faking sick, reading the textbook, etcetera; however, their knowledge of the possibilities and beliefs about the consequences of such actions will affect how they decide to use their energy. Someone is very unlikely to engage in an action that he or she never deemed possible nor is he or she likely to perform an action that is perceived as having undesirable consequences.
In a mathematics classroom, action possibilities can consist of behavioral intentions and learning strategies students perceive as relevant to their purpose or goals in the lesson or class. Researchers have made a connection between achievement goals and perceived action possibilities and several interventions have focused on self-regulation strategies with mathematics students (Corte, Verschaffel, and Eynde, 2000). Because action possibilities are relevant to goals, the two facets are undoubtedly connected; however, all four facets presented above dynamically interact as explained below in the theoretical framework. Because the motivational processes are reciprocal in nature (Pajares, 1996), each of the four facets dynamically interact with one another (Kaplan, 2014). Researchers have shown this dynamic interaction in many studies. For example in Harkness, Ambrosio, and Morrone’s (2007) study, an intervention not only influences students’ goal orientations but also affected their self-perceptions of ability to do well in mathematics.

Rather than implementing an intervention that only focuses on one facet of identity, researchers have implemented identity exploration interventions that look to promote more adaptive alignment of identity contents. For example, Granit-Dgani, Kaplan, and Flum (2011), Sinai, Kaplan, and Flum (2012), and Kaplan, Sinai, & Flum (2014) looked to promote exploration in middle school environmental education, a middle school literature classroom, and a middle school mathematics classroom. In each of the studies, the intervention proved to promote student engagement and motivation with the academic material, with many students experiencing identity exploration. Within the mathematics class, some students resisted identity exploration triggers when they were highly motivated towards grades and demonstrating high ability; however,
some of these students experienced changes in self-perceptions or used the tasks as a way to engage in in-depth learning and reflection (Kaplan, Sinai, and Flum, 2014).

Research on Mathematical Identity of Preservice and In-Service Teachers

While many studies and interventions have focused on specific aspects of the contributing factors in identity, other studies have focused specifically on mathematical identity. The idea that identity can be used as an analytical tool in education has been presented in prior research (Gee, 2001; Kaplan & Flum, 2012), and several mathematics education studies have focused on using the idea of identity to understand student motivation, achievement, and engagement with the subject (e.g., Anderson, 2007; Anderson & Gold, 2006; Esmonde, 2009). Yet, fewer studies have focused on mathematical identity of preservice and in-service teachers. This section gives an overview of existing research on mathematical identity of PSTs and in-service teachers. The objectives of the studies include categorizing mathematics identities, examining the connection between mathematical identity talk and classroom practices, investigating different interventions that shift negative identities to more positive identities, comparing the impact on mathematical identity of courses with different focuses, and analyzing mathematical identity talk.

Kaasila and colleagues have published several studies focused on mathematical identity of PSTs. Kaasila (2007) listed three components that make up a PSTs’ view of mathematics, which influence their identity. These include (1) how they view themselves as both learners and teachers of mathematics, (2) their view of mathematics in general and its teaching and learning, and (3) the social context or classroom in which learning and teaching mathematics takes place. Furthermore, Kaasila, Hannula, and Laine (2012)
focused on how to analyze mathematical identity talk and methodological challenges that may occur. The researchers gave PSTs two questionnaires at the beginning of a mathematics education class to measure their beliefs and skills in relation to mathematics and conducted two interviews. Participants changed from having negative discourses to having discourses that were more positive at the end of the course. Negative discourses, such as Victim or Fatalist, included categorizing oneself as a victim and internalizing beliefs about talents. Positive discourses, such as Self-development, included demonstrating optimism about change. The authors concluded that the use of the multiple methodologies in analyzing data gave a deeper understanding of the PSTs’ identities. However, the researchers make elicit that when looking at the identity of PSTs, they studied the change in beliefs, emotions, attitudes, and knowledge. Similar to the interventions in the previous section, the study was missing components of identity such as goals and actions.

McCulloch, Marshall, DeCuir-Gunby, and Caldwell (2013) studied kindergarten through second grade teachers’ identities as mathematics learners using autobiographies and searched for how to categorize such teachers’ identities. During a professional development experience, researchers asked teachers to write their mathematics autobiographies, including details from their earliest years as a student through the present day, which ranged from two to twenty+ years of teaching. While the researchers asked teachers to write about both people and activities that influenced their experiences, the teachers mainly focused on people. The researchers categorized the participants’ experiences as learners as smooth track, minor setback, consistently frustrated, roller coaster, negative turning point, and positive turning point. These categories ranged from
having exclusively positive experiences to fluctuating between positive and negative experiences. Some even started positive and then experienced an event that made learning mathematics a negative experience. Regardless of the category, participants accredited positive and negative experiences to teachers, family, and peers. For example, participants talked about good and bad experiences with teaching and experiences at home with parents. While this study provides insight into how teachers form mathematics identities, the researchers did not attempt to change identity or specific aspects of identity to improve the teachers’ relationship with mathematics. Rather, the study simply sought to help teachers reflect on their identities and to understand the development of identity in their own students.

Gujarati (2013) furthered the research on mathematics identity with in-service teachers by examining the relationship between three elementary teachers’ mathematics identities and their classroom practices. The author stated that she purposefully chose the participants to provide a diverse sample in terms of their beliefs about mathematics. Results revealed that all three teachers fell into an “inverse” relationship category due to possessing negative mathematical identities while at the same time exerting a great amount of effort to ensure their students would have more positive experiences and relationships with mathematics than what they had experienced. The findings showed that a negative mathematical identity could – in some ways – have positive effects on teaching. However, the researchers only look at participants’ beliefs about themselves in relation to mathematics and the relationship between beliefs and practices when studying mathematics identity. Again, this leaves out particular components of identity such as epistemological and ontological beliefs and goals.
Although having PSTs complete tasks involving non-traditional mathematics problems has been shown to have some positive changes (Namukasa et al., 2009), other interventions containing narrative rehabilitation and bibliotherapy have also led to such positive changes. Narrative rehabilitation and bibliotherapy involve having the participants create narratives and use this as a way of therapy to correct a potential issue.

The purpose of Lutovac and Kaasila’s (2011) case study was to describe, in an exhaustive way, how narrative rehabilitation and bibliotherapy implemented during a mathematics education course enabled the development of reflection in mathematical identity work for one student, Ulla. Ulla was a student who started her teacher education program with negative views of mathematics due to experiences in secondary school. To see how narratives enhanced Ulla’s view of mathematics and of teaching, the researchers collected a mathematics teaching portfolio and conducted a narrative interview after Ulla completed a mathematics education course and participated in a four-week teaching practice session. Results indicated that Ulla underwent a positive change in her view of mathematics and in her view of herself as a mathematics teacher after partaking in narrative rehabilitation and bibliotherapy during the education course. Through the analysis of the interview, the authors were able to conclude that narrative rehabilitation and bibliotherapy helped in managing and reshaping Ulla’s negative experiences.

In a similar study, Lutovac and Kaasila (2013) compared a course in Finland and a course in Slovenia. In Finland, PSTs participated in a single identity-focused mathematics education course involving narrative rehabilitation and bibliotherapy along with a teaching practice session. In Slovenia, PSTs participated in three mathematics education courses, one focusing on mathematics concepts, one on methodological
principles, and one on developing mathematical thinking. From the results, the researchers concluded that the Finland participants all discovered a solution in learning to become a mathematics teacher. On the other hand, the Slovenia participants all maintained fears and failed to make decisions about their future-oriented identity. Thus, participating in a more identity focused education course led to more positive future-oriented identity for PSTs than that of skills, knowledge, and attitude focused courses.

The above studies provide a great deal of information regarding identity in relation to mathematics of both preservice and in-service teachers. Findings suggest that regardless of category, teachers, family, and peers greatly influence teachers’ positive and negative experiences in mathematics; an inverse relationship can exist where teachers possess negative mathematical identities but still exert a great amount of effort to ensure their students have more positive experiences; shifts in identity can occur as a result of completing mathematics methods courses or non-traditional mathematical tasks; narrative rehabilitation and bibliotherapy can evoke change in mathematical identity; and identity focused education courses can lead to more positive mathematical identity than that of a course focused on skills and knowledge. Again, some of the studies focus only on particular facets of identity. These studies of mathematical identity in PSTs and in-service teachers demonstrate the potential for affecting students’ view of themselves in relation to mathematics in a positive way as well as having positive effects on teaching. However, the literature is missing studies that examine and intervene on identity earlier in PSTs’ teacher education program. While these studies provide insight on identity and how to shift identity, influences of an earlier implementation of an intervention are unknown.
Methods Courses versus Content Courses

Most research focusing on identity in relation to mathematics of PSTs, including the studies presented above, involve observations and research on the effects of methods courses in changing students’ attitudes, beliefs, anxiety, and efficacies relating to mathematics and to teaching subjects such as mathematics and science. To add to the studies above and to demonstrate this idea further, Bintas (2008) found that a mathematics methods course focusing on kindergarten mathematics helped to change PSTs’ negative attitudes towards mathematics. One participant’s statement suggested an increase in interest for the subject after completing the methods course. Researchers have also found methods courses to enhance PSTs’ efficacy and beliefs on the integration of mathematics and science (Sackes, Flevares, Gonya, & Trundle, 2012). However, mathematics methods courses generally follow the required mathematical content courses. Hence, PSTs’ beliefs that are rooted in their experiences as students continue to influence the PSTs’ knowledge of mathematical content presented primarily during their content courses. If PSTs hold negative beliefs and attitudes towards mathematics while completing mathematical content courses, not only might students think of the class as not valuable, but also the knowledge and understanding taken from the courses may not be adequate for teaching. “Often, efforts to change prospective teachers’ beliefs are initiated in methods courses after subject matter courses have been completed and come too late to support them in developing beliefs that will help them to develop a deep understanding of fundamental mathematics” (Ambrose, 2004).

Universities generally structure mathematics content courses in a similar manner to high school courses and often include traditional teaching practices (McDuffie &
Graeber, 2003). Although there are many publications that stress using reform-methods in college level instruction (e.g., NSF, 1993), many instructors continue to use traditional methods that include lecture or drill and practice. These content courses taught with traditional methods may fail to change PSTs’ beliefs about mathematics. Rather, student autonomy, conceptual thinking, active participation, and meaningful tasks – properties of reform-based mathematics – can help improve students’ attitudes towards mathematics (Stipek, 2002; Turner, Meyer, Midgley, & Patrick, 2003; Newton, 2009). PSTs who already do not identify with the subject of mathematics are not likely to change if instruction remains the same. Thus, rather than implementing identity exploration tasks during a mathematics methods course to enhance mathematical identity of PSTs, it may be beneficial to implement such exploration tasks in content courses. This might not only help to transition content courses away from traditional practices, but also it might influence PSTs’ mathematical identity at an early stage of their teacher education program.

Therefore, one significant gap that appears in the literature focusing on the identity of PSTs in relation to mathematics is the implementation of an intervention during an initial mathematics content course. The majority of past studies include interventions that researchers implemented during grade school or during a mathematics methods course or teaching session, or they involve interventions that focused only on a particular facet of identity as the studies in this literature review illustrate. While any attempt at changing identity of teachers to being more positive is highly regarded, an earlier implementation may provide more benefits for PSTs. For instance, it might allow for more time while completing their degree to continue to improve their relationship
with mathematics. Other potential benefits may include more of a decrease in mathematics anxiety, a choice to take additional mathematics content courses to increase content knowledge in an area that they may be lacking, and an increase in motivation to promote positive mathematical identity in their own future students. Multiple studies have looked at the effects additional mathematics content courses have on PSTs content knowledge and beliefs about mathematics (e.g., Matthews, Rech, & Grandgenett, 2010; Smith, Swars, Smith, Hard, & Haardorfer, 2012). Results have varied from increases in content knowledge to additional courses not resulting in noticeable differences in knowledge for teaching. Regardless, an increase in motivation to better one’s content knowledge is favorable.

Justification for Study and Research Questions

This chapter outlines the literature on identity-relevant studies of interventions specifically focused on a particular facet of identity. These studies demonstrated the potential for influencing PSTs’ views of themselves in relation to mathematics in a positive way as well as having positive effects on academic performance. Also discussed was the research on mathematical identity of preservice and in-service teachers. A review of this literature revealed that interventions have focused primarily on one specific facet of identity, typically during mathematics methods courses. An earlier implementation that involves shifting mathematical identities of PSTs from negative to more positive may change their perspective on the importance of such content courses as well as motivate the PSTs to continue gaining knowledge of the subject. Also, implementing an intervention that uses the identity exploration principles that are broad reaching in working with what the PSTs find to be salient identity issues may provide
significant results. It is important for teacher education programs to invest in improving PSTs’ relationship with mathematics. The Dynamics Systems Model of Role-Identity acknowledges such improvement and change through exploration that entails dynamic reconstruction of identity in a safe environment (Kaplan, 2014). Therefore, the current study involved implementing an identity exploration intervention early in a teacher education program, specifically during a mathematics content course.

There are countless demands for research concerning the improvement of early childhood and elementary teachers’ knowledge and understanding of mathematics, mathematics pedagogy, and mathematics identity (e.g., Ball, Lubienski, & Mewborn, 2001; Cardetti & Truxaw, 2014; Hill, 2010; Lutovac & Kaasila’s, 2011 Namukasa, et al., 2009; NCTM, 2003). These demands for research along with the gaps that exist within identity literature, lead to the following research question: What patterns of change occur in the mathematical identity and motivation of PSTs’ who participate in a mathematics content course containing an identity exploration intervention, and what is the relationship between PST’s initial identity and subsequent exploration? Thus, this study looks not only at the patterns of change in PSTs’ identity, but also at their motivation to strengthen their mathematics skills by taking additional mathematics courses and/or continuing to learn mathematics through outside resources. This study involved a design-based intervention implemented in a college algebra course specifically designed for education students. The intervention incorporated identity exploration in mathematics and included Kaplan et al.’s (2014) four identity exploration principles and conceptualizes identity using the DSMRI model.
CHAPTER 3

METHODS

This chapter provides a detailed description of the methodology that I used to understand the identity exploration of PSTs in a mathematics content course within a teacher education program. The chapter begins with a statement of the purpose of the study, followed by a description of the research design. This includes the role of the researcher, context of the study, instruments and procedures, data collection, and data analysis procedures.

Research Design

As mentioned above, the purpose of this study was to implement an intervention on PSTs identities in mathematics and analyze its effects on their identities and motivation in hopes of providing insight into PST’s experiences in a mathematics content course and the patterns of change in identity and motivation towards mathematics. The study’s design initially included a design-based collaborative intervention involving the researcher and instructor of a college algebra course. Brown’s (1992) approach that she called “design experimentation” was designed to bridge the gap between laboratory studies and complex instructional interventions. The central idea of design-based research is to design experiments that use new theoretical models with authentic learning contexts (Brown, 1992) and to test design variants for effectiveness on learning (Collins, 1992). Thus, design-based research intends to develop effective learning environments and use such environments to study teaching and learning (Sandoval & Bell, 2004).

Some of the main characteristics of design-based research include understanding the messiness of practice in real-world contexts, flexible design revision, capturing social
interaction, treating participants as co-participants in design and analysis rather than as subjects, and a constant connection of design interventions and theory (Barab & Squire, 2004). In addition, design-based research involves the practitioner and researcher working together to produce change in the context (Design-Based Research Collective, 2003). However, the instructor of the course informed me early in the semester that she would not be available to help in the design of the intervention and entrusted me to create the assignments individually. Researchers warn that without collaboration between researchers and practitioners, an intervention may be unlikely to elicit change in the context (Design-Based Research Collective, 2003; Wang & Hannafin, 2005). Regardless of the instructor’s involvement in the design of the tasks, the intervention aimed to apply the four principles of promoting identity exploration to class assignments as to promote students’ identity exploration and motivation for leaning mathematics.

Using qualitative methods, researchers use the natural settings to study specific topics or phenomena (Hays & Singh, 2012, Creswell, 2014), which allows for emphasis on qualities, processes, and meaning (Lincoln & Guba, 1995). This emphasis then allows researchers to capture rich descriptions. “Being situated in a real educational context provides a sense of validity to the research and ensures that the results can be effectively used to assess, inform, and improve practice in at least this one (and likely other) contexts” (Anderson & Shattuck, 2012). In addition, collecting multiple sources of data allows researchers to find themes across all data sources (Creswell, 2014), providing triangulation and increasing validity and reliability. By focusing on participant’s meanings, a qualitative researcher is able to learn about the problem through participants’ perspectives rather than his or her own perspective. The social constructivist paradigm
assumes that individuals construct meaning and understand the world through lived experiences (Crotty, 1998). This paradigm provided further foundation for the study by setting a goal of capturing and interpreting PST’s views and meanings within the context of their required content course (Creswell, 2014).

As the researcher, I coordinated and conducted all data collection including observations, surveys, interviews, and student assignments. I worked closely with a fellow graduate student who was preparing to teach the course during an upcoming semester in designing exploration tasks for the students. One key advantage to design-based research is the collaboration between the researcher and the practitioner, helping to reduce the gap between research and educational practices. Another advantage is the iterative process. By using multiple iterations, we were able to use prior tasks and assignments throughout the process to improve the design (Anderson & Shattuck, 2012). Because the instructor was not involved in the creation of the tasks, the gap between research and practice was difficult to bridge; however, I used the topics and concepts taught by the instructor in the design of exploration tasks to make connections between the assignments and in-class lectures. The graduate student and I were able to use this iterative process when creating the four exploration tasks. I describe this iterative process below. Prior identity exploration tasks, along with students completed identity worksheets and reflective writings, informed subsequent task design.

The design-based intervention implemented in this study did not follow classic experimental designs. Classic experimental designs use random assignments to control and experimental groups that supports controlling for influential factors (Kaplan, 2014). Rather, this study included these otherwise excluded factors as devices aiding in
explanation. Design-based research has the capability to capture and express the complete story of the iterative design and implementation. Squire (2005) captures the essence of design-based research when stating, “simply measuring for a few variables and ironing out all extraneous variables would miss some of the most important parts of the story, from the perspective of generating better instructional programs and theory” (p. 13). Thus, an important part of this research study was the design of the tasks and the process of designing each subsequent task.

Finally, to determine the effects of the intervention on identity, motivation, and anxiety, the methods must allow for causal conclusions. While causation is a longstanding controversy in qualitative research, some researchers believe that by looking at causal processes that result in particular outcomes, qualitative research can determine causation (Maxwell, 2012).

The nature of causality in social programmes [sic] is such that any synthesis of evidence on whether they work will need to investigate how they work. This requires unearthing information on mechanisms, contexts, and outcomes. The central quest is to understand the conditions of programme [sic] efficacy and this will involve the synthesis in investigating for whom, in what circumstances, and in what respects a family of programmes [sic] work (Pawson, 2006, p. 25).

By providing detailed accounts of the process by which a change occurs, a researcher is able to support the cause of the improvement or change (Maxwell, 2004).

Context and Participants

The study took place in a university located in the northeastern portion of the United States. The student population, approximately 37,000 undergraduate and graduate
students, encompasses a wide range of demographics including ethnicities, SES, and international students. A college algebra course specifically designed for education majors in non-mathematics concentrations provided the students for this study. These concentrations include early childhood/elementary education, special education, secondary social studies, secondary English, and world languages education.

Although the secondary education PSTs will not teach mathematics, I believed exploring and potentially improving their identity in relation to mathematics while enrolled in a mathematical content course might prove to be beneficial. While elementary education PSTs have the highest levels of mathematics anxiety, social sciences majors and humanities majors still have mathematics anxiety levels higher than mathematics and science majors (Hembree, 1990). Although Hembree did not include secondary social studies and English education majors, social sciences and humanities closely relate to these concentrations. In addition, since mathematics is more relevant to the early childhood/elementary education students, comparing the level of impact of an intervention for early childhood/elementary PSTs to that of secondary education PSTs showed interesting differences. The connection from the shared role identity as mathematics students to the different role identities as teachers that the students aim to hold in the future is a theoretical rationale for expecting meaningful differences.

The students involved in the early childhood/elementary education program at the university used in this study are required to take both a college algebra course and a course that focuses on basic arithmetic and geometric concepts for their mathematics content requirements. The college algebra requirement can be fulfilled either through a college algebra course offered in the mathematics department or through a course in the
education department designed specifically for education majors. The students also take a mathematics methods course during their teacher education program. For the secondary education concentrations (social studies, English, and world languages), the only mathematics requirement is the college algebra course either offered in the mathematics department or education department.

The focus of the college algebra course designed specifically for educators is on key algebraic concepts, including polynomial, rational, and algebraic expressions, equations, and inequalities. Students engage in problem solving to build conceptual understandings of algebraic thinking, variables, and functions. Data collection occurred during the fall semester of the 2015-2016 academic year. The class took place during the evening, once a week, for three and a half hours. Data collection began during the third week of class and concluded during the final week of class, providing twelve weeks of data. An adjunct instructor who taught the course multiple times during prior semesters taught the class; however, she was terminating her position as an instructor at the conclusion of the semester. The adjunct instructor’s methods for teaching involved a lecture-style classroom with material presented through PowerPoint slides and occasional class discussions. The instructor took attendance weekly, as it counted towards students’ grades; however, she took attendance during the initial few minutes of class. This led many students to attending only the beginning of class to sign the attendance sheet and hear announcements before leaving. The class originally consisted of 33 PSTs; however, this study only included 24 participants, 16 early childhood education PSTs and 8 secondary education PSTs. Nine PSTs were not included in the study due to withdrawing from the course, not providing consent, or missing a significant amount of data. More
information for the 24 participants is included below in Table 1 under the corresponding pseudonym.

Table 1.
Participant Demographic Information

<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
<th>Gender</th>
<th>Race</th>
<th>Income</th>
<th>Concentration</th>
<th>Year</th>
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<tbody>
<tr>
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<td>M</td>
<td>White</td>
<td>75-100</td>
<td>Social Studies</td>
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<tr>
<td>Alexa</td>
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<td>Freshman</td>
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<tr>
<td>Alice</td>
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<td>F</td>
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</tr>
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<tr>
<td>Annie</td>
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<td>Ava</td>
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<td>F</td>
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<tr>
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<td>F</td>
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<tr>
<td>Cara</td>
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<td>White</td>
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<td>ECE, Special</td>
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<td>20-Oct</td>
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<td>Junior</td>
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<tr>
<td>Sally</td>
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<td>ECE, Special</td>
<td>Freshman</td>
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<td>White</td>
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<td>Freshman</td>
</tr>
<tr>
<td>Sophia</td>
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<td>White</td>
<td>75-100</td>
<td>ECE</td>
<td>Junior</td>
</tr>
</tbody>
</table>

Measure to Ensure Safety of Participants

Prior to data collection, I obtained approval from the university’s Institutional Review Board (IRB). At the beginning of the data collection process, participants signed an informed consent document that outlined the project including uses of data, confidentiality, and released class documents for the study. I provided all participants
with pseudonyms and stored all files using password-protection to protect students’ identities.

**Instruments and Procedures**

This study employed the use of a survey, focus group and individual interviews, identity worksheets, reflective writing assignments, and identity exploration activities.

**Survey**

During the initial class, students consented to the researcher having access to all data collected and to participating in a survey. Students then completed a questionnaire providing demographic information, followed by a survey consisting of 40 statements (see Appendix A). Students completed the survey a second time during the final week of data collection. The survey included statements regarding mathematics anxiety, valuing of mathematics, achievement goals, ability perceptions, intelligence beliefs, self-regulation strategies, and motivation for taking additional mathematics courses. The 40-question survey was adapted from the work of Eccles, Wigfield, and colleagues (Eccles et al. 1993; Wigfield & Eccles, 2000; Wigfield & Cambria, 2010; Wigfield & Meece, 1988), Elliot and Murayama (2008), Dweck and colleagues (Good & Dweck, 2012; Rattan, Good, & Dweck, 2012), and Patrick, Ryan, and Kaplan (2007). Newton (2009) used a variation of Eccles and colleagues’ survey questions with undergraduate students, which was adapted for this study because it was more applicable.

**Focus-Group and Individual Interviews**

The researcher conducted pre- and post- interviews to engage PSTs in conversation about their experience in mathematics, in the semester’s course, and their thoughts of a future in teaching. One focus group consisted of three early childhood/elementary PSTs. All three PSTs participated in the pre-interview; however,
only two of the participants attended the post-interview. A second focus group consisted of two secondary PSTs, one with a concentration in English and the other with a concentration in Spanish; however, because the students did not show up during scheduled times, each pre-interview was conducted individually. In addition, the English PST withdrew from the course, thus the data was not a part of the study, and the post-interview only consisted of the secondary Spanish education student. Willingness to participate in a focus group and times available determined the students selected to participate. The focus group meetings were audio-recorded and transcribed. Pre-interviews took place during the second and third week of data collection, and the post-interviews took place at the conclusion of the course, before finals.

The protocols for focus-group interviews are included in the Appendix B. The researcher designed the protocol questions to guide participants to discuss aspects of the class and prior mathematics classes that influence their self-perceptions, goals, personal epistemology, and action possibilities as seen in the DSMRI theoretical model. The questions pertain to the participants’ role as students and their future role as educators. For example, the question – “What do you think it takes for a student to succeed in math/mathematics class” - guides participants to think about his or her beliefs about knowledge and learning in relation to mathematics. However, since each of the categories in the DSMRI model are related, there could be a great deal of overlap in what each question elicits from students. A question that directs students to think about their self-perceptions may also influence students to discuss epistemological beliefs, purposes or goals, or action possibilities. The following table provides a breakdown of the
questions pertaining to the constructs of the DSMRI model with regard to participants’
student role, teaching role, and the course.

Table 2.
*Specifications for Focus-Group Interview Questions*

<table>
<thead>
<tr>
<th>Questions Regarding:</th>
<th>Self-Perceptions</th>
<th>Purpose &amp; Goals</th>
<th>Epistemological Beliefs</th>
<th>Action Possibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Post</td>
<td>Pre</td>
<td>Post</td>
</tr>
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<td>1, 2, 3, 4, 5, 8, 9</td>
<td>1, 2, 3, 4, 5, 6, 7, 9</td>
<td>1, 2, 3, 4, 6, 7, 9</td>
</tr>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Teaching Role</td>
<td>3, 8, 9, 10, 11, 12, 13</td>
<td>5, 8, 9</td>
<td>3, 8, 9, 10, 11, 12, 13</td>
<td>5, 8, 9</td>
</tr>
<tr>
<td>Content Course</td>
<td>4, 5, 7</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
<td>4, 5, 7</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9</td>
</tr>
</tbody>
</table>

*Identity Worksheets*

Students completed identity worksheets regarding their roles as mathematics
students at the end of each class in which they completed and/or submitted an exploration
task, resulting in four completed student-centered worksheets. They also completed
identity worksheets regarding their roles as future teachers at the beginning and end of
the data collection process. Participants turned in both the exploration tasks and
worksheets to the researcher before leaving class. For the worksheets pertaining to a
PST’s role as a mathematics student, participants wrote at least one salient belief, at least
one salient goal, at least one salient aspect of himself or herself, and at least one action
they took during that day’s class (see Appendix C). Each student also provided
information on how central he or she felt each component was to himself or herself and a
mathematics student at the time. The worksheets pertaining to a PST’s role as a future teacher asked each participant to repeat the process of writing beliefs, goals, self-perceptions, and action possibilities he or she holds for his or her future teacher role. These worksheets were structured to assess the DSMRI components and its potential change following exploration.

*Reflective Writing*

After each class, students completed a weekly journal where they reflected on the course/assignment that week. The students completed the assignment using the online interface for which both the instructor and researcher had access. The reflective writing assignments prompted students with the following directions and questions:

Please take a moment to think about the following questions. Write a response to one or more of the questions that you feel are appropriate in reflecting on this week’s class. You may also engage in free writing about your emotions and experiences in mathematics.

1. What about this week’s class/activities did you find most relevant to your life? Please explain.

2. What, if anything, about this week’s class/activities do you feel made you question who you are as a mathematics student? For example, think of the questions you answered about your goals, beliefs, personal characteristics, and actions as a mathematics student. Would any of your answers change because of this week’s activities? How and why?

3. What about this week’s class/activities did you find most relevant to your future as a teacher? Please explain.
(4) What, if anything, about this week’s class/activities do you feel made you question who you will be as a future teacher? For example, think of the questions you answered about your goals, beliefs, personal characteristics, and actions as a future teacher. Would any of your answers change because of this week’s activities? How and why?

These questions should have promoted identity exploration due to encouraging students to see the relevance in the week’s content/class and contemplate how their feelings as a mathematics student and/or as a future teacher have changed due to the class/activities. More identity exploration should have occurred during the weeks for which students complete the identity exploration tasks. The subsequent occurrence of the identity worksheets - which helped students to think about their beliefs, self-perceptions, goals, and actions - and the reflective writing encouraged students to further explore their identity in relation to mathematics and reflect on changes that have occurred throughout the semester’s course, hence constituted scaffolds. The reflective writing assignments were private, meaning that only the instructor and I could view them, providing a sense of safety. Triangulation of the reflections, worksheets, and interview data ensured validity.

Observations

I conducted weekly class observations and took field notes on the class lectures, focusing on both the instructor and PSTs. These observations also included any class activities or time spent on the identity exploration tasks and assignments. In addition, I collected notes from the planning sessions where I collaboratively designed the identity exploration tasks with the graduate student previously mentioned.
Identity Exploration Tasks

With a fellow graduate student, I designed identity exploration tasks for the students to complete. I individually designed the first exploration task and discussed the task with the instructor prior to the start of the course. The instructor of the course did not have any problems or suggestions for the first exploration task, but did ask how she should grade the tasks. I explained that she should grade student work for mathematical accuracy and encourage students to reflect more when necessary. The instructor later informed me that she graded the assignments based on completion; therefore, I graded the remaining three exploration tasks before returning them to the instructor. I designed each subsequent task in collaboration with a graduate student and collected notes from the meetings. Information pertaining to the prior task(s) informed the creation of each subsequent task. This information included reflections on the observations taken during class, reflections on past tasks, and on the students’ reflective writings from throughout the semester. Each task involved the four principles of the exploration theory presented in the theoretical framework including promoting relevance, triggering exploration, facilitating a sense of safety, and scaffolding exploration. A description of each task along with a detailed explanation of how the four components of identity exploration are included in each task is below. The four exploration topics included linear functions, function transformations, quadratic equations, and systems of equations.

Design of Identity Exploration Tasks

Initially, the instructor of the course and I were to collaboratively design the identity exploration tasks together during meetings so as to design tasks that we both felt would promote relevance, trigger exploration, provide a sense of safety, and provide
scaffolding. However, the instructor of the course informed me early in the semester that she would not be on campus nor have time to meet to give input into the design of the exploration tasks. Therefore, I created the four exploration tasks throughout the semester, often discussing ideas with another mathematics education graduate student. This particular graduate student holds a license in teaching secondary mathematics, and she was preparing to teach the course during the upcoming semester. She also was familiar with the theoretical framework on identity and identity exploration. When grading the first exploration task, the instructor gave students full points if attempting each question, regardless if their mathematical ideas were correct or not. Therefore, to promote students to put time and effort into the assignments, I graded the remaining three exploration tasks and gave the graded work to the instructor before the upcoming class. To design each subsequent exploration task, we used the previous explorations as well as students’ responses to the exploration tasks in the reflective writing assignments.

The four exploration topics included linear functions, function transformations, quadratic equations, and systems of equations. These four topics followed the main concepts covered in the course and were spaced evenly throughout the semester. However, all of the concepts are important for the PSTs to learn. Not only do all PSTs have to pass a mathematics exam for certification, these four topics are relevant to what the PSTs will teach in early grades and secondary grades. The Common Core State Standards list standards specific to each grade level and group the standards into categories (CCSS, 2010). Two such categories for mathematics are “Operations and Algebraic Thinking” and “Measurement”. Within the standards of “Operations and Algebraic Thinking” and “Measurement” for grades K-4, students are expected to gain
familiarity with multiples and factors, analyze and generate patterns, and represent and interpret data including graphs. All of these standards and competencies are included within the four concepts used in the exploration tasks. In addition, Shulman’s (1986) argument of vertical curriculum knowledge holds teachers accountable for knowing slightly more advanced concepts than that of which they teach in a given year, making these four algebraic concepts important for PSTs to learn and understand. For the secondary education students (English, Social Studies, and Language education), the CCSS list standards that require students to be able to integrate quantitative and technical information expressed in works with a visual representation such as a diagram or graph (CCSS, 2010), again showing the relevance of PSTs learning such mathematical concepts.

*Linear Equation*

The first exploration task involved having students create two graphs of linear functions. For the first graph, each early childhood education student was to create a linear graph that represented his or her opinion on the relationship between a teacher’s mathematical knowledge and a teacher’s success. For the second graph, each early childhood education students was to create a linear graph that represented his or her opinion on the relationship between how much a teacher likes mathematics and a teacher’s success in teaching mathematics. The secondary education students had slightly different variables as to promote relevance to their future teaching careers. For the first graph, each secondary education student was to create a graph representing his or her opinion on the relationship between mathematical knowledge and a teacher’s success in making connections between subjects. For the second graph, each secondary education student was to create a graph representing his or her opinion of the relationship
between how much a teacher likes a subject and a teacher’s success in teaching. Participants then elaborated on what they learned about themselves from completing the exploration task.

I designed the first exploration prior to starting data collection and designed it to include promoting relevance, triggering exploration, providing a sense of safety, and providing scaffolding. The task promoted relevance by having the participants use teaching and relate teacher knowledge of a subject to success in teaching. When elaborating on what they learned about themselves from completing the activity, students could experience a discrepancy between their graph and their identity as a student or future teacher, triggering identity exploration. Some students (40%) in the study experienced such discrepancies. For example, Chloe wrote,

The graphs I created tell me that it may be difficult for me to be a successful mathematics teacher (for third and fourth [grades]) because I do not like it and I am not good at it. When I student taught in kindergarten, I had so much fun with the mathematics lessons and so did the students. I hope I can do the same with the higher grades. However, just because you like the subject doesn’t mean you will be successful as a teacher (Chloe, Exploration 1, 9/22/2015).

Chloe was experiencing a discrepancy between her current level of knowledge and her belief that the more knowledge you have, the more successful you will be as a teacher. In relation to the DSMRI model, Chloe experienced tension between her self-perceptions and her ontological beliefs. When reflecting on the first exploration task, Chloe wrote, “This helped me realize that I must focus on the benefits of mathematics and try my hardest to better myself” (Exploration Reflection, 11/20/2015). This discrepancy then
made Chloe realize that she should better herself as a mathematics student to be successful teaching higher grades in early childhood education that she was not comfortable with at the time. This tension prompted Chloe to consider a goal and action possibilities. Similarly, Jill experienced a discrepancy with her graph. Based on the graph that Jill created, she felt that her dislike for mathematics could influence her abilities as a teacher. Jill wrote, “I may be a terrible teacher in the future” (Exploration 1, 9/22/2015). Unlike Chloe, Jill did not use this discrepancy to explore possible actions she could take to solve the discrepancy, indicating that Jill may have needed scaffolding.

Some students did not experience the task as an exploration trigger. For example, Kyle drew the following graph (See Figure 1).

![Figure 3: Kyle’s Exploration Task 1 Graph 1](image)

In the graph, Kyle’s horizontal line shows that regardless of the amount of mathematical knowledge a teacher has, he or she will only be moderately successful in teaching. He elaborated on this graph and his beliefs by stating,
The linear functions represent my relationship with mathematics pretty well. I have never enjoyed it. I do not believe that it will be critical to my success as an early childhood education teacher. The foundations are already there from high school math. I have the knowledge to teach 6 year olds the mathematics they need to learn (Kyle, Exploration 1, 9/22/2015).

Since Kyle did not feel mathematical knowledge had any effect on success in teaching, he did not experience exploration of his identity because he felt he already had an adequate foundation in the mathematics he will one day teach. In addition, four participants (17%) did not create linear graphs for the task, indicating that they were not comfortable with the concept of linear function prior to completing the assignment.

Although the instructor spent a week covering linear functions and graphs, without having an understanding of the concept used in the exploration, some students struggled to complete the task.

To facilitate a sense of safety, students formed groups of two to four students and took the first ten minutes of class to discuss what they wrote for their exploration tasks or to ask a friend for help if they were struggling to complete the task. Having students share their experiences in small groups of their choosing rather than through whole class discussions helped them to feel less anxious and provided peer support when needed.

After the groups discussed their graphs, the class came together to discuss as a whole some of the similarities and differences they came across in their work. One group of students provided an example of the differences in opinions of whether or not a teacher must like a subject to be successful. Some student in the group thought teachers needed to like a subject and others felt teachers could teach anything regardless of how much
they like a subject. Another group then gave an example of the differences of opinions on the level of knowledge needed to teach a subject. Some students felt you should be fluent in a subject regardless of the level taught while others felt you do not need to know any more than the level you will be required to teach.

The task included scaffolding exploration by providing guiding suggestions and questions for the participants. In addition, the instructor and I told students that they could ask for additional help if struggling and we would provide additional guidance. However, none of the participants reached out for additional help on the first exploration task.

After collecting and reviewing students’ first exploration task, both the graduate student and I felt the task provided too much information and the questions should remain more open ended. Rather than providing students with the x- and y-variables for their linear functions, the task should leave both variables open or only provide one variable and allowing students to create the other variable. When discussing the task as a whole class, some students shared that they believed there are more factors that influence success in teaching than just content knowledge. Thus, by leaving the questions more open ended, students would be more likely to create unique responses that they perceive as more self-relevant. Finally, students did not appear to think deeply about the mathematical concept of linear functions when completing the task; therefore, for the second task, we added an additional question to promote student thinking of the concepts used in the exploration task.

Function Transformations

The second exploration task involved having students complete two separate problems involving function transformations. For the first problem, students were to
provide both x- and y- variables given a graph and discuss what would cause the graph to shift left and right (see appendix). As discussed above, we designed the exploration to be more open ended for students to use variables that they felt were more self-relevant, thus incorporating the principle of promoting relevance. For the second problem, students were to provide both x- and y- variables, create an original graph, shift the graph vertically up and then down, and discuss what would cause the shifts to occur. Again, students completed a question asking them to elaborate on what they learned about themselves from completing the activity, incorporating the second principle of triggering exploration.

During the class in which students were turning in the second exploration task, the instructor was also giving an exam. This put time constraints on the amount of time available for students to discuss the exploration in groups. Thus, to save time but still provide a sense of safety, I asked if any student would be willing to volunteer to provide an example of the variables used for the exploration. Sally volunteered and told the class her examples. I asked for another volunteer, but when none of the students volunteered, I did not push students to discuss their examples further.

Finally, the order of the questions provided students with scaffolding. At the top of the exploration task, we provided an example of a horizontal shift. This was to help students who may have struggled in understanding the concept of transformation in class have a visual representation and explanation of a horizontal shift. Then, the first question students had to complete involved a horizontal shift. We provided the three graphs for the first problem (see Exploration Task 2 in Appendix). The middle graph represented the original graph. This graph was in the shape of a parabola. Thus, the relationship
between the variables used should rise and then fall, creating a parabola. Then, the two graphs on the left and right involved shifting the parabola horizontally. Again, we provided the graphs of the parabolas that demonstrated the horizontal shifts. Finally, for the second problem, we left all three graphs blank. Students were to create their own graph of a function (not necessarily parabolas) and correctly draw vertical shifts, up and down. In addition, to promote students reflecting back on the concepts, we asked students to describe how the graphs aided in understanding function transformations.

Most students were able to apply the correct mathematics when completing the assignments, but some students (35%) had errors in the mathematical concepts when completing the assignment. For example, Cara, Alice, Kyle, and Jessa all made mathematical errors. Cara correctly completed the first problem but switched her independent and dependent variables in her explanation. However, she was still able to correctly draw and discuss the vertical transformations. Like Cara, Alice was able to discuss vertical transformations correctly but was unable to draw the graphs representing the transformations. Kyle also had difficulty in the second problem, specifically with drawing the vertical shifts in the graphs. Rather than shifting the graph up and down, he changed the steepness of his linear line, changing the slope. Jessa was able to draw her transformations correctly but her explanations did not properly represent the shifts.

The x-variable is the amount of time spent at work. The y-variable is the amount of time spent with family and friends…The vertical shift down may occur because of how busy my job is. If I am scheduled more hours because of events going on such as wedding, catered events, the less time I have to spend with family and friends. The vertical shift up may occur because we have more staff, other people
are able to work more hours, or we do not have as many events planned.

Therefore, I am able to spend more time with people (Jessa, Exploration 2, 10/6/2015).

The occurrences that Jessa described effect the amount of time spent at work (her x-variable). These occurrences would cause the shift to move horizontally left or right rather than vertically up or down.

Some, but not all, students (45%) experienced the task as an exploration trigger. For example, Jessa felt that the graphs she created indicated that she needed to find a balance in managing her time, which made her explore the actions she perceived possible as a student. “As a mathematics student, I know that mathematics does not come as easily. So, I will need to spend more time on homework and less time in leisurely activities in order to be successful” (Jessa, Exploration 2, 10/6/2015). Some students (59%) also elaborated on how the assignment aided in their understanding of transformations. For example, Caitlyn wrote, “I had to apply function transformations to real life situations in order to understand them a little. The graphs are helping me interpret things that I can relate to” (Caitlyn, Exploration 2, 10/6/2015). Another student wrote:

These graphs help me understand the concept of transformations with functions by showing me real life examples of a graph. It helps to see a real life example for me to understand the applications of functions in the real world (Kat, Exploration 2, 10/6/2015).

However, because some students struggled with properly implementing the mathematical concepts, we felt that a balance between providing more structure and leaving a problem
more open-ended would be beneficial in the design of subsequent tasks. Thus, for the third exploration, we provided students with the x-variable of a function and left the y-variable open. We also added the words “aspect of yourself” to encourage more students to think deeper about self-aspects for the assignments and increase the exploration triggers.

**Quadratic Equations**

The third exploration task used the mathematical concept of the properties of quadratic functions. Prior to completing the task, the instructor taught students how to find maximum and minimum values, zeros of functions, the vertex of a quadratic function, and how to graph quadratic functions. Therefore, the exploration task involved having each student select a y-variable representing an aspect of his or her self that would change over time to form the shape of a quadratic function containing a maximum value. The graph also had to have two real zeros. Again, by allowing each student to select a y-variable that represented an aspect of his or her self, we incorporated the principle of self-relevance. Next, students had to explain the meaning of the vertex, explain the meaning of both zeros, and explain how the task aided in their understanding of the concepts of vertex and zeros. As an optional question for extra credit, students could also complete a problem that involved finding a self-relevant example of a quadratic function that would not have any real zeros. They had to explain the example and explain why it would not have any real zeros to receive the extra credit point.

Each student completed a question asking how the graph related to his or herself and what he or she learned about his or herself from completing the activity, incorporating the second principle of triggering exploration. Some students (50%) used examples they found self-relevant in the second exploration but did not necessary include
a self-aspect. By adding in the words “aspect of yourself,” more students used self-aspects than in the previous exploration (64%). For example, in the second exploration task, Alexa compared the number of assignments students have to the number of hours dedicated to the assignments. In her third exploration, Alexa compared the weeks in the semester to the level of stress she feels. Similarly, Alice compared number of hours of sleep to drowsiness in her second exploration task, then compared days spent in class to the level of interest she has in the subject for her third exploration task.

To facilitate a sense of safety, we gave students the first fifteen minutes of class to talk to a peer about the exploration task and make any corrections they needed to make based on the conversation with their peers. After the fifteen minutes, Jill went to the board to explain her example she made for the extra credit problem. Prior to class, Jill had me look over her exploration. I was impressed with Jill’s work and asked Jill if she would be comfortable going to the board and explaining her example. She said she had no problem showing her peers the example she created. She drew her example using a parabola to represent the relationship between her age and financial stability. She explained the decrease as going from parental support to being on her own, the minimum value as her current position in college, and the increase in the graph as making money once securing a full time teaching position. She also explained why her graph had no real zeros. Jill went on to say she understands mathematics so much more when it is put into a real-life situation as in the exploration task but she struggles with memorizing formulas and procedures. She also stated that she would use such real-life example in her own classroom. A short discussion followed Jill’s example. Some students said that they could relate and found Jill’s example to be helpful. Others found that they could not use
the example towards their own lives. For example, Justin said he was in debt because of school so he explained that the example would not work for his life. Jill responded to Justin and said that she did not consider school debt as financially unstable but would consider the zero as being homeless, which she has never been and hopes never to be.

To provide scaffolding, I informed students that I had an example already created and would send it to them if they needed additional guidance. When students accessed the third exploration task online, the instructions included, “If you need additional guidance or find yourself struggling and need an example, feel free to email Kayla” followed by an email address to reach me. Jessa, Kat, and Ava reached out after attempting the task on their own and I sent them each the example that I found to be self-relevant and incorporate an aspect of myself (see appendix). By providing the example only to students who reached out through email, students who had the ability to create a graph on their own were able to do so without being influenced by an example.

*Systems of Linear Equations*

The final exploration task involved students working in pairs to create a system of linear equations. With a partner, students had to choose a pair of variables that represented an aspect of themselves and that created a linear graph. Again, allowing students to select their own variables incorporated the principle of promoting relevance. Once students agreed on both an x- and y-variable, they had to individually graph the function, locate two points on the graph, and find the equation of the linear function. Then, students had to graph both his or her own graph and his or her partner’s graph on the same coordinate plane. After graphing the system on one coordinate plane, students had to find the intersection and explain the meaning of the intersection. Students then answered the questions, “What does the graph tell you about yourself, and what does the
graph tell you about your partner? Please Explain.” These questions incorporated the second principle of triggering exploration. Again, we used the words “aspect of yourself” to encourage students to use a self-aspect in the variable selected. For example, Jessa and Sally worked as a pair and Sally wrote, “My graph tells me that I study and grasp information slower than [Jessa]. With more hours of studying, I can do as well as her” (Sally, Exploration 4, 11/17/2015). When comparing herself to Jessa, Sally recognized the possibility of putting more time and effort into the class if wanting to keep up with her peer.

To provide a sense of safety, the instructor and I allowed students to use the first part of class to complete the assignment and allowed them to select their partners. We also were available to answer any questions they had while working on the assignment. For some students, when graphing both functions on one coordinate plane, the graphs would run parallel, thus not intersecting. When this happened, students would ask the meaning behind not having an intersection, and the instructor or I would help them in remembering what it meant when two lines were parallel. Some students also had lines that were identical and again, we would provide guidance on the meaning behind coincident lines. In addition, for students struggling to start the exploration task, I had an example available. I created the example with the graduate student who helped design the exploration tasks. The example included comparing the number of years in graduate school to the number of manuscripts submitted for publication (see appendix). We created this example because while it had relevance to our own lives, it had no relevance to the students in the class; but it would help show students who were struggling with a system of equations using a real-life example. Amanda and Matt, Jill and Alexa, Ava and
Annie, and Scarlett and Jazmyn all asked to see the example after struggling to start the assignment, indicating that they needed more scaffolding when completing the task.

Data Analysis

Data analysis occurred in stages. Stages included preparing the data, developing and testing a coding scheme, coding all data, and drawing conclusions and conducting case comparisons. Further detail for each stage appears below.

Stage 1: Preparing the Data

The first stage of data analysis involved transcribing the recorded focus group and individual interviews and clearing all identifying information from all data sources, including surveys, interviews, identity worksheets, reflections, identity exploration tasks, and observation notes. It also involved analyzing the survey data. Since the sample size is small, to analyze the survey pre- and post-data, I compared mean scores for each question from the pre- and post-surveys and compared mean scores for each composite score based on the aspect measured. After calculating the mean scores, t-tests determined whether the differences in mean scores for each item were significant. Changes in the mean scores determined if the participants’ anxiety, values, goals, and ability perceptions increased or decreased over the course of the semester.

Stage 2: Developing and Testing a Coding Scheme

The second stage of data analysis involved developing a coding scheme, using both inductive and deductive coding (Merriam, 2009), and using a sample of the data to test the coding scheme. The deductive codes came from the theoretical framework and DSMRI model. Throughout the process of data collection and data analysis, I kept and updated a codebook that included codes, definitions, and examples from the data. Inductive codes created and revised throughout the analysis were also included in the
codebook. Below are the codes from the DSMRI model and a full list of codes is included in the codebook (see appendix).

Codes established from the DSMRI model included self-perceptions (as learners and as future teachers) personal ontological and epistemology (about the nature of mathematics, students and learning, and teaching practices), purpose and goals (extrinsic, mastery, social, other, and as a future teacher) and action possibilities (as a current student and as a future teacher). In addition, the codebook included codes for identity exploration, perceived relevance, and perceived relevance for teaching, prior experiences, experiences in class, mathematics anxiety, personal background, and value. The codebook originally included codes for student ego-goal, scaffolding, and safety; however, the codes remained unused when coding the documents. Students did not self-report wanting to outperform others in their reflective writing, worksheets, nor exploration tasks and did not self-report scaffolding nor feeling a sense of safety. Examples of codes are below.

Self-perceptions: Statements relating to self-perceptions included those that referred to a participant’s perceptions, beliefs, and feelings about himself or herself as a learner or future teacher. Examples for self-perceptions as a learner or student in mathematics included, “I am doing better and am able to understand the material more” (Alexa), “I have learned that I am afraid of failure and being wrong” (Scarlett), and “I can achieve this semester” (Sophia). Examples for self-perceptions as teachers included, “I am nervous about being a mathematics teacher but I am ready for the challenge” (Alexa) and “I am feeling better about teaching math” (Sophia).
Personal epistemology: Statements relating to personal epistemology included those that referred to beliefs about the nature of knowledge, teaching, and learning. An example for teaching beliefs included, “As a teacher you get to have fun and everything isn’t so strict all the time” (Ava). An example for learning beliefs included, “All students learn differently. No two students are the same. Some students will be content with the lesson after one example, while others may need to see three examples” (Kat). An example for beliefs about the nature of mathematics included, “Mathematics is a subject that needs a solid foundation. If you cannot do basic algebra, you won’t be able to get any further because the more complex mathematics often use algebra” (Chloe).

Purpose and Goals: Statements relating to a student’s sense of purpose or goals included those that referred to the different reasons people advocate for carrying out certain activities. An example for extrinsic goals included, “My motivation is really just that I want to pass and maintain a good GPA” (Chloe). An example for mastery goals included, “I want to make sure that I understand all of the concepts I need to teach well” (Jessa). An example for social goals included, “I'm excited to strengthen my skills in college algebra as much as I can to…prove myself a strong student” (Sally). Finally, an example of a goal labeled as other included, “[I] want to help overcome my low confidence of my mathematics skills” (Alexa). Teaching goals included statements that related to a student’s sense of purpose or goals in relation to teaching. An example of a teaching goal included, “It is my goal to instill from the beginning that mathematics should not be feared” (Molly).

Action Possibilities: Statements relating to a student’s perceived action possibilities included those that referred to students perceived options for actions in a
given situation. Examples of action possibilities as a current student included, “I know I did poorly on my first quiz, but I am going to continue to study and work hard” (Amanda) and “I have to sit down and take up my personal time to review the material I didn’t understand the first time around” (Sally). An example of action possibilities as a future teacher included, “I will have extra worksheets, after school assistance, and review previous chapters before moving onto something new” (Chloe).

The graduate student researcher who helped design the exploration tasks coded a subset of the data using the codebook to ensure reliability of coding. We randomly selected 35 documents (10%) including exploration tasks and reflective writings using a random number generator. We coded the first five documents together as a training. Then, we coded the remaining documents separately. Initially, reliability was 86%; however, in the case of discrepancies, we engaged in in-depth dialogue until reaching a consensus. Thus, reliability reached 100%. We also coded ten worksheets (10%) including both student-centered and teacher-centered worksheets. Again, reliability reached 100%.

**Stage 3: Coding All Data**

I coded the interviews, identity worksheets, reflections, identity exploration tasks, and observations using the developed codes and Atlas.ti software designed for qualitative research. In instances where new codes or themes emerged, I updated the codebook and re-checked all documents previously coded and analyzed for consistency.

**Stage 4: Drawing Conclusions and Conducting Case Comparisons**

Stage four of the data analysis included constructing themes from the codes and conducting case comparisons. These case comparisons helped to find overarching themes across participants pertaining to identity exploration and their experiences in the
mathematics content course as well as the relationship between initial identity and exploration. Comparing pre- and post-interview data, looking at identity worksheets and reflections across time, and comparing pre and post-survey data aided in answering the research question by determining the patterns of change in identity and motivations of the PSTs. Comparing initial survey responses, initial worksheets, initial reflections, and pre-focus group interviews to coded data representing students’ involvement in identity exploration demonstrated the relationship between initial identity and exploration.
CHAPTER 4

RESULTS AND DISCUSSION

This study sought to implement an intervention on early childhood and secondary PSTs identities in mathematics and analyze its effects on their identities and motivation. The findings below are in multiple parts. First, I will discuss the patterns of change that emerged in both the early childhood participants and the secondary education participants. Then, I will summarize the themes that arose across cases, indicating the relationship between PST’s initial identity and subsequent exploration. Finally, I will present the results from the pre- and post-surveys.

Patterns of Change in Mathematics Identity and Motivation

The analysis of the data collected from the 24 participants of this study revealed that five patterns of change occurred. Specifically, the early childhood PST’s experiences fell into three categories, while the secondary PST’s experiences fell into two categories.

*Early Childhood Education Participants*

Analysis of student worksheets, reflective writings, exploration tasks, and interviews indicate that most early childhood education students made connections between the mathematical concepts and aspects of their lives and identities. Many of these connections indicate the self-relevance a student perceived between mathematics content and his or her self. Data collected over the duration of the semester suggested three patterns in early childhood education students’ identity exploration as a mathematics student. Broadly speaking, three early childhood education students appeared to be *unchanged*, indicating that they did not, or rarely, engaged in significant
gathering, questioning, and reflecting on self-aspects related to their identities as students. Six early childhood education students seemed to have *nominal positive change* in their mathematical student self-aspects and slightly engaged in gathering, questioning, and reflecting on their identities as mathematics students. The remaining seven early childhood education students appeared to have *notable positive change* in their mathematical student self-aspects and engaged significantly in gathering, questioning, and reflecting on their identities as mathematics students. For many of the participants, the experiences in the class and intervention led to changes in self-perceptions, attitudes, goals, beliefs, and/or motivation towards mathematics and mathematics learning. I categorized the PSTs that changed in only one self-aspect of identity as nominally changed; however, as explained below, Mia experienced changes in two categories. Mia’s changes in the two categories were minimal, meaning she did not experience significant changes on identity, and thus categorizing her as nominally changed. I categorized the PSTs who experienced significant changes in two or more self-aspects as notably changed.

Table 3. *Early Childhood Education Participants Patterns of Change as Mathematics Students*

<table>
<thead>
<tr>
<th>The Unchanged ECE Participants</th>
<th>The Nominally Changed ECE Participants</th>
<th>The Notably Changed ECE Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ava</td>
<td>Alice</td>
<td>Alexa</td>
</tr>
<tr>
<td>Molly</td>
<td>Chloe</td>
<td>Caitlyn</td>
</tr>
<tr>
<td>Sally</td>
<td>Cara</td>
<td>Joan</td>
</tr>
<tr>
<td></td>
<td>Jessa</td>
<td>Jill</td>
</tr>
<tr>
<td></td>
<td>Kat</td>
<td>Kyle</td>
</tr>
<tr>
<td></td>
<td>Mia</td>
<td>Scarlett</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sophia</td>
</tr>
</tbody>
</table>

*Early Childhood PSTs Who Were Unchanged in Identity as Mathematics Students*
The three participants in this category showed little to no changes during the course in the self-aspects that make up their identities as mathematics students and demonstrated little to no identity exploration as mathematics students. Ava entered the class with self-perceptions of being a hard-worker and in week four of data collection, described herself as “someone who is trying to improve on skills that I struggle with [in math]” (Journal 4, 10/2/2015). While Ava did report in the first exploration that she is someone who does not particularly like math, she also reported that she likes to review mathematics topics and fully understand them. This positive mentality appeared throughout Ava’s reflections, worksheets, and explorations and appeared unchanged throughout the semester. Although Ava seemed to report and keep overall positive attitudes, self-perceptions, beliefs, goals, and actions as a mathematics student, she did report that the initial survey changed her perspectives as a student. “Because of this survey and the many low 3’s and 4’s I chose I feel that I have changed my perspective on how I perform in my classes, and will do better in them.” (Journal 1, 9/11/2015). Ava felt she gave initial survey responses that were low. As participants took the survey in the beginning of the semester, it is unknown how Ava would have responded to the other intervention components such as the reflective writings and explorations without the initial survey changing her perspectives. However, this finding indicates that each data collection – in this case the survey – was an intervention on PSTs’ identities as mathematics students. In Ava’s post survey, a few of her responses were higher when a question dealt with value of math, self-perceptions, goals, and action possibilities. The increase in survey responses showed that Ava found mathematics to be more interesting (a two point increase), felt she was better at mathematics (a one point increase), placed
more emphasis on mastery (a two point increase), and felt that it is important to be good at mathematics compared to other subjects (a three point increase). However, Ava also showed decreases in survey responses. The decreases were in value, increasing content knowledge, goals, and actions possibilities. The decreases indicate that Ava likes mathematics less (a one point decrease), is less likely to take additional mathematics courses and use outside resources (both one point decreases), finds mathematics less useful compared to other classes and activities (a two point decrease), and finds the topics covered in class less important to her career (a three point decrease). However, because she showed little to no change in self-perceptions, beliefs, goals, and action possibilities in other data, Ava was categorized as unchanged.

In response to the four identity components in relation to teaching, Ava did not show any significant changes. In both the beginning and end of the semester, Ava felt that in her future career as an early childhood teacher she will be creative and helpful to students and had strong beliefs in needing a fun and positive environment when teaching. However, again Ava reported that the initial worksheet on teacher identity, “made me really think deeper into what kind of teacher I think I will become” (Journal 1, 9/11/2015). Again, this finding indicates that each data collection – in this case the worksheet – was an intervention on PSTs’ identities as mathematics students. Ava only reported reflecting on self-aspects immediately after the initial survey, writing, and worksheet and maintained self-perceptions, epistemological beliefs, goals, and perceived action possibilities throughout the semester. Her self-perceptions as a future teacher remained positive. She reported early in the semester,
As I was writing, I really started to come to terms with how I felt being in my major. I feel even more confident as a future teacher, because given this chance to really sit, think and reflect on the future, it helped me to get a better idea of where my life is heading and where I want it to go (Ava, Journal 1, 9/11/2015). This exploration provides validation and strengthens the commitments that Ava held. Although Ava’s exploration did not lead to changing from negative to positive in terms of identity, perhaps Ava began to strengthen her commitment and alignment within the role identity and integration with other identities. Ava maintained this confidence throughout the course and reported using her confidence when helping her peers who struggled with the content. She also felt she would enjoy her job as a teacher and not mind teaching mathematics to early childhood students. Her goals also remained positive. She wrote about wanting to influence her students, help them when struggling with content, and be able to explain material in steps for students who struggle. Her beliefs aligned with her self-perceptions and goals. Ava’s beliefs including ideas such as teaching is fun but also challenging and rewarding and teachers have to be flexible in how they teach to reach all students. Ava did not express significant identity exploration beyond the first week. At no point in the semester did Ava continue to gather, question, or reflect on self-aspects related to her future as an early childhood education teacher, but rather she maintained positive attitudes, self-perceptions, beliefs, and goals towards her future teaching career.

Similar to Ava, Sally felt the initial survey made her come to some realizations about herself as a student and her future as a teacher. “When answering questions about myself in the survey handed out, I started to realize that I need to strengthen myself as a mathematics student in order to feel extremely confident in my teaching abilities”
Sally also wrote about the initial teaching-centered worksheet completed in the same day. “I found the activity of filling out a questionnaire about myself the most relevant to my life because it forced me to think about myself not only as a future educator but a learner.” However, after the first week, Sally seemed to sustain this idea of strengthening herself as a student and often wrote about her self-perceptions and goals centered on this idea. She often wrote in her reflective journals that she needed to strengthen her algebra skills, become the best student she can be, and improve how she feels as a student in mathematics; yet, she never reported her ability as coming to fruition. She upheld self-perceptions throughout the class about not reaching her fullest potential, struggling with course concepts, and sometimes feeling disappointed in herself. For example, Sally wrote, “Furthermore, I'm a little disappointed because I let content breeze over my head, which typically puts me in a bad position for the quiz, and especially for the final” (Journal 9, 11/6/2015). Again, it is unknown how Sally would have responded to the other intervention components such as the reflective writings and explorations without the initial survey influencing her thought on herself as a mathematics student.

Interestingly, Sally was the only student to show a large improvement in her response to the survey question regarding taking elective mathematics courses to increase content knowledge. Sally originally responded with a two on a seven-point scale, indicating she felt close to a response of “Not at All.” On her post-survey, Sally increased her response to a five, moving her answer closer to “Very likely.” She also increased her response to the question asking about the likelihood of using outside resources to increase content knowledge, going from a pre-survey response of one to a post-survey response of four.
Molly entered the course with a very positive outlook on mathematics. Throughout the weeks, Molly made it known that mathematics was always her strongest and favorite subject, and she did not see that changing. She also kept a mastery goal of learning as much information as possible in the course along with extrinsic goals of doing her best and getting an A in the course. While Molly started the course with a positive relationship with mathematics and maintained that relationship throughout the duration of the course, she did self-report that she found the exploration tasks to be helpful, stating, “[they] gave me the opportunity to see how mathematics can be used in the future and everyday life” (Exploration Reflection, 11/20/2015). She also mentioned the importance of students seeing real world examples, understanding why mathematics is important, and knowing the effects mathematics can have on students’ future, which she felt teachers often overlook in the classroom.

While Molly did not engage in significant gathering, questioning, and reflecting on self-aspects related to their mathematics identity as a student, she did report questioning herself at times in relation to her future in teaching. For example, Molly reported,

This week’s class made me question who I will be as a future teacher. After filling out the survey, I was able to think about future teaching techniques and characteristics of myself as a student, as well as a teacher…Furthermore, after the survey I questioned my goals for future teaching (Molly, Journal 3, 9/25/2015). In this quote, Molly was talking about the first student-centered worksheet that students completed regarding identity as a mathematics student. In providing self-perceptions, beliefs, goals, and actions as a student, Molly conveyed that she began to question who
she would be as a teacher and the goals she will have. Although Molly did not show significant changes in self-aspects as a student, completing the worksheets in class helped her to start the preliminary process of developing her teacher identity. When completing the final worksheet on identity as a teacher, Molly expressed that she felt she still had “a lot to learn” (Teaching-Centered Worksheet 2, 12/1/2015) to be successful as an early childhood teacher. Interestingly, in the pre- and post-surveys, Molly improved in both questions regarding increasing content knowledge by electing to take additional mathematics courses (a one point increase) and by using resources outside the classroom (a two point increase).

_Early Childhood PSTs Who Experienced Nominal Positive Changes in Goals and/or Beliefs as Mathematics Students_

The six participants showing nominal change in their mathematical student self-aspects slightly engaged in gathering, questioning, and reflecting on their identities as mathematics students. These six participants showed changes in particular aspects, but did not show significant changes as a whole in their identities as mathematics students. Three categories split the nominal changes: goals, knowledge of one’s self, and beliefs on importance of math.

_Table 4.
Nominally Changed Categories in Student Identity_

<table>
<thead>
<tr>
<th>Goals</th>
<th>Knowledge of One’s Self</th>
<th>Beliefs on Importance of Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alice Cara</td>
<td>Chloe Kat</td>
<td>Jessa</td>
</tr>
</tbody>
</table>
| Mia | }
Alice, Cara, and Mia demonstrated positive shifts in their goal orientations from the beginning to the end of the course. Alice maintained negative self-perceptions in relation to mathematics and maintained negative beliefs about the nature of mathematics such as mathematics being “so serious” and mathematics having “no room for error”; however, she had a change of goal orientation after the first exploration task. Alice originally held an extrinsic goal of passing the class. After completing the first exploration task, Alice began to shift her goal from being extrinsically oriented to being mastery oriented.

As a mathematics student this activity [Exploration Task 1] made me realize how I feel about taking this class. One of the goals I wrote down was to be able to remember this material. If they’re making me take this class I might as well try to remember what I learn. The reason for saying this is that I’ve taken so many Gen Ed. classes and passed so many exams. But when it came to remembering what I learned, I could only recall a couple facts. So for this class I’m trying to make sure I can take with me more than just a couple facts (Alice, Journal 3, 9/25/15).

After completing the first exploration task, Alice began to change her self-reported goals as a mathematics student on her student-centered worksheets. Her self-reported goals changed from wanting to “simply pass” the class to want to understand the material taught in the class in hopes that she could take what she learned with her after completing the class.

Similarly, Cara had positive shifts in her goal orientation. Cara was a student who remained neutral throughout the duration of the course in her relationship with mathematics as a student. Cara felt she struggled with mathematics, but she also put
emphasis on her beliefs about the importance of all subjects, including mathematics. She also continuously admitted that she needed to work harder in mathematics classes to become a better teacher. For example, Cara wrote, “I will have to work harder in classes (like math) to become a better teacher and gain that interest to better me and my future students” (Exploration Task 1, 9/22/2015). Cara recognized the possibility of putting more effort into changing her relationship with mathematics to better her future as a teacher to early childhood students. The one aspect of Cara’s identity as a mathematics student that changed was her goal. Cara entered the class with wanting only to learn the basics of mathematics that she knew she would one day teach. Starting in the ninth reflective writing, Cara began to shift her goal to wanting to “fully understand what I am learning instead of just learning the basics to the problems” (Journal 9, 11/6/2015). Cara frequently was absent from class and missed many assignments. She was not present during the weeks where students completed the third and fourth exploration tasks and student-centered worksheets. While Cara admitted in her reflective writing that she could not reflect on the in-class activities due to her absences, she felt the homework in the course was making her shift her goals. Although Cara was able to complete homework problems, she began to realize she was missing the deep understanding of what was occurring in each problem and was simply learning the procedural knowledge needed to complete each assignment.

Chloe and Kat both demonstrated gathering information and reflecting on their selves as mathematics students. During her first two reflective writings, Chloe focused more on teaching and prior experiences with mathematics; however, during the third reflective writing, Chloe began to reflect on herself as a student:
While we were answering the survey questions in class this week [Student Worksheet], I thought about who I am as a mathematics student. I have struggled with mathematics for almost 10 years now. It’s very upsetting to me because I do so well in all of my other classes (Chloe, Journal 3, 9/25/15).

Prior to this particular reflective writing, Chloe frequently referred only to the fact that she struggled with mathematics. After reporting that she began to think about who she is as a mathematics student, she started to explore why she faced struggles with the subject. For example, Chloe began to write about self-perceptions such as having no intrinsic motivation, needing to be present in class to learn, not liking to ask questions, and lacking curiosity with mathematics.

I think my biggest issue is I have no intrinsic motivation when it comes to math. I do not wish to explore new ideas, I am not curious how problems work, and it does not bring me pleasure. My motivation is really just that I want to pass and maintain a good GPA (Chloe, Journal 5, 10/9/2015).

After completing the third exploration task, Chloe seemed to have a breakthrough in the self-relevance perceived between the mathematics content and herself, which began to shift her beliefs. Chloe reported in her third exploration task, “These graphs make WAY more sense to me in real-life situations. When you add equations and numbers, it means nothing” (Exploration 3, 11/3/2015). After reporting this new found self-relevance to parabolas, Chloe began to emphasize the importance of real-life examples in mathematics. In her tenth reflective journal, she wrote about students often saying that they will never use the concepts taught in mathematics classes because teachers rarely show students how and when to use such mathematics in real-life. She discussed how
students are often missing the conceptual understanding behind mathematics. She also later reported that she felt teachers and textbooks should introduce real-life examples in the beginning of each lesson and chapter rather than at the end. Finally, when reflecting back on the exploration tasks at the end of the semester, Chloe wrote, “The explorations helped me to see when real-life scenarios can be graphed… [and] to see that just like in an equation, real-life situations have shifts, variables, and maximum values” (Exploration Reflection, 11/20/2015). She also stated that the exploration did not necessarily help with the course content, but rather helped her mindset about mathematics throughout the semester.

They helped me realize that I must focus on the benefits of mathematics and try my hardest to better myself…[and] I must keep in mind as a teacher that my students need me to have a positive attitude about every subject so that they have the desire to learn it (Chloe, Exploration Reflection, 11/20/2015).

Chloe’s nominal shifts in her self-aspects as a mathematics student influenced changes in her overall feeling about who she is going to be as an early childhood teacher. In the initial teaching-centered worksheet, Chloe reported feeling “Strong Satisfaction” (a seven on a seven-point scale) in who she will be as a teacher. Chloe changed her overall feeling to “Mild Satisfaction” (a five on a seven-point scale) on her final teaching-centered worksheet. Her initial strong satisfaction was from feeling she knew her strengths and weaknesses, but her final mild satisfaction feeling sourced from feeling that she could be smarter. In addition, Chloe began to question her ability to teach mathematics at the third and fourth grade levels due to her dislike for mathematics and not being good at the subject. As a mathematics student, Chloe’s experience with the
perceived self-relevance began to make her reflect and explore how to change her mindset with mathematics; however, with this realization occurring late in the semester, Chloe did not have adequate time to reconstruct her attitude and motivation and utilize the reconstructed attitude and motivation in increasing her knowledge while in the course. Accordingly, Chloe left the class feeling as if she could have stronger content knowledge in mathematics, which in turn lowered her overall feelings towards teaching. However, when asked if she would elect to take additional mathematics courses to increase content knowledge, Chloe’s response remained “Very Unlikely” (a one on a seven-point scale) and she reported she would be less likely to use outside resources to increase her content knowledge (a pre-survey response of four to post-survey response of two on a seven-point scale).

Kat, like Chloe, had nominal change in her identity as a mathematics student in the sense that she began to see the importance of knowing one’s self as a student. At the end of the semester, Kat wrote that she felt the most important aspect of the class was the reflective writing assignments and exploration tasks. She felt that these assignments helped her grow both as a student and as a future teacher in addition to helping her enjoy the course. Kat wrote, “Self-reflection is important in today’s society” (Exploration Reflection, 11/20/2015) and began to understand the importance of knowing one’s personal beliefs and missions. She also wrote, “Using an aspect of yourself to make an equation and a graph helps immensely to understand the way that the graphs themselves work” (Exploration Reflection, 11/20/2015). So, not only did Kat see benefit in the assignments helping her grow as a student and future teacher, she felt they benefited her in terms of learning the content taught in the course.
The idea of understanding one’s self carried over into Kat’s teaching reflections. Kat put emphasis on student’s understanding who they are as individuals. She reported on her final teaching-centered worksheet, her main goal as a teacher will be to “help students learn who they are and learn new things along the way” (Teaching-Centered Worksheet 2, 12/1/2015). In fact, Kat’s construction of and reflection on her teaching goals throughout the semester were making her want to continue studying and learning everything possible in order to help her future students. However, like Chloe, Kat’s pre- and post-survey responses indicated no change in motivation to increase mathematics content knowledge. Kat’s response to electing to take additional mathematics courses remained “Not at All” (a one on a seven-point scale) and her likelihood of using outside resources to increase her content knowledge decreased by two points (a pre-survey response of six to a post-survey response of four on seven-point scale).

Mia demonstrated growth in both the goal and knowing one’s self categories. While Mia did not change drastically in her overall self-aspects that make up her identity as a mathematics student, she did begin to engage in gathering and reflecting on her goals in teaching. She also began to recognize the importance of thinking about who she is as a student in mathematics and who she will be as a teacher of early childhood students. Mia held positive self-perceptions throughout the semester as a student, reporting that she had confidence, felt determined, and enjoyed many parts of both the research assignments and mathematical concepts taught in the class. She felt she struggled with the exploration tasks, yet she enjoyed thinking about topics in a realistic way and felt that this type of thinking enhanced her understanding of the mathematical concepts taught in the class.
Overall, Mia held a positive attitude towards both the class and mathematics throughout the semester.

When filling out the first student-centered worksheet, Mia confessed that she had never thought about the particular type of questions before that ask for self-reported qualities as a mathematics student.

Taking the time to figure out who I am as a mathematics student is a great way to plan for the kind of teacher I want to be when I am teaching math. Having a better understanding of how I learn allows me to set a basis for my teaching (Mia, Journal 3, 9/25/2015).

It was after the realization of the importance of knowing herself as a student that Mia began to report the self-perceptions of confidence, enjoying parts of the course, feeling frustrated at times due to not having a mathematics class for three years, and reflecting on struggling with mathematics anxiety in her past.

In Mia’s reflective writing, shifts in her goals as a future teacher became apparent across time. Mia originally reported goals of wanting to teach lower grades such as first or second grade and wanting students to feel comfortable with her as a teacher. Her goals later began to shift to focus more on mathematical knowledge and real-life examples. Mia wrote she wanted to have as much knowledge as possible in each subject when teaching. She also wrote in her ninth reflective writing that her plans for teaching mathematics to young students were big.

They include activities that help the students truly comprehend the material because they are able to relate the concepts to their lives. Going along with this, I want to teach my students mathematics that they will be using in real life (of
course, what is age appropriate for them) instead of just memorizing the steps in order to pass a test (Mia, Journal 9, 11/06/2015).

Mia began to change towards a reform-oriented teaching identity. These shifts in goals aligned with Mia’s reported teaching belief of knowledge effecting a teacher’s success and ability to answer student questions and belief that students need to learn real-life mathematical skills such as measurement and money.

Jessa demonstrated positive changes in her beliefs on the importance of the mathematical content taught in the course. Jessa originally spoke of herself as a mathematics student who needed to work harder in mathematics classes for average grades, someone who dreaded mathematics as a subject, and someone who needed to work hard to build confidence in mathematics. She admitted that once mathematics became complicated during high school, she began to focus less on understanding mathematics and more on how to solve particular problems to be able to pass an exam. Still, Jessa spent a considerable amount of time in her reflective writings talking about the importance of now learning the higher-level mathematical concepts and algebraic thinking taught in the class. Starting in her third reflective writing, Jessa wrote about graphing as an essential skill, the importance of understanding how to manipulate algebraic questions to make sense of other mathematical concepts, and how evaluating complex equations aids in the ability to break down equations into simpler contexts. For example, Jessa wrote,

Learning these fundamental graphing skills not only prepares students for success in their mathematics life, but also sets students up for success in the real world. Graphs can tell you an endless amount of information. Obtaining knowledge
about interpreting graphs can prepare students for financial stability and success in the workforce. For example, graphs can tell us about stocks, amount of interest gained on loans, and in bank accounts, as well as how successful a company may be doing for yearly domestic growth and product. As educators it is essential to prepare students to be well rounded, and obtain all the skills necessary to be successful in their future as well as real world pursuits (Jessa, Journal 3, 9/25/2015).

She also wrote about how these skills and mathematical concepts are relevant to and important for early childhood and elementary teachers:

Having knowledge about all concepts in algebra will allow me to have a well rounded view of the necessary skills for my students to be successful in their mathematics endeavors. My knowledge about mathematical concepts will become apparent in my ability to teach mathematics effectively to my students as well as relate to their individual needs, learning styles, and mathematical abilities. I believe that it is important, as teachers, to understand how mathematics concepts build upon one another as we go about our education so that we can ensure that, as elementary educators, the foundation of knowledge for mathematics is concrete in order for our students to build upon their skills (Jessa, Journal 5, 10/9/2015).

Jessa maintained a response of “Not at All Important” in her survey when asked how important the topics taught in the class are to her career. However, what Jessa stressed as important related more to the higher-level thinking ability rather than simply the topics and concepts taught in the course.
Jessa’s shifts in beliefs about the importance of higher-level mathematics also appeared in her beliefs about teaching. Jessa originally wrote about her belief that knowing mathematics that is more complex hinders a teacher because they then remember higher-level details and are unable to explain simpler terms to students. Jessa’s beliefs later began to reflect the importance of algebraic knowledge. “Having knowledge about all concepts in algebra will allow me to have a well-rounded view of the necessary skills for my students to be successful in their mathematics endeavors” (Journal 5, 10/9/2015), and “Understanding how to compute higher-level equations helps teachers to understand the process of problem solving, algebraic equations, and how to break problems into steps” (Journal 10, 10/2/2015) are two examples of the shift in Jessa’s teaching beliefs. Jessa also began to emphasize beliefs about teaching with relevance and interest. She wrote about how a teacher knowing how to apply basic mathematical concepts to everyday life and activities helps him or her better relate to students. She connected her beliefs of importance of knowledge and relevance in her statement,

Maintaining a strong grasp on the material will also help me to be able to relate the concepts to my students, things that interest them as well as gauge their understanding of material and adjust my teaching as necessary to meet their needs (Jessa, Journal 12, 12/1/2015).

On Jessa’s teaching-centered worksheet, she went from reporting a neutral overall feeling towards teaching early childhood grades to feeling well prepared, confident, and excited about teaching.
Early Childhood PSTs Who Experienced Notable Changes in Multiple Components of Identity as Mathematics Students

The seven participants labeled as showing notable change in their mathematical student self-aspects engaged in gathering, questioning, and reflecting on their identities as mathematics students. These seven participants showed significant changes in particular self-aspects, which in many cases led to the start of the construction of a more positive identity as a mathematics student. The seven students vary in which of the four self-aspects they experienced changes in; however, they all experienced changes in multiple aspects.

Table 5. Categories with Changes in Student Role-Identity

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<th>Self-Perceptions</th>
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<th>Goals</th>
<th>Action Possibilities</th>
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<td>Caitlyn</td>
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<td>Sophia</td>
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Joan maintained an extrinsic goal orientation throughout the semester and continuously reported having a main goal of receiving an A in the course. However, Joan experienced shifts in her self-perceptions, beliefs, and actions as a mathematics student throughout the semester. Joan entered the class feeling as if mathematics was always a subject in which she struggled. She began to question her ability in mathematics even more when not performing well on the class quizzes; however, when completing the exploration tasks that she felt made a connection to her own life, she began to have a
deeper understanding of some of the mathematical concepts taught in the course. In her second exploration task, Joan wrote:

Seeing the graphs and their changes drawn out helps me visualize the transformations better and understand them. Relating them to real life aspects also creates a deeper understanding on a personal level (Joan, Exploration Task 2, 10/6/2015).

Once Joan began to feel a deeper level of understanding, she began to report feeling confident, began to feel as if she could participate more while in class, and began to make changes in her study habits. Joan started to set aside time in her schedule to work on mathematics daily, stayed after class to take advantage of her peers’ questions and extra practice problems provided by the instructor, and began to make study guides and flashcards to increase her exam scores. The increase in Joan’s class participation also showed in the field notes when Joan began to provide answers to practice problems during class progressively as the semester proceeded.

Joan remained optimistic throughout the course and reported that she used the worksheets as motivation to reach her goal of getting an A in the course. While her goal did not change – she wanted to get an A in the course – the worksheet may have raised an awareness of her goal. Joan also reported that her beliefs on mathematical knowledge and interest in the subject changed both after the first exploration task and at the end of the semester when reflecting back on the exploration tasks.

It wasn’t until I started answering the questions after drawing my linear functions that I fully realized the importance of knowledge in mathematics versus interest in mathematics and how it impacts our success in teaching. Although I said that I
think one’s interest in a subject is more influential in successful teaching, I am beginning to see that knowledge in the subject can fuel that interest (Joan, Journal 3, 9/25/2015).

These changes also reflected in her reported beliefs about teaching. Joan began to write about how early childhood teachers should strive to learn as much as possible in mathematics regardless of how basic the mathematics is that they will teach, and that learning mathematics while in college will be an important asset later while teaching.

Scarlett experienced shifts in her self-perceptions, beliefs, and goals as mathematics student throughout the course. For Scarlett’s self-perceptions, she began the semester by thinking she was bad at mathematics and was afraid of failing. As the class progressed, Scarlett began to report that she liked some of the activities and began to feel she could succeed in the course with dedication and hard work. She also held initial beliefs that a college algebra course would be wasteful for early childhood education students. This belief changed as Scarlett started to report that she could begin to see how the class would be important. She wrote, “If I thought I knew everything about Algebra and didn't take it and once I started teaching years later realized I should have taken it, I would have looked down upon myself for not taking the course” (Journal 3, 9/25/2015).

Finally, Scarlett reported her main goal for the first three-weeks as succeeding in the course; however, in the last student-centered worksheet, Scarlett reported her main goal as wanting “to fully understand the concepts” taught in the course. She felt the exploration tasks aided in learning these concepts throughout the semester.

Moreover, Scarlett questioned herself as a future teacher. In her second reflective writing, Scarlett wrote,
As the weeks continued and the subject matter increased in difficulty I found myself slowly forgetting how to do certain problems or getting more than two problems wrong on the entire problem set. This made me question if I actually knew what I was doing or if I was going to be a good teacher if I couldn’t figure out simple graphing problems I learned how to do in middle school. Part of me wonders if I will be a good teacher and know how to answer any questions my students have for me or about mathematics (Scarlett, Journal 2, 9/18/2015).

Although Scarlett began to question her success as a future teacher early in the semester, as she began to experience shifts in her self-perceptions, beliefs, and goals as a mathematics student, this questioning seemed to subside. Scarlett wrote in her tenth reflective writing, “I will be more confident than scared in the future when I teach. I will master what I need to teach and feel good about mathematics and hopefully make my students feel good about mathematics as well” (Journal 10, 11/13/2015). Her overall feeling about becoming a teacher remained at “Moderate Satisfaction” (a six on a seven-point scale) and Scarlett mentioned being more excited to teach due to the classes she was taking and beginning to think about who she will be as a teacher.

Kyle experienced significant changes in both his self-perceptions and beliefs as a mathematics student. Kyle entered the class reporting that he had very little regard for higher-level mathematics. He described the subject of mathematics as one that is “very much reliant of predisposition” (Journal 1, 9/11/2015). He also stated, “When you are not particularly well versed at something, you tend to lose interest and any enthusiasm for the subject” (Journal 1, 9/11/2015). This aligned with his initial self-perceptions as a mathematics student when reporting that he struggles with mathematics, does not ever
see himself become proficient in the subject, and finds the subject to be less interesting and more difficult to grasp. Yet, Kyle felt he could still enjoy the class without particularly enjoying the subject. Kyle’s self-perceptions went from being negative to being more positive as the semester continued. On the student-centered worksheets, Kyle wrote that his most defining personal characteristics were his pessimistic attitude towards mathematics and lack of motivation for mathematics; however, in the final student-centered worksheet, Kyle wrote about his ability to problem solve and finish mathematical problems. This positive shift in self-perception showed in his later reflective writings when Kyle wrote that he would do fine in the class and knew he could do better on the final exam than he did on the midterm.

In terms of the shifts in beliefs about mathematics, Kyle went from having very little regard for higher-level mathematics to developing an understanding for why preservice teachers must take mathematics in college. Initially Kyle wrote about how it is difficult to appreciate problems in higher-level mathematics that have no bearing on anything in real-life. He further wrote about how students in college should only take college algebra as an elective rather than as a requirement. It was in the reflective writings that Kyle completed after the third exploration that his beliefs began to shift to understanding the importance of mathematics. Kyle began to emphasize the importance of both a strong foundation in mathematics and the use of real-life examples. Kyle wrote, “When students use tools that put situations in real life situations it is often easier for them to understand… The more you can relate something to yourself the simpler the subject will most likely be” (Journal 11, 11/20/2015). Kyle felt that the four exploration
tasks aided in his understanding of concepts taught in the class and added relevancy to real-world situations and his future as a teacher. He wrote,

The explorations were a good measure of what we learned. I believe they are a better measure than quizzes; the reason is because they test us on how much we truly understand the content. Quizzes test us on how much or what we can memorize, when we apply our mathematics concepts to our real and everyday lives, I believe that we are proving that we actually know what is going on in the class and have a strong grasp of the content at hand (Journal 11, 11/20/2015).

Kyle also wrote that he plans to use similar tactics in his future classroom of putting real-life situations in mathematics to help younger students understand the subject more.

Thus, Kyle manifested change in the action possibilities of his teaching identity.

Like Kyle, Sophia experienced a shift in her self-perceptions as a mathematics student. Sophia started the semester with self-perceptions of not being good at mathematics, not feeling confident in the material, not feeling sure of her ability to pass the class, and having high mathematics anxiety. Sophia rated her overall feeling about who she is as a mathematics student with “Moderate Dissatisfaction.” She wrote, “I don’t understand half of the material presented” (Student-Centered Worksheet 1, 9/22/2015). Towards the end of the semester, Sophia began to report more positive self-perceptions such as persistence, determination, and feeling better about herself as a mathematics student overall. She rated her overall feeling about being a mathematics student as “Neutral.” When reflecting back on the exploration tasks, Sophia recognized her lack of confidence when completing the assignments. “When I look back at the exploration it seems that I doubted myself” (Exploration Reflection, 11/20/2015). She
further elaborated on the exploration tasks, displaying her more positive self-perceptions towards the end of the semester:

I feel that I am understanding the material a lot more by looking back at the previous explorations. Even though I feel that I am grasping the material more now, I do feel that it helped me tremendously in the moment. It helped me to realize that I can connect with mathematics on a personal level (Sophia, Exploration Reflection, 11/20/2015).

Sophia also experienced shifts in her goals throughout the semester. Initially Sophia only emphasized student goals of passing the class and becoming less anxious with mathematics. In the third student-centered worksheet, Sophia wrote that she wanted “to understand the material” in the course, shifting to a goal that is more mastery oriented than extrinsically oriented; yet, in her last worksheet, Sophia returned to reporting an extrinsic goal of wanting to pass the course. Although Sophia returned to an extrinsic goal, she again emphasized fully understanding content when writing her final goal for her future as a teacher, indicating that her goal of mastery learning did not subside. Instead, it is likely that Sophia held both goals.

Jill entered the class with one of the worst attitudes towards mathematics amongst her peers. Jill felt that she was not a good mathematics student, was disconnected with mathematics, and found mathematics classes to be boring. Jill described herself as someone who dislikes school in general and considered herself a terrible student. After completing the first exploration task, Jill wrote that she might even be a terrible teacher one day. Nevertheless, Jill held strong beliefs in mathematics needing a connection to real-life. Jill wrote in her fifth reflective writing, “I feel that being able to connect the
information to a task, like trying to find a midpoint of a table, is where the magic happens” (Journal 5, 10/9/2015). She also expressed in her ninth reflective writing, “I just wish that that wonderful aha moment would happen and this class wouldn't feel so pointless” (Journal 9, 11/6/2015). However, after taking a self-reported four college algebra courses while in college, and repeating the current mathematics course for the second time, Jill was persistent on not giving up. While Jill kept an overall negative self-perception for most of the semester, her outlook seemed to make a positive shift when reflecting back on the assignments in her last reflective writing.

In one of the last reflective writings, Jill expressed that for the first time in her years as a student, a teacher tried to relate algebra to real-life through the explorations. Jill described her experiences with the exploration tasks as the first time “seeing” mathematics and expressed how she wishes all algebra instructors would teach mathematics in this manner. When describing her experience with the first exploration, Jill wrote,

This was the first algebra assignment I have received that gave a real-world example for a line graph and the first time I understood the relationship between the x and y axes. Before this semester, the x axis was right to left and y axis up and down, that was the extent of their representations in my mind (Jill, Exploration Reflection, 11/20/2015).

In completing the exploration, not only did Jill begin to see algebra through real-life examples, she also began to understand how a graph could represent a relationship between two variables, generating a better understanding of the concept of linear equations. Although the instructor presented some real-life application problems in the
class, Jill did not seem to perceive the application problems as relevant to herself. Jill further wrote that, “This class has sparked my interest as how educators could explain point-slope, mid-point, and other formulas in a visual way” (Exploration Reflection, 11/20/2015). In addition, when reflecting on the third exploration task, Jill wrote, “I have a new appreciation for the parabola.” Jill’s newfound relevance with mathematics helped shift her negative outlook on the subject. “Where I used to think it was a useless torture tool of scholars to bore me to death, I now see its potential meaning; which makes for less learning resistance.” Thus, Jill began to form beliefs of mathematics learning being meaningful.

Jill’s attitude shift towards mathematics was apparent towards the end of the semester in the field notes. In the beginning of the semester, Jill rarely participated when in class. She would sit in the back of the classroom and would switch between taking sporadic notes and drawing pictures in her notebook. At times, she would raise her hand but put it down quickly if not called upon right way, and later when asked if she had a question, she would shake her head indicating that she did not. However, during the third exploration, Jill’s effort and attitude seemed to make a slight shift. Before the instructor started class on the day the third exploration task was due, Jill came to ask if I could check her answers for the assignment. She said she put a lot of thought into trying to come up with examples that have either a maximum or a minimum value. Originally, she wanted to write about how much fun she has when consuming alcohol because there is a point at which the level of fun peaks before going downhill, but she felt the example was not appropriate for the class assignment. Therefore, Jill decided to use age and physical ability. She felt confident in her example, but was unsure about her second example of
comparing her financial state to her age, creating a minimum value. She explained her reasoning behind her chosen example. After, I asked if she would be willing to share her example with the class. Jill drew her example on the board and explained her thought process to her peers. Jill’s peers then engaged in conversation as to whether or not the example Jill presented would work in their own lives. Some students thought that her example could compare to their own personal lives while other felt that the example did not pertain to their life, but nonetheless students expressed that Jill’s example was extremely helpful in understanding the concept of parabolas. After this experience, Jill began to write more in her weekly reflective writing assignments. She wrote about the importance of mathematics in everyday life and how in early grades, students are more likely to learn using manipulatives and graphic visual aids. She also expressed that she learned to stop focusing on hating algebra and began to focus on trying to apply the mathematical concepts to an object, even when the teacher does not do so. Thus, not only did Jill begin to experience shifts in her self-perceptions and beliefs about learning math, she began to experience shifts in her actions and perceived action possibilities as a mathematics student by redirecting her thoughts to making connections with mathematics.

Alexa showed shifts in her self-perception, goals, and perceived action possibilities throughout the course. Alexa was a student who entered the course not liking mathematics.

I still, I hate math. Like, just because of like, just bad experiences from catholic school, like I hate going to math. Like, I will sit there and be like, uhhhh. Like fractions, I hate fractions. They kill me inside (Pre-Interview, 9/17/2015).
She described herself as someone with very little confidence in the subject. She described mathematics as her weakest subject and described past experiences as making her feel “dumb” when it came to mathematics classes. Her lack of confidence seemed to weigh heavily on her mind. She mentioned her lack of confidence multiple times in reflective writings and chose to use it as her example in the first exploration task. She described herself in the first exploration as someone who would fall in the middle of her linear graph when being successful at teaching (See Figure 1). She labeled herself as being in the middle because she felt she knows the mathematical content taught in early grades but lacks the confidence in herself when it comes to the subject. As the weeks past, Alexa began to build confidence with mathematics. Not only did she self-report her newfound confidence, but it also showed in her increase in participation during class. In her last reflection, Alexa wrote, “As I said before, mathematics is my weakest subject but taking this class has actually made me work on my confidence in mathematics and makes me challenge myself to do better” (Exploration Reflection, 11/20/2015). While Alexa did not feel the exploration tasks helped her with the mathematical content in the course, she did say that the tasks helped her to learn about herself as a student.
Alexa also experienced shifts in her goals as a mathematics student. In her student-centered worksheet responses, Alexa originally mentioned goals of wanting to increase her confidence and pass the class with either a B+ or A-. In her last student-centered worksheet, Alexa wrote that she wanted to understand the material and refine her mathematics skills. This change in goal orientation appeared again during her last reflective writing.

I really do not like mathematics but I want to change this because I do not want to put off a vibe to my students that mathematics is going to be horrible. I want to refine my mathematics skills and make sure my students learn as much as they can and do not have a prejudice because their teacher does (Alexa, Exploration Reflection, 11/20/2015).

Alexa’s goal shift aligns with the idea of an “inverse relationship” with her students.

While she did not find herself liking mathematics any more after the completion of the
class, she did come to the realization that she does not want her students to feel the same about the subject as she does.

Finally, Alexa appeared to have developed perceived action possibilities as a mathematics student. Originally, she spoke of being a procrastinator, which led to her putting many assignments off until the last minute and spending at most five hours on any given homework. She wrote about how difficult it was for her to complete the assignments because she spent a lot of time in her dorm room alone. Once Alexa began to build confidence, she began writing about applying her newfound confidence to her homework and to in-class participation. When Alexa began to apply this confidence, she started to ask the instructor more questions during class, began to report studying more for exams, wrote about trying to stay focused more in the class, and wrote about listening to music as a way to be able to complete homework while alone in her dorm room.

In terms of Alexa’s self-aspects as a future early childhood teacher, confidence again appeared to be important to her. In her beliefs about teaching, Alexa wrote that a teacher can build skills and confidence, building confidence will make an indestructible teacher, a teacher will be more passionate about a subject if they feel confident, and a teacher will be afraid to teach if they lack confidence. Within her beliefs, Alexa also stressed the importance of refining knowledge. She mentioned multiple times that teachers can relearn material and that for students to be successful, teachers must be knowledgeable. Finally, Alexa wrote on her final teaching-centered worksheet that she plans to show students why they need to learn the material taught in mathematics. This emphasis on her students learning why mathematics is important shows that Alexa began to see the relevance behind learning mathematics.
Caitlyn appeared to gain the most in terms of content knowledge from the tasks designed to promote self-relevance. Caitlyn entered the course as a student who was repeating the class. She held negative self-perceptions such as lacking foundations needed to be successful in algebra, being nervous and feeling intimidated by the subject, disliking mathematics, and struggling to keep up with concepts taught in the class. It was not until she began to apply the mathematical concept of transformations to real-life situations in the second exploration task that she started to understand the concept. Caitlyn wrote in her reflective journals about how she felt the final exploration task was also helpful in her understanding of the course content. However, Caitlyn took the idea of algebra being relevant to her personal life further than some of her peers took the idea. Over a weeklong break in the semester, Caitlyn experienced needing algebra first-hand when frying a turkey:

The questions, like how am I going to apply it to a real life situation. And you know it didn’t click until like thanksgiving. How to apply any of this mathematics to anything until I was frying my turkey. I had to figure out how much oil I had to put in that pot. I was like ‘Damn, I wish I understood that damn algebra’ (Post-Interview, 12/3/2015).

Caitlyn needed to determine the amount of oil to place in a fryer based on the weight of the turkey and experienced the use of an algebraic equation in a real-life situation. Caitlyn not only mentioned this situation with a lot of enthusiasm during the final interview, she also wrote about it in her reflective writings. After experiencing mathematics as self-relevant, Caitlyn began to write about how she was able to think algebraically to some degree. Although Caitlyn did not leave the class feeling as if she
was a strong mathematics student, she went from saying “I feel really dumb” (Student-Centered Worksheet 3, 11/3/2015) to “I need a lot of help” and “I am learning some things” (Student-Centered Worksheet 4, 11/17, 2015). She also went from feeling “Strong Dissatisfaction” (a one on a seven-point scale) to feeling “Mild Satisfaction” (a five on a seven-point scale) overall as a mathematics student.

Caitlyn also began to see some changes in her perceived action possibilities. Originally, Caitlyn felt she needed to use her cellphone and a calculator to do the homework problems. She originally felt that she could not get through the homework without using a mathematics app on her smartphone.

They help you. They give you the solution to everything. The graphs, like everything. So, when I am doing my homework and I know that I should have been studying all week (picks up her phone), like ‘oh, well I don’t have enough time’ (pretends she is typing in the problem on her phone) (Pre-Interview, 9/17/2015).

The app allowed Caitlyn to take a picture of the problem on her phone and it would provide her with the answer. Caitlyn even confessed that her actions were not okay, “It’s bad, and I know it’s bad” (Pre-Interview, 9/17/2015). As the semester continued, Caitlyn began to look for other ways to succeed in the class and complete the homework such as reading the textbook, watching videos online, meeting with the professor outside of class time, and using the resource center available through the college. She also admitted to trying to lower her dependency on her phone and calculator.

Caitlyn felt that the design of the course and the tasks used for the research project helped her both in succeeding in the course and in thinking about who she is as a
mathematics student. Caitlyn started to think about her relationship with mathematics, her feelings towards the subject, and the type of teacher she will be to early childhood students. She felt that the weekly reflective writing assignments helped to think about her strengths and weaknesses as well as how to improve upon her weaknesses. Caitlyn also began to question her ability to teach mathematics concepts at the early childhood education level. In her post interview, she mentioned experiences in her job as an aid and substitute for early grades where she had to go to other second grade teachers for explanations of the mathematics concepts she was responsible for teaching because she could not understand them. “And sometimes, I would be like, can we swap and you tell me if they are doing what they are supposed to be doing because I don’t want to make them dumber” (Post-Interview, 12/3/2015). When asked what she thought she could do to prevent asking other teachers for help, Caitlyn said, “Just practice and keep looking for videos….try hard, learn.”

Secondary Education Participants

Analysis of student worksheets, reflective writings, exploration tasks, and interviews indicate that the secondary education students, regardless of concentration, perceived many of the class activities as self-relevant by making connections between the mathematical concepts and his or her self; however, seven of the eight secondary education participants remained unchanged in their identities as mathematics students. These seven secondary education students did not engage in significant gathering, questioning, and reflecting on self-aspects related to their mathematics identities as students. One secondary education participant changed nominally as a mathematics
student due to slightly engaging in gathering, questioning, and reflecting on his identity as a mathematics student by shifting his beliefs about the importance of mathematics.

Table 6.
Secondary Education Participants Patterns of Change as Mathematics Students

<table>
<thead>
<tr>
<th>Unchanged</th>
<th>Nominal Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aaron</td>
<td>Matt</td>
</tr>
<tr>
<td>Amanda</td>
<td></td>
</tr>
<tr>
<td>Annie</td>
<td></td>
</tr>
<tr>
<td>Jazmyn</td>
<td></td>
</tr>
<tr>
<td>Justin</td>
<td></td>
</tr>
<tr>
<td>Nate</td>
<td></td>
</tr>
<tr>
<td>Rick</td>
<td></td>
</tr>
</tbody>
</table>

Secondary PSTs Who Were Unchanged in Identity as Mathematics Students

Five of the seven secondary education participants labeled as unchanged entered the class with negative self-perceptions in relation to mathematics and those negative self-perceptions remained for the duration of the semester-long course. Two participants entered with positive self-perceptions and maintained positive self-perceptions throughout the course’s entirety. Although the seven participants did not experience changes in their identities as students, many emphasized the exploration tasks as being beneficial to their understanding of concepts taught in the course.

Both Nate and Jazmyn entered the course with positive attitudes towards mathematics. Jazmyn remained confident in her mathematical abilities and frequently reported feeling bored when attending class. She often completed the homework ahead of class time. Jazmyn felt that she could not learn mathematics through a lecture-style class but was able to learn through repetition when completing homework problems. Jazmyn also believed that the concepts covered in the course were the same as material covered in high school mathematics. She wrote in a reflection that the algebra concepts
taught in the course were the same basic algebra concepts “crammed into our heads over and over since eighth grade” (Journal 4, 10/2/2015). However, Jazmyn felt that through repetition she was able to fully learn and understand the concepts. Jazmyn reported student goals of wanting to thoroughly understand the material and succeed in the class, but in her last student-centered worksheet, she stated a goal of wanting to relate mathematics to her personal life. This followed the four exploration tasks designed to promote self-relevance. Jazmyn wrote in her last reflection that the exploration tasks helped her relate to mathematics on a personal level and helped her to learn the content more. She further elaborated,

I think that this has helped me become a better mathematics thinker because of how personal and relatable it has seemed, and that as a future teacher, it has helped me gain perspective in possible ways to implement this in the classroom as well (Jazmyn, Exploration Reflection, 11/20/2015).

In relation to her identity as a teacher, throughout the course Jazmyn began to think about the methods she would one-day use as a teacher and the actions she would take for students who struggle in her classes. She wrote about including fun activities in her lessons and incorporating one-on-one instruction for students who are struggling. She also often emphasized needing interest and passion as a teacher.

Nate also entered with and maintained a positive attitude towards mathematics. He maintained positive self-perceptions as a student, believed “practice makes perfect” in mathematics, and felt confident enough to be able to take a quiz with little to no studying beforehand. However, Nick frequently missed assignments and received failing grades on some of the assessments in the class resulting in him not passing the course. Nate’s
self-reported student goals shifted from becoming “as skilled as possible” (Student-Centered Worksheet 1, 9/22/2015) in mathematics to wanting to “pass this class” (Student-Centered Worksheet 4, 11/17/2015). This shift from a mastery-oriented goal to an extrinsically oriented goal is likely due to the state of Nate’s course grade towards the end of the semester. He entered the course wanting to take as much information as possible; but, when his grades started to decline, he began to focus on passing the course to avoid having to repeat it. Still, Nate felt that he took important information from the class. When asked during an interview what he felt was the most meaningful experience in the class, he said,

I guess the explorations were pretty meaningful because they like um, they gave a real world meaning to what we were doing in class and that…I feel like that would have been hard to do without the explorations. Like for myself, I would have figured there was nothing we could have applied this to ever…. And, I mean I can take what I learned here, I guess, especially with the explorations with applying things to the real-world and doing that more and more in class instead of just kind of remembering everything and spitting it out on the test (Nate, Post-Interview, 12/15/15).

Nate believed completing the exploration tasks to be the most meaningful experience for him in the class. He, like many of his peers, originally felt that he could not apply the algebraic concepts taught in the course to his personal life, but began to change this view when completing the exploration tasks.

Amanda, Justin, Aaron, Rick, and Annie all maintained negative attitudes in relation to mathematics throughout the course. Amanda maintained negative self-
perceptions about not being good at mathematics, maintained negative beliefs about mathematics such as students either love or hate the subject, and maintained an extrinsic goal of wanting to pass the class. Amanda usually attended class and reported dedicating as much time as she could to studying and completing the class assignments; however, she frequently mentioned experiencing time constraints due to having children. Amanda used pregnancy as her self-relevant example in the second exploration task and wrote in her final reflection how it was the most meaningful of the four explorations.

This was far and away my most helpful Exploration…This was the most real life, non-school related Exploration I did. I couldn’t think of a different area of my life to relate the task too. I enjoyed using something that had nothing to do with this class, my pregnancy, and applying it to the material we were learning (Amanda, Exploration Reflection, 11/20/2015).

Although Amanda frequently reported being confused when starting the exploration tasks, she felt that the tasks helped her understand and learn the concepts taught in the class. When speaking about the second exploration task, Amanda wrote, “I see how it helped me understand quadratic functions in the terms of maximum and zero values” (Exploration Reflection, 11/20/2015). Although Amanda did not seem to shift her negative feelings about mathematics nor did she change her identity in relation to mathematics, she began to see how mathematics could relate to her own life through completing the assignments designed to promote relevance.

Justin was very similar to Amanda in that he had negative beliefs and self-perceptions in relation to mathematics and held extrinsic goals throughout the semester. For example, he felt that he was a student who constantly struggled in mathematics and
thought mathematics is not naturally interesting. For Justin, simply passing the course was not enough. His extrinsically oriented goal was to get an A in the course. When not doing well on exams, he questioned himself as a student in the class, but wanted to work at raising his grade to leave the class with an overall A. Similar to Amanda, Justin felt that the relevant assignments in the class were helpful with his understanding of the concepts in which he struggled. In his third exploration task, Justin wrote, “Giving a story behind what the zeros and vertex can mean can make it easier to understand why quadratic equations behave the way they do. It is not to say that I understand them completely, but I am getting there” (Exploration Task 3, 11/3/2015). Justin mentioned multiple times in his reflective writings that he struggled with relating the concepts taught in mathematics classes to his own life and other real-life situations. With the exploration tasks helping Justin connect mathematics to his own life, he felt he increased his knowledge and understanding of the concepts.

Aaron also enjoyed the exploration tasks and their connection to real-life examples. When applying mathematics to his own life, he reported beginning to see the importance of the subject. For the most part, however, Aaron upheld negative self-perceptions. He did not consider himself a good mathematics student and felt he always made stupid, mental errors when working on mathematics. He was also frustrated and disappointed in himself when not doing as well as he had hoped on his quizzes and exams. Aaron also maintained negative beliefs about mathematics such as mathematics being complicated, frustrating, and boring. As the semester progressed, Aaron began to put more emphasis on his belief that a student has to put more time and effort into studying to do well. In the beginning, Aaron said he was looking forward to simply
being done with mathematics altogether; however, his goals often included both retaining and understanding the material and passing the class with a high grade. Aaron also stated that he spent significant time outside of class completing homework and studying for the quizzes. In addition, Aaron reported spending extra time checking his work on exams, but also relying on luck.

Of all the participants in the study, Rick and Annie gave the least amount of effort in the assignments used for the research project. Rick wrote the exact same reflection week after week for almost every reflective writing assignment. He wrote about how he did not find anything relevant to his life, about mathematics not being his strongest subject but still believing in learning mathematics, his belief that all subjects in school relate to one another, and how his answers about his self-aspects would not change. His fifth reflective writing was the only time where Rick gave different answers to the reflective questions. In his fifth reflective writing, Rick wrote about how he was able to find an effective way to track his fitness, diet, and productivity through completing the exploration task. He also wrote about how he realized he needed to reassess the amount of effort he puts towards the class. Yet, Rick did not seem to place this extra effort into the class. He continued to miss assignments and fail quizzes and exams in the class. In Rick’s student-centered worksheets, he wrote, “My attitude towards mathematics has improved greatly” (Student-Centered Worksheet 4, 11/17/2015). He also wrote that his most defining characteristic was his newfound interest in the subject. Yet, he continued to write that the material in class was irrelevant to his life in his reflective writing.

Like Rick, Annie missed many of the assignments throughout the semester. She also gave almost no information about herself in the assignments she did complete.
Annie maintained a negative attitude throughout the course. She felt that she was not good at learning mathematics, nor did she feel that learning mathematics was high on her priority list or necessary for a secondary English education major. Her goals went from wanting to get better at the subject to wanting to pass the class with a C. In relation to her future as a teacher, Annie reported that she would never use the methods that the instructor used in her own classroom. On her final teaching-centered worksheet, Annie went from feeling neutral about teaching to feeling strong dissatisfaction. She wrote, “Honestly, this isn’t for me” (Teaching-Centered Worksheet 2, 12/1/2015) indicating that teaching was not the career path she wished to continue pursuing.

The Secondary PST Who Experienced Nominal Change in Beliefs as a Mathematics Student

Matt, the secondary education student labeled as showing nominal change in his mathematical student self-aspects slightly engaged in gathering, questioning, and reflecting on his identity as a mathematics student. He showed changes in his beliefs as a mathematics student, but did not show significant changes as a whole in his identity as a mathematics student. Matt upheld negative self-perceptions about himself as a mathematics student throughout most of the semester. He felt that he always struggled with mathematics, had little to no confidence in his ability in the subject, often doubted himself, and felt he had mathematics anxiety. He maintained an extrinsic goal of wanting to get an A in the course and felt he would do anything to get an A regardless of his personal feelings towards mathematics. He felt that his actions of coming to class, completing the homework, and not giving up would allow him to reach his goal.
In the beginning of the semester, Matt held beliefs about learning and the nature of mathematics such as mathematics is a subject of chance, mathematics could never be easy, the average person does not need to know algebra to get through life, and people know mathematics or they do not. He demonstrated these beliefs in his reflective writing assignments. However, at the end of the course, in his final reflective writings, Matt seemed to have a positive reflection when looking back on the semester. He wrote,

Throughout this semester I feel as if I learned a lot of information, not just about math, but about myself as well… Overall, I took a very positive learning experience away from this class. I did not always fully appreciate what I had at the time but I believe this class did help shape my view of mathematics and new ways of processing the information (Exploration Reflection, 11/20/2015).

He began to demonstrate this shift in his appreciation when writing his tenth reflective writing. Matt began to write about the importance and value of learning mathematics:

I believe there is a lot of value and importance from learning math, algebra in particular…. I have also always believed that most students that do not think something is important is simply hiding their own insecurities with the subject matter (Matt, Journal 10, 11/11/2015).

Therefore, Matt experienced a shift in his beliefs, moving away from his early beliefs of the average person not needing algebra to seeing the value behind knowing such mathematical concepts. Matt also wrote in his eleventh reflective writing, “Overall, I do believe the explorations have been helpful in giving the class as a whole a better understanding of the mathematics they see around them every day without being aware of it” (Journal 11, 11/19/2015). Thus, it was due in part to the explorations that Matt was
able to shift his beliefs in the importance of learning mathematics and walk away with a new appreciation for the subject and feeling that he learned about himself as a mathematics student.

Themes

The above cases provide insight into the patterns of change in mathematics identity and motivation for early childhood education students and secondary education students that emerged from cross-case synthesis of the data collected on the 24 participants. While each case was unique, cross-case analysis revealed commonalities and differences across cases, which helped to develop themes and categories for the patterns of change. Cross-case analysis also aided in finding the relationship between initial identity as a mathematics student and a student’s subsequent exploration of identity.

_Early Childhood PST’s vs. Secondary Education PST’s Level of Change_

Students experienced various levels of change in their identities as students and as future teachers. Early childhood education participants (81%) were more likely and more willing to evaluate various self-aspects that make up their identities as students and make changes to self-aspects than secondary education participants were willing to evaluate and change (13%). This is most likely because they will one day be teaching mathematics along with other various subjects and they feel some level of perceived relevance to their future careers as teachers more so than secondary education students do with concentrations in social studies, English, and world languages.

_PST’s Initial Identity_
The majority of early childhood education students did not necessarily make large changes in their identity as mathematics students, but some made changes in particular self-aspects as mathematics students, self-aspects as future teachers, or both as students and teachers. To have a better understanding of student identity exploration and shifts, looking at initial identity in relation to mathematics is helpful.

When starting with an initial identity that involved having positive self-perceptions, beliefs, goals, action possibilities, and/or attitudes towards mathematics, early childhood education students were less likely to engage in exploration with their identity (e.g. Molly). However, this was not the case with all early childhood education students entering with positive attitudes (e.g. Mia). When starting with an initial identity that involved holding negative self-perceptions, beliefs, goals, action possibilities, and/or attitudes towards mathematics, early childhood education students were more likely to explore at least one self-aspect relating to their identity. However, those who changed nominally only experienced changes in their goals and/or beliefs. Nominal shifts in beliefs involved changing either beliefs on the importance of knowing one’s self as a student or beliefs about the importance of mathematics. The early childhood education students who changed notably experienced shifts in self-perceptions and at least one other facet of identity. That is, when a student was able to shift perceptions of his or herself as a mathematics student to being more positive, even in a slight manner, he or she experienced exploration in his or her beliefs, goals, and/or action possibilities as well. Interestingly, the early childhood education students who entered the class with what appeared to be extremely negative attitudes towards mathematics (e.g. Jill, Kyle, and Caitlyn) all fell into the notably changed category. These changes in one facet – as a
result of completing components of the interviews such as the exploration tasks and reflective writing assignments – often leading to changes in other facets emphasizes the dynamic nature of the identity model. Ideally, the participants who experienced nominal changes in their goals and/or beliefs will continue to explore and formulate self-perceptions, beliefs, goals, and action possibilities as both students and teachers that are more positive, utilizing the interactive nature of the model.

Regardless of exploring and/or shifting self-aspects as students and regardless of initial identity in relation to mathematics, early childhood education students often explored self-aspects in relation to their future as teachers. Although three of the early childhood education participants remained unchanged in their identity as mathematics students, Molly was still able to begin to gather and question self-aspects related to her identity as a teacher and begin to form her teaching identity, unlike Ava and Sally. Some of the early childhood education participants who experienced nominal shifts in their beliefs (83%) began to think ahead to the relevance of the mathematical concepts taught in the class to their future classrooms. For example, Chloe began to think ahead to how she will make sure to help students understand how to use mathematics in their everyday lives and Jessa continuously tried to relate the topics in class to what she will one day teach in early childhood education grades. Thus, when changing particular self-aspects as students, many times participants were beginning to form facets of their teacher identity as well.

In contrast, initial identity – either positive or negative – did not appear to influence secondary education PSTs’ likelihood to engage in exploration with their identities. Secondary education PSTs that held negative or positive self-perceptions,
beliefs, goals, action possibilities, and/or attitudes towards mathematics mostly did not experience changes in their identities as students. The only student to experience nominal changes held a negative initial identity.

**Perceived Relevance and Impact of Identity Exploration**

The identity exploration tasks incorporated mathematics concepts taught in the weeks prior and required students to relate to the mathematics concepts and reflect on the self. For many, the tasks helped students to perceive the mathematical topics in class as relevant for thinking about and questioning aspects of their lives as students and future teachers. Without the tasks, it is unlikely that the students would perceive the mathematical topics as self-relevant. This stems from the discussion on causation within qualitative research. By providing detailed accounts of the process by which a change occurs in each of the participants, a researcher is able to support the cause of the improvement or change (Maxwell, 2004). It was during the weeks that students completed the exploration tasks that they reflected on the self the most. During weeks where there was only lecture from the instructor, there was less exploration of self-aspects among the participants. Further, for some students during these weeks, the intervention components helped to change self-aspects such as perceptions in relation to mathematics, adapt motivation towards the subject, and/or gain a better sense of understanding of the mathematics content used in the task, as shown in this chapter. Thus, by looking at the causal processes, it is clear that the intervention played a role in the changes students made to self-aspects of their role identities.

Interestingly, all but one of the early childhood education students who perceived the exploration tasks as relevant (self-reported) to their own lives experienced either
nominal or notable change in their identity as mathematics students. For example, Chloe focused on the third exploration task during her subsequent reflective writing, indicating that it was the most interesting, and relevant part of the class that week to her daily life. As seen in Chloe’s reflective writing, many of the students not only found the tasks to be self-relevant; they also self-reported finding them to be helpful in the understanding of the mathematics concept.

The only exception for early childhood education students was Molly. Molly is a student categorized as unchanged, but she perceived the exploration tasks as relevant. The other unchanged early childhood education students did not self-report the exploration tasks as relevant. While Molly’s perceived relevance did not influence identity exploration, she felt it did help her with understanding the mathematic concept for the third exploration task. “These graphs help me understand these concepts because I am able to relate it to something that I do on a regular basis. It also allows us to conceptualize concepts that are more theoretical” (Molly Exploration 3, 11/3/2015). Molly was the only early childhood student to self-report perceived relevance and not engage in identity exploration.

For the secondary education students, perceived relevance did not seem to have any influence on identity exploration. All but one secondary education student self-reported perceived relevance towards the four exploration tasks. Annie was the only secondary education student who did not self-report perceived relevance towards the four exploration tasks. Thus, when having early childhood education students complete tasks that apply the identity exploration promoting principles to mathematic concepts taught in class, there is potential for identity exploration to occur in addition to increasing
understanding of mathematic topics; however, the same does not hold true for secondary education students with non-mathematical concentrations.

Pre- and Post-Survey Mean Score Comparisons

To look at the changes in participants’ survey results as a whole, I calculated the mean scores for each question from the pre- and post-survey measures and combined items into single composite scores for each facet measured including ability perceptions, beliefs of intelligence, goals (mastery and performance), action possibilities (self-regulation), value, and mathematics anxiety. All survey questions pertaining to value, ability perceptions, mathematics anxiety, and intention to increase in content knowledge were on a 7-point scale. Survey questions pertaining to self-regulation, goals, and beliefs were on a 5-point scale. Changes in mean scores demonstrate the increases and decreases and provide information on changes in survey results.

Table 7. 
*Pre- and Post-Survey Means*

<table>
<thead>
<tr>
<th></th>
<th>Pre-Survey Mean</th>
<th>Pre-Survey SD</th>
<th>Post-Survey Mean</th>
<th>Post-Survey SD</th>
<th>Increase/Decrease in Mean Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beliefs</td>
<td>6.458</td>
<td>2.637</td>
<td>6.625</td>
<td>3.228</td>
<td>0.167</td>
</tr>
<tr>
<td>Mastery Goals</td>
<td>22.375</td>
<td>3.954</td>
<td>20.250</td>
<td>4.830</td>
<td>-2.125</td>
</tr>
<tr>
<td>Performance Goals</td>
<td>22.000</td>
<td>6.528</td>
<td>21.250</td>
<td>6.898</td>
<td>-0.750</td>
</tr>
<tr>
<td>Value</td>
<td>31.667</td>
<td>8.313</td>
<td>30.417</td>
<td>9.846</td>
<td>-1.250</td>
</tr>
<tr>
<td>Anxiety</td>
<td>19.833</td>
<td>5.731</td>
<td>19.583</td>
<td>5.348</td>
<td>-0.250</td>
</tr>
<tr>
<td>Increase Content Knowledge</td>
<td>4.708</td>
<td>1.967</td>
<td>5.208</td>
<td>2.284</td>
<td>0.500</td>
</tr>
</tbody>
</table>
When comparing composite mean scores for all twenty-four participants using t-tests to determine significance, ability perception, self-regulation, and mastery goal orientation all showed significant decreases ($p < .05$). However, limited statistical power due to the small sample size may have limited the significance of some of the comparisons. Therefore, the majority of survey results were not significant when looking at the entire group of participants and had very small changes from pre- to post-survey.

An interesting finding from the survey comparisons is that no significant changes in mathematics anxiety occurred in the group as a whole, indicating that the intervention had no impact on mathematics anxiety regardless of changes in identity. However, each student represents a unit of analysis in this study, making it more interesting and valuable to look at the participants individually rather than together in the above figure. Thus, the following graphs represent PSTs’ individual change in particular components measured in the survey. In the following graphs, the early childhood PSTs are blue, red, and yellow, corresponding to the categories of unchanged, nominally changed, and notably...
changed respectively. The secondary education PSTs are green and purple, corresponding to the categories of unchanged and nominally changes respectively.

When looking at change in mathematics anxiety from pre- to post-survey, there is variability in type of change – increase, decrease, and constant – for individual participants (see Figure 6). Comparing the means as a whole group (Figure 5) masks this variability when looking at the overall decrease in mathematics anxiety. In fact, the mean comparison masks the variability in each component measured in the survey. For mathematics anxiety, the graph in Figure 6 shows how the secondary education PSTs have more variability than the early childhood PSTs. The early childhood PSTs generally have higher mathematics anxiety during both the pre- and post-survey. Interestingly, the notably changed early childhood PSTs all decreased in mathematics anxiety with the exception of Kyle and Sophia. In addition, the unchanged early childhood PSTs remained constant with the exception of Sally. Sally increased significantly from a composite score of 10 to a composite score of 20. The secondary students all decreased in mathematics anxiety with the exception of Rick and Justin, who both increased in mathematics anxiety.
Figure 6: Mathematics Anxiety Pre- and Post-Survey Results

In contrast to the mathematics anxiety graph, the early childhood education PSTs – especially the notably changed early childhood PSTs – appear lower than the secondary education PSTs concerning self-regulation (see Figure 7). The early childhood education PSTs appearing lower than the secondary education PSTs indicates that they generally have lower self-regulation. In addition, the PSTs who started with high self-regulation scores tended to decrease while those who started with lower self-regulation scores remained constant or increased. This may be due to students who entered the course with low self-regulation being unsure of themselves in relation to mathematics and being more open to reconsidering their perceptions.
When looking at the individual changes in intention to increase content knowledge, the early childhood PSTs who experienced notable changes started higher in their intentions; however, these PSTs have variability in change (see Figure 8). For example, Kyle remained constant with little intent to increase mathematics content knowledge, and Sophia remained constant with medium intent to increase mathematics content knowledge. Caitlyn, Alexa, and Joan show decreases in their intention to increase mathematics content knowledge, but the decreases are small (1 – 2 points), meaning that they remain neutral in intention to increase content knowledge. Scarlett and Jill both increase in intention to increase mathematics content knowledge; however, Scarlett remained neutral (increased 1 point) while Jill increased by 3 points in her composite score. Jill’s larger increase may be due to her views of mathematics changing and viewing mathematics as “bearable” rather than “torturous” at the conclusion of the course.

*Figure 7: Self-Regulation Pre- and Post-Survey Results*
Another interesting finding when looking at Figure 8 is that both Sally and Molly – unchanged early childhood PSTs – both increased in intention to increase mathematics content knowledge. Sally’s early realization that she needs to strengthen herself as a mathematics student in order to feel confident teaching mathematics and Molly’s exploration of her teaching identity may explain these increases.

When looking at the individual graphs relating to ability perception (see Figure 9), the notability changed early childhood PSTs generally start lower or remain constant. Those who were unchanged had higher ability perceptions and slightly increased with the exception of Sally, who believed that she could increase her mathematics knowledge, potentially lowering her ability perceptions. The nominally changed early childhood PSTs generally were mid-level during the pre-survey and decreased. Alice is the only exception to this decrease. Alice increased from pre- to post-survey in relation to the ability perception questions. Alice’s goal shift from extrinsically oriented to mastery-
oriented may have influenced her ability perceptions at the end of the course even though
she did not report this in other forms of data collection.

Figure 9: Ability Perception Pre- and Post-Survey Results

Mostly, the secondary education PSTs remain the same in ability perceptions throughout
the course, with the exception of Rick. Rick showed a larger decrease than other
secondary education PSTs, potentially due to poor grades in the course.

Another interesting finding occurs with value of mathematics. The notably
changed early childhood PSTs appear mid-level to high-levels in relation to value (see
Figure 10). They also generally remain the same from pre- to post-survey. The
exception to this finding is Jill. Interestingly, Jill decreased significantly; however, this
decrease dealt with questions pertaining to liking mathematics and the usefulness of
mathematics classes compared to other classes. Jill did not leave the course reporting
that she enjoys mathematics, but rather found it to be bearable. In addition, it is likely
that Jill was enrolled in education courses focusing on pedagogy due to being in her
junior year in college. If this was the case, it is possible that Jill found the pedagogical courses more relevant than a course focusing on college algebra.

**Figure 10: Value Pre- and Post-Survey Results**

Finally, another interesting finding occurs in the graph of pre-and post-survey results for beliefs of intelligence. Alexa, Caitlyn, and Sophia represent large increases in beliefs. However, these increases indicate the belief that mathematics intelligence cannot change but students are still able to learn new things in mathematics. These three PSTs are the only notably change early childhood PSTs who did not experience positive shifts in beliefs as mathematics students. Those notably changed early childhood PSTs who did experience changes in beliefs remained constant or decreased in their survey responses to beliefs about intelligence (see Figure 11).
Figure 11: Intelligence Belies Pre- and Post-Survey Results.

Although students did not show significant changes in most survey responses as an entire group, the individual graphs above and the qualitative analysis and results, demonstrate that many early childhood education students began exploration of identity and show changes to self-aspects as mathematics students. Some also began to explore and develop their identity as future teachers.
CHAPTER 5
CONCLUSIONS

This study sought to implement and investigate the influence of an identity exploration intervention on PST’s identities in mathematics during their required mathematics content course of a teacher education program. The aim was to provide insight into the patterns of change in identity and motivation towards mathematics because of participating in the intervention. The purpose of intervening on PST’s identity in relation to mathematics was to help minimize the negative attitude and consequences of such attitudes when becoming teachers as demonstrated in the literature. In this design-based, qualitative study, the results apply directly to the PST’s involved; however, the results provide meaningful insights to teacher education programs and further research. This chapter provides a summary of the findings, limitations of the study, implications for practice, and future research.

Summary of Findings

The findings from this study support that the intervention designed to promote identity exploration did so for many, but not all students. As shown in previous research (Granit-Dgani, Kaplan, & Flum, 2011, Sinai, Kaplan, & Flum, 2012; Kaplan, Sinai, & Flum, 2014, Kaplan, 2014), tasks designed using the four principles for promoting identity exploration can help students to explore their identity in relation to a subject. Each measure in this intervention had a role in making an impact of student’s identity exploration. For some students, simply filling out the initial survey and worksheets led them to begin to reflect upon self-aspects as mathematics students and/or future teachers. Some students found the four exploration tasks to be the most beneficial aspect of the
intervention because of the perceived relevance. The weekly reflective writing assignments led some students to reflect upon how the course was relevant to their future as teachers and to think in a deeper way about the mathematics concepts taught that week. Moreover, for some students, a combination of all of the measures led to exploration and change. Thus, the data from the four identity exploration tasks, reflective writing assignments, identity worksheets, and interviews indicated that the exploration tasks, reflective writings, worksheets, and/or surveys promoted identity exploration for most early childhood education students but not for many secondary education students. The data for the study strongly indicates that the tasks designed for the intervention triggered identity exploration to occur by causing students to perceive the academic content as relevant to the self. For those students whom the intervention provided a trigger and scaffolding, the perceptions of mathematics concepts as self-relevant itself was a discrepancy between their perceptions of mathematics and themselves in mathematics, and their experiences of self-relevance of mathematics concepts. At times, some student gathered, questioned, or explored aspects of themselves such as perceptions, beliefs, goals, and actions.

Tasks that promoted perceived relevance and identity exploration for one student may not have promoted perceived relevance and exploration for other students. While each PST in this study provided a unique case, commonalities and differences found in cross-case comparisons aided in characterizing the patterns of change. Analysis of the data in this study suggested three categories representing the level of change in student mathematics identity for participants. The three categories included “The Unchanged,” “The Nominally Changed,” and “The Notably Changed.” PSTs labeled as unchanged did
not, or rarely, engaged in significant gathering, questioning, and reflecting on self-aspects related to their identities as mathematics students. PSTs labeled as nominally changed slightly engaged in gathering, questioning, and reflecting on self-aspects as a mathematics student. PSTs labeled as notably changed significantly engaged in gathering, questions, and reflecting on their identities as mathematics students. In addition, those labeled either as nominally changed or notably changed experienced positive shifts rather than negative shifts in self-aspects, meaning they showed self-perceptions, beliefs, goals, and/or actions that were more positive than initial self-aspects. Finally, regardless of category, PSTs did not experience changes in mathematics anxiety because of participating in the intervention.

Early childhood education participants fell into all three categories while the secondary education students mainly fell under unchanged, with the exception of one student falling under nominally changed. This is most likely due to early childhood education students not only perceiving the content as self-relevant in many instances but also perceiving it as relevant to their future career, whereas the secondary students often did not perceive mathematics as relevant to teaching social studies, world languages, or English. While other research focusing on early childhood and elementary PSTs and in-service teachers has shown that interventions involving writing autobiographies or narrative rehabilitation can help to reshape negative attitudes towards mathematics (e.g., McCulloch, Marshall, DeCuir-Gunby, & Caldwell, 2013; Lutovac & Kaasila, 2011), this study shows that promoting perceived relevance of the academic content to students own lives while triggering exploration can also help reshape negative attitudes towards mathematics. In addition to exploring and reshaping self-aspects in many cases, when
completing the tasks for the intervention, the early childhood education PSTs were often able to see the relevance in learning particular content and how knowing such content will help in their futures as teachers.

When early childhood education PSTs held initial identities that involved positive self-perceptions, beliefs, goals, action possibilities, and/or attitudes towards mathematics, the PSTs were less likely to engage in exploration with their identity regardless of perceived relevance. On the contrary, early childhood education PSTs who held initial identities that involved negative self-perceptions, beliefs, goals, action possibilities, and/or attitudes towards mathematics explored at least one self-aspect relating to identity. In many cases, the early childhood education PSTs explored two to three self-aspects. For those who experienced shifts in self-perceptions, shifts also occurred in other self-aspects.

Perceived relevance differed among participants. Early childhood education PSTs who self-reported perceiving the exploration tasks as relevant to their own lives almost all were categories at nominally or notably changed due to partaking in identity exploration. For the secondary education PSTs, perceived relevance did not appear to influence identity exploration and was not an identity exploration trigger for the salient role identity. All but one secondary education PST self-reported perceived relevance towards the exploration tasks. Thus, early childhood education students completing identity exploration tasks involving the identity exploration promoting principles were more likely to explore, question, or reflect on self-aspects as mathematics students than secondary education PSTs.
Finally, the majority of survey results were not significant. The results that were significant were decreases in survey response to questions pertaining to ability perception, self-regulation, and mastery goal orientation. Interestingly, no significant changes occurred in mathematics anxiety. While survey results did not provide significant outcomes, the qualitative analysis demonstrated the exploration of identity and changes in self-aspects as mathematics students – and in some cases initial exploration of identity as future teachers – which many early childhood education PSTs experienced.

Limitations

This study contained a few limitations that could have influenced the results. First, the design of the study initially included a design-based intervention involving a collaboration between the instructor of the course and the researcher. Due to the instructor’s limited schedule, she was not involved in the construction of the exploration tasks. She also was not involved in the grading of the last three exploration tasks and class discussions of the exploration tasks. Rather, as the researcher, I graded three of the tasks as to guide students to reflect more when necessary and to verify that students implemented correct mathematics when completing the tasks. I also guided most of the discussion due to the instructor not having much knowledge of the assignments. Had the instructor been involved in the design of the intervention tasks, there may have been a deeper connection made between the concepts taught in class and the four exploration tasks. The instructor also may have included the concept of identity and identity formation more in her design of her lessons.

Second, at times, the instructor’s teaching style and techniques caused conflict with the viewpoints and objectives of the intervention. For example, the instructor did
not place much value on application problems nor did she spend much time on
application problems. While mathematics application problems do not always appear
relevant to students’ selves, they do demonstrate the relevance of mathematics to the real
world and should be included in an algebra course. In addition, algebraic application
problems are often included in the exams required for teacher certification. The
instructor made statements that may have led some students to believe that skipping
application problems is acceptable. Researches have shown that teachers are agents –
intentionally and unintentionally – in students’ identity formation (e.g., Harrell-Levy &
Kerpelman, 2010). The following excerpt from field notes demonstrates the instructor’s
viewpoints and methods for teaching application problems. After walking through an
example of how to set up an application problem on her PowerPoint lecture slides, the
instructor asks students if they understood the problem and procedures to solve the
problem.

Justin shakes his head no and [the instructor] says she cannot either. She says if
she did not look at the answer, she would not know how to do the problem. She
further says she is one of those teachers that skip word problems. When no one
volunteers with an answer, [the instructor] waits. A girl says she did it the way
the book does it. [The instructor] asks how the book did the problem. The girl
explains and [the instructor] writes it on the board. [The instructor] says “good”
and asks if it clarifies the problem for everyone. Students laugh and say no. Jill
puts her head down on her desk. Another student asks the girl what page the
problem is on in the book. [The instructor] asks Alexa understand it and Alexa
says she will just look at it later. [The instructor] says “okay.” Another girl asks
if she can go through the problem step-by-step. [The instructor] quickly goes through the steps. A student asks if it will be on the test and [the instructor] says word problems would be extra credit… She describes word problems as “a necessary evil” (Field notes, 9/15/2015).

The instructor made it clear throughout the semester that word problems would only count as extra credit if given on exams or quizzes. She also would often spend less than a minute working through an application problem in class. Her statements and actions indicated her feelings of uneasiness with application problems, which also appeared with students. Students frequently would come to class asking for help on the word problems from homework assignments or mention that they would skip the application problems when completing homework assignments because the instructor only required students to receive a 70% on an assignment for the instructor to give full credit. This avoidance of application problems limited the perceived relevance of academic content to the four exploration tasks. In addition, students could potentially adopt the instructor’s feelings towards, beliefs about, and actions pertaining to application problems. This could have influenced their beliefs about the importance of relevance in mathematics.

Third, nine students who participated in the class were not included in the study. Five of these participants originally provided consent but withdrew from the course during the initial weeks of data collection. Of the remaining four students, two participants did not consent to the study and two students were missing a significant amount of data due to poor attendance. One of the students that withdrew from the course was a participant in the secondary education focus group. After withdrawing from the course, the focus group became an individual interview. Having the entire population
of PSTs who completed the course in the study may have provided additional insights into the patterns of change in identity since each student was a unit of analysis and provided a unique case.

Finally, the structure of the course may have influenced student motivation to attend class and student ability to focus. Often times, students would either not attend class or attend only the initial portion of class to sign the attendance sheet, hear announcements, and/or submit assignments. This often placed limitations on data collection. For example, if a student was absent during the completion of an identity worksheet, data was missing. In addition, many students expressed concerns about their ability to focus for the entire three and a half-hour class. On the identity worksheets, some students included the length of the class as the strongest factor that influences who they are as mathematics students. Thus, results may have differed had the course been a three-day a week course that meets for one to two hours.

Implications for Practice and Future Research

Understanding both the experiences PSTs have in mathematics content courses and their experiences with developing and negotiating student and teacher identities is beneficial for teacher education programs. The DSMRI model and principles of identity exploration provide teacher education programs and instructors with a framework to design identity exploration tasks and understand student identity. While many mathematics courses taught at the university level remain traditional in structure and teaching techniques (McDuffie & Graeber, 2003), encouraging the adoption of tasks that promote exploration of identity – both as students and as teachers – can help to shift PSTs’ perspectives on and attitudes towards mathematics. This research also displayed
the importance of promoting self-relevance to mathematics concepts and the implications of promoting relevance. As mentioned in the results, PSTs who perceived the assignments as self-relevant often engaged in gathering, exploring, and questioning self-aspects as students and teachers in relation to mathematics. This perceived relevance helped PSTs to see the importance of learning mathematics concepts and the relevance of such concepts to their future teaching careers.

While most early childhood education participants in this study did not report wanting to elect to take additional mathematics courses to increase content knowledge, helping PSTs to shift to beliefs and attitudes that are more positive during their initial mathematics content course potentially could help PSTs engage more and gain more knowledge from their remaining required college mathematics courses as well as their methods courses. While secondary education students will not continue taking mathematics courses, gaining more knowledge from their required mathematics course can benefit them in helping to pass required state tests for certification. To have a better understanding of such implications, additional research should focus on following early childhood PSTs through their remaining mathematics courses and perhaps into the initial teaching years. Longer studies that include the experiences of PSTs during a mathematics content course that implements an identity exploration intervention, additional required mathematics content courses, and mathematics methods courses would be helpful in understanding longitudinal impacts of such interventions. In addition, following the PSTs into their initial years of teaching could shed light on the implications of the intervention on their teacher identity and practices as teachers. For the secondary PSTs in this study, many did not explore identity as mathematics students. For secondary
education PSTs to experience triggering exploration, different tasks that include making a connection between mathematics and other subjects such as social studies and/or English may help to provide such triggers.

Future research should also analyze the influence of having the instructor involved in the design of the identity exploration intervention and implementation of identity related tasks. A key advantage to design-based research is the collaboration between the researcher and the practitioner, which helps to reduce the gap between research and practice. By having the instructor involved, he or she may show more commitment to including identity exploration and perceived relevance to additional aspects of class outside of the designed identity exploration assignments. Comparing such results to the findings of this study may shed additional insight into the importance of teachers as agents in student identity development and implications of teachers as agents.

Conclusions

The current study attempted to implement an intervention on PSTs identities in mathematics and analyze its effects on their identities and motivation. It uncovered patterns of change in the mathematical identity and motivation of PSTs’ who participated in a mathematics content course and the relationship between PST’s initial identity and subsequent exploration. The current study demonstrated that identity exploration can have a positive impact on early childhood PSTs’ mathematical identity, particularly for those who begin the course with negative beliefs and attitudes towards mathematics. In addition, by using a design-based intervention implemented during a college algebra course specifically designed for education students, the current study demonstrated the
patterns of change in identities as students for both early childhood education PSTs and secondary education PSTs. Finally, the study demonstrated the relationship between initial identity and subsequent identity exploration for both early childhood and secondary participants.
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APPENDICES

APPENDIX A

ANXIETY, VALUE, GOALS, AND ABILITY PERCEPTIONS SURVEY

The following questions ask you to rate on a scale some of your feelings towards mathematics. Answer each question by circling the number that best describes your particular feeling. There are no “right” or “wrong” answers, only answers that are most true for you.

1. In general, I find mathematics assignments:

   Very Boring 1 2 3 4 5 6 7 Very Interesting

2. How good in mathematics are you?

   Not at all 1 2 3 4 5 6 7 Very Good
   Good

3. When someone asks you questions to find out how much you know about mathematics, how much do you worry that you will do poorly?

   Not at all 1 2 3 4 5 6 7 Very Much

4. When I run into difficulty doing a mathematics problem, I go back and work out where I went wrong.

   Not at all True 1 2 3 4 5 Very True

5. My aim is to completely master the material presented in this class.

   Strongly Disagree 1 2 3 4 5 Strongly Agree

6. My aim is to perform well relative to other students.

   Strongly Disagree 1 2 3 4 5 Strongly Agree
7. Compared to other subjects, how good at mathematics are you?

Much worse 1 2 3 4 5 6 7 Much better

8. You have a certain amount of mathematical intelligence and there is no way to change this.

Strongly Disagree 1 2 3 4 5 Strongly Agree

9. How well would you expect to do in mathematics this semester?

Not at all 1 2 3 4 5 6 7 Very Good

10. When I am taking a mathematics test, I usually feel:

Not at all 1 2 3 4 5 6 7 Very nervous
nervous or and uneasy uneasy

11. When other students are distracting me in mathematics class, I often find a way to keep concentrating on my work.

Not at all True 1 2 3 4 5 Very True

12. People are born with fixed mathematical intelligence and cannot change this intelligence level throughout their lives.

Strongly Disagree 1 2 3 4 5 Strongly Agree

13. My aim is to avoid learning less than I possibly could.

Strongly Disagree 1 2 3 4 5 Strongly Agree

14. Compared to other subjects, how important is it to you to be good at mathematics?

Not at all 1 2 3 4 5 6 7 Very important
important
15. When I notice that I haven’t been listening to my mathematics teacher, I try to concentrate harder.

Not at all True 1 2 3 4 5 Very True

16. How much do you like mathematics?

Not at all 1 2 3 4 5 6 7 Very much

17. How good would you be at learning something new in mathematics?

Not at all Good 1 2 3 4 5 6 7 Very Good

18. My goal is to learn as much as possible.

Strongly Disagree 1 2 3 4 5 Strongly Agree

19. My goal is to avoid learning less than it is possible to learn.

Strongly Disagree 1 2 3 4 5 Strongly Agree

20. Taking mathematics tests scares me.

I never feel this way 1 2 3 4 5 6 7 I very often feel this way

21. I dread having to do math.

I never feel this way 1 2 3 4 5 6 7 I very often feel this way

22. In general, how useful is what you learn in math?

Not at all Useful 1 2 3 4 5 6 7 Very useful
23. How likely are you to elect to take additional mathematics courses (beyond those required) to increase your content knowledge?

Not at all 1 2 3 4 5 6 7 Very Likely

24. Compared to other students, how good at mathematics are you?

Much worse than other students 1 2 3 4 5 6 7 Much better than other students

25. I am striving to avoid an incomplete understanding of the course material.

Strongly Disagree 1 2 3 4 5 Strongly Agree

26. My aim is to avoid doing worse than other students.

Strongly Disagree 1 2 3 4 5 Strongly Agree

27. For me, being good at mathematics is:

Not at all important 1 2 3 4 5 6 7 Very important

28. Compared to most of your other activities and classes, how useful is what you have learned about mathematics?

Not at all useful 1 2 3 4 5 6 7 Very useful

29. It is very important for me to get good grades in math.

I never feel this way 1 2 3 4 5 6 7 I very often feel this way

30. The topics in this class are important to my career.

Not at all important 1 2 3 4 5 6 7 Very important
31. How likely are you to increase your content knowledge through resources outside of the classroom (e.g., online video lectures, readings, workshops, professional development opportunities)?

Not at all Likely 1 2 3 4 5 6 7 Very Likely

32. I am striving to understand the content of this course as thoroughly as possible.

Strongly Disagree 1 2 3 4 5 Strongly Agree

33. I am striving to do well compared to other students.

Strongly Disagree 1 2 3 4 5 Strongly Agree

34. Before I begin my mathematics work, I think about the things I will need to do.

Not at all True 1 2 3 4 5 Very True

35. When I’m working on a mathematics problem, I think about whether I understand what I’m doing.

Not at all True 1 2 3 4 5 Very True

36. My goal is to perform better than other students.

Strongly Disagree 1 2 3 4 5 Strongly Agree

37. When I finish my mathematics work, I check it to make sure it’s done correctly.

Not at all True 1 2 3 4 5 Very True

38. I am striving to avoid performing worse than others.

Strongly Disagree 1 2 3 4 5 Strongly Agree
39. You can learn new things in mathematics, but cannot change your mathematical intelligence.

   Strongly Disagree  1  2  3  4  5   Strongly Agree

40. My goal is to avoid performing poorly compared to others.

   Strongly Disagree  1  2  3  4  5   Strongly Agree
APPENDIX B

INTERVIEW PROTOCOLS

**Pre-Interviews**

Interviewer: Hi, everyone. My name is Kayla. Thank you for agreeing to talk with me today. I’m a graduate student here at the university and I am conducting research on the changes students may experience as they complete this college algebra class. The purpose of our meeting today is to better understand the students who are participating, and what they hope will happen in the course this semester. So, the focus of today’s interview is your personal perspective.

The online survey you took included an informed consent statement at the beginning. This told you about the project, confidentiality, and how the information will be used. The interview data will be used to understand participants’ experiences in the project, in order to inform ways to provide effective mathematical experiences for prospective teachers.

One part of the informed consent statement indicates that interviews will be recorded. This allows me to pay attention to what you say rather than try to write it all down. The recordings are going to be kept completely confidential and will not be connected to your name. Recordings will be transcribed and transcripts will be used for analysis. We remove any identifiable details, so when we present our report there is no way to know who said what. Is it OK if I record the interview? (If they say no, continue but take notes and review/revise them afterwards).

1. What were some of the most meaningful experiences you had as a student in mathematics class? Why were they meaningful?

2. Can you think of other mathematics experiences that were meaningful, perhaps in a different way? (If they mentioned negative experiences, probe them to think of positive experiences and vice versa.)

3. How do you think these experiences have effected your relationship with mathematics?

4. What provides you the most satisfaction now as a student in a mathematics class?

5. What dilemmas or challenges do you have now as a student in a mathematics class?

6. What do you think it takes for a student to succeed in math/mathematics class?
   a. Do you feel you possess the qualities you just mentioned?
7. What are your hopes and expectations for this class?

8. Where do you image yourself in relation to mathematics in the future?

9. Tell me about how you came about choosing to study <early-childhood, elementary, English, social studies, world language> education.

10. What are your hopes and expectations for your future students?

11. (For early childhood and elementary PSTs) What are your hoped and expectation for your future students in relation to math?

12. (For early childhood and elementary PSTs) How will you help your students succeed in math?

13. (For early childhood and elementary PSTs) How do you feel about teaching mathematics to children in the future?

Interviewer: Thank you again for speaking with me today. I would like to talk with you again at the end of the course. Let’s plan to meet during the study days before your final exam at a day and time that is convenient for you. [Discuss what day works best for the students and schedule post-interview focus group].
Post-Interviews
Interviewer: Hi, everyone. Thank you for agreeing to talk with me again. The purpose of our meeting today is to better understand your experience in the class and project. So, the focus of today’s interview is your personal perspective.

I would like to remind you about the informed consent statement you signed at the beginning of the semester. This told you about the project, confidentiality, and how the information will be used. The interview data will be used to understand participants’ experiences in the project, in order to inform ways to provide effective mathematical experiences for prospective teachers. Is it OK if I record the interview? (If they say no, continue but take notes and review/revise them afterwards).

1. Could you please tell me about your experiences in the course?

2. What were the most meaningful experiences you had in the course? Why were they so meaningful?

3. Can you think of other experiences you had in the course, perhaps in a different way?

4. Could you please tell me about your experiences with the four exploration tasks?

5. How do you think these experiences relate to who you will be as a teacher?

6. What dilemmas and challenges did you experience in the course?

7. What might you take from these experiences for the remainder of your time in the program?

8. What might you take from these experiences to your own classroom one day?

9. How, if any, did your relationship with mathematics change over the course of the semester?
APPENDIX C

IDENTITY WORKSHEETS

Who Are You Currently as a Mathematics Student?

Who are you as a mathematics student right now? Please take a few minutes and think about the core things that make you the mathematics student you currently are. Then, please respond to the following:

1. Currently, one of the strongest factors in my environment that influences who I am as a mathematics student is…

1a. On a scale of 1 – 5, how central is this factor to who you are as a mathematics student now?

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<tbody>
<tr>
<td>Not central</td>
<td>Not very central</td>
<td>Moderately central</td>
<td>Quite central</td>
<td>Highly central</td>
</tr>
</tbody>
</table>

2. Currently, one of my main beliefs as a mathematics student is that in order for mathematics learning to occur well,…

2a. On a scale of 1 – 5, how central is this belief to who you are as a mathematics student now?

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<tr>
<td>Not central</td>
<td>Not very central</td>
<td>Moderately central</td>
<td>Quite central</td>
<td>Highly central</td>
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</tbody>
</table>

3. Currently, one of my most defining personal characteristics as a mathematics student is…

3a. On a scale of 1 – 5, how central is this personal characteristics to who you are as a mathematics student now?

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<tbody>
<tr>
<td>Not central</td>
<td>Not very central</td>
<td>Moderately central</td>
<td>Quite central</td>
<td>Highly central</td>
</tr>
</tbody>
</table>
4. Currently, one of my main goals as a mathematics student is…

4a. On a scale of 1 – 5, how central is this goal to who you are as a mathematics student now?

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<tbody>
<tr>
<td>Not central</td>
<td>Not very central</td>
<td>Moderately central</td>
<td>Quite central</td>
<td>Highly central</td>
</tr>
</tbody>
</table>

5. Currently, one of my main modes of action as a mathematics student is…

5a. On a scale of 1 – 5, how central is this action to who you are as a mathematics student now?

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</tr>
</thead>
<tbody>
<tr>
<td>Not central</td>
<td>Not very central</td>
<td>Moderately central</td>
<td>Quite central</td>
<td>Highly central</td>
</tr>
</tbody>
</table>

6. Currently, my overall feeling about who I am as a mathematics student is:

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<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong dissatisfaction</td>
<td>Moderate dissatisfaction</td>
<td>Mild dissatisfaction</td>
<td>Neutral satisfaction</td>
<td>Mild satisfaction</td>
<td>Moderate satisfaction</td>
<td>Strong satisfaction</td>
</tr>
</tbody>
</table>

If you circled any answer other than Neutral, what is the source of your feeling? ______

7. How do the environmental factor, your belief, personal characteristic, goal, and action as a mathematics student relate to each other? Try to make a logical sentence using what you wrote above to fill-in the blanks: “In light of (the environmental factor from Q1) and (my assumption from Q2), as someone who (my personal characteristic from Q3), I try to achieve (my goal from Q4) by (my action from Q5)”:

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8. How much do the environmental factor, your assumption, personal characteristic, goal, and action as a mathematics student relate to who you are going to be as a future _____________ (early childhood, elementary, special, history, English, language, etc.) school teacher?

<table>
<thead>
<tr>
<th></th>
<th>Not at all related</th>
<th>Not so much related</th>
<th>Somewhat related</th>
<th>Quite related</th>
<th>Completely related</th>
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<tbody>
<tr>
<td>8a. Environmental factor</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8b. Belief</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8c. Personal characteristic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>8d. Goal</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>8e. Mode of action</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

9. Comments (please share any thoughts you have on what you wrote above and/or on your experience answering these questions): ____________________________________________

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________________________________________
Who Are You Going to be as a ________________ (early childhood, elementary, special education, history, English, language, etc.) Teacher?

Who are you going to be as a ______________ teacher? Please take a few minutes and think about the core things that would make you the teacher you are going to be. Then, please respond to the following:

1. One of the strongest factors in my environment that influences who I am going to be as a ________________ teacher is…

______________________________________________________________________________________________

1a. On a scale of 1 – 5, how central is this factor to who you are going to be as a ________ teacher?

Not central  Not very central  Moderately central  Quite central  Highly central

2. One of my main beliefs as a future ____________ teacher is that in order for students to learn well,…

______________________________________________________________________________________________

2a. On a scale of 1 – 5, how central is this belief to who you are going to be as a ________ teacher?

Not central  Not very central  Moderately central  Quite central  Highly central

3. One of my most defining personal characteristics as a future ________________ teacher will be…

______________________________________________________________________________________________

3a. On a scale of 1 – 5, how central is this personal characteristics to who you are going to be as a ________ teacher?

Not central  Not very central  Moderately central  Quite central  Highly central
4. One of my main goals as a future _________ teacher will be...

4a. On a scale of 1 – 5, how central is this goal to who you are going to be as a___________ teacher?

1 Not central 2 Not very central 3 Moderately central 4 Quite central 5 Highly central

5. One of my main modes of practice as a future _________ teacher will be...

5a. On a scale of 1 – 5, how central is this mode of practice to who you are going to be as ____________ teacher?

1 Not central 2 Not very central 3 Moderately central 4 Quite central 5 Highly central

6. Currently, my overall feeling about who I am going to be as a _____________ teacher is:

1 Strong dissatisfacti 2 Moderate dissatisfacti 3 Mild dissatisfacti 4 Neutra 5 Mild satisfactio 6 Moderate satisfactio 7 Strong satisfacti

If you circled any answer other than Neutral, what is the source of your feeling? ________

7. How do the environmental factor, your assumption, personal characteristic, goal, and action as a future _____________ teacher relate to each other? Try to make a logical sentence using what you wrote above to fill-in the blanks: “In light of (the environmental factor from Q1) and (my assumption from Q2), as someone who (my personal characteristic from Q3), I try to achieve (my goal from Q4) by (my action from Q5)”:
8. Comments (please share any thoughts you have on what you wrote above and/or on your experience answering these questions): ______________________________

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APPENDIX D

EXPLORATION TASKS

Exploration 1 – Linear Functions
(Early Childhood/Elementary/Special Education)

1. Create a linear function that you think represents the relationship between a teacher’s mathematical knowledge and his or her success as an early childhood/elementary teacher.

2. Create a linear function that you think represents a teacher’s level of “liking the subject” to success teaching the subject.
Would your answer change if the subject was different (e.g., reading, history, etc.)? Please explain.

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What do the linear functions that you created tell you about yourself? Please explain.
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Exploration 1 – Linear Functions
(Secondary English/Social Studies/World Languages Education)

1. Create a linear function that you think represents the relationship between a teacher’s mathematical knowledge and his or her success in creating connections between his or her subject (e.g., English) and mathematics.

2. Create a linear function that you think represents a teacher’s level of “liking the subject” to success teaching the subject.
Would your answer change if the subject was different (e.g., mathematics)? Please explain.

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What do the linear functions that you created tell you about yourself? Please explain.
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Exploration 2 – Transformations

The following is an example of an application problem that uses transformations.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following polynomial graph shows the profit that results from selling math books after September 1. The polynomial is $p(x) = 5x^3 - 20x^2 + 40x - 1$, where $x$ is the number of weeks after September 1. The publisher of the math books were one week behind however; describe how this new graph would look and what would be the new (transformed) function?</td>
<td>Since we’re moving the time in weeks by 1 week, we are shifting the graph horizontally, or shifting the inside, or $x$ values. Since our first profits will start a little after week 1, we can see that we need to move the graph to the right. When we move the $x$ part to the right, we take the $x$ values and subtract from them, so the new polynomial will be $d(x) = 5(x-1)^3 - 20(x-1)^2 + 40(x-1) - 1$. See how this was much easier, knowing what we know about transforming parent functions?</td>
</tr>
</tbody>
</table>

The above problem involves a horizontal shift. Your assignment is to complete the two questions below. The first question will use a horizontal shift and the second problem will use a vertical shift.

The graphs below represent horizontal shifts. If the graph in the middle is the original function, then the graph on the left is the original function with a horizontal shift left and the graph on the right is the original function with a horizontal shift right.

Horizontal Shift Left | Original Graph | Horizontal Shift Right
---|---|---

Think of an aspect of yourself that could be represented by the original graph in the middle. What are the two variables that you would use for $x$ and $y$ to represent this?


aspect of yourself? Label the x- and y-axis with your variable names. Explain the aspect you have chosen and how you think the middle graph represents the relationship between your two variables.

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What would cause the graph to shift left as represented in the left-hand graph? (In the example above, the publisher being one week behind caused the shift.)

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What would cause the graph to shift right as represented in the right-hand graph?

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Create three graphs below to represent another aspect of yourself that could be represented by a polynomial function. Use the middle graph to represent the original function. Use the left graph to represent a vertical shift down and the right graph to represent a vertical shift up.

<table>
<thead>
<tr>
<th>Vertical Shift Down</th>
<th>Original Graph</th>
<th>Vertical Shift Up</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
<td><img src="image3.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

Explain the aspect and how you think the middle graph represents the relationship between your variables. What are the two variables? Label the x- and y-axis with your variable names. What would cause the vertical transformations to occur?

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What do the graphs and transformations in the above two questions tell you about yourself? Do they tell you anything about yourself as a mathematics student? Please explain.

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How do these graphs help you understand the concept of transformations with functions?
Create a graph of a quadratic function in the graph above. The quadratic should have the following characteristics:

a. An independent x-variable of time (Label the interval of time you are using. For example minutes, days, months, hours, etc.).
b. A maximum value
c. Two real zeros (x-intercepts)
d. A dependent y-variable of your choosing that represents some aspect of yourself that changes over time. (Label the y-axis with your variable name).

Explain what the vertex is in your quadratic function and its meaning.

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Explain the two zeros and the meaning of each.

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How does this graph relate to who you are? What does the graph tell you about yourself? Please explain.
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How do these graphs help you understand the concepts of vertex and zeros with quadratic functions?
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Bonus Question: Can you think of a self-relevant example of a quadratic that would not have any real zeros? Explain your example and why it does not have real zeros.
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This example relates to who I am now and a large part of my life (my career). Think of an example that related to an aspect of yourself and complete the exploration.
With a partner, choose a pair of variables that represents some *aspect of yourselves* expressed with a linear function.

X-Variable:_________________________  Y-Variable:_________________________

Individually create a graph representing your linear functions in the above coordinate plane. Locate two points and find the equation that represents your linear function.
Plot both graphs for you and your partner on the same axes below.

Find the intersection and explain its meaning.

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What does the graph tell you about yourself? What does the graph tell you about your partner? Please explain.

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How does this graph help you understand the concepts of systems of two linear equations?

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With a partner, choose a pair of variables that represents some aspect of yourselves expressed with a linear function.

X-Variable: Years Past Graduation       Y-Variable: Number of Publications

Kayla: (0,2), (1,3), …
Abbey: (0,1), (1,3), …

Intersect at (1,3). This intersection means that one year after graduation, we will have the same number of publications.

This tells me that in order to keep up with Abbey, I should increase my goal of number of publications per year. The graph shows that with a goal of only one publication per year, Abbey will quickly pass me up after we have the same number of publications one year after graduating.
## CODEBOOK

<table>
<thead>
<tr>
<th><strong>Code Name</strong></th>
<th><strong>Code Description</strong></th>
<th><strong>Example Quote</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning/Student Self-Perception</td>
<td>Statements that denote a PST’s perceptions of himself or herself as a learner/student.</td>
<td>“I am doing better and am able to understand the material more.”</td>
</tr>
<tr>
<td>Teaching Self-Perception</td>
<td>Statements that denote a PST’s perceptions of himself or herself as a future teacher.</td>
<td>“I am nervous about being a mathematics teacher but I am ready for the challenge.”</td>
</tr>
<tr>
<td>Learning/Student Beliefs</td>
<td>Statements that denote perceptions and ideas that a PST seems to hold as true about learning.</td>
<td>“All students learn differently. No two students are the same. Some students will be content with the lesson after one example, while others may need to see three examples.”</td>
</tr>
<tr>
<td>Teaching Beliefs</td>
<td>Statements that denote perceptions and ideas that a PST seems to hold as true about teaching.</td>
<td>“As a teacher you get to have fun and everything isn’t so strict all the time.”</td>
</tr>
<tr>
<td>Nature of Mathematics Beliefs</td>
<td>Statements that denote perceptions and ideas that a PST seems to hold regarding the nature of mathematics. This includes beliefs such as there is only one correct answer to a mathematics problem, the mathematics learned in school has little to no relation to the real world, etc.</td>
<td>“Mathematics is a subject that needs a solid foundation. If you cannot do basic algebra, you won’t be able to get any further because the more complex mathematics often use algebra.”</td>
</tr>
<tr>
<td>Student Goal - Mastery</td>
<td>Statements that express a PST’s goals as a student in wanting to increase his or her competence or knowledge.</td>
<td>“I want to make sure that I understand all of the concepts I need to teach well.”</td>
</tr>
<tr>
<td>Student Goal – Social</td>
<td>Statements that express a PST’s goals as a student in wanting to receive social acceptance.</td>
<td>“I’m excited to strengthen my skills in college algebra as much as I can to…prove myself a strong student.”</td>
</tr>
<tr>
<td>Student Goal - Extrinsic</td>
<td>Statements that express a PST’s goals as a student in wanting to receive praise or reward. Also includes grades.</td>
<td>“My motivation is really just that I want to pass and maintain a good GPA.”</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td>Example</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Student Goal - Other</td>
<td>Statements that express a PST’s goals as a student other than mastery, ego, social, and extrinsic.</td>
<td>“[I] want to help overcome my low confidence of my mathematics skills.”</td>
</tr>
<tr>
<td>Teaching Goal</td>
<td>Statements that express a PST’s goals as a teacher.</td>
<td>“It is my goal to instill from the beginning that mathematics should not be feared.”</td>
</tr>
<tr>
<td>Student Action Possibilities</td>
<td>Statements that express a PST’s behavioral alternatives or options that he or she perceives to be available to him or her in any given situation as a student.</td>
<td>“I know I did poorly on my first quiz, but I am going to continue to study and work hard.”</td>
</tr>
<tr>
<td>Teacher Action Possibilities</td>
<td>Statements that express a PST’s behavioral alternatives or options that he or she perceives to be available to him or her in any given situation as a teacher.</td>
<td>“I will have extra worksheets, after school assistance, and review previous chapters before moving onto something new.”</td>
</tr>
<tr>
<td>Change</td>
<td>Statements that indicate any change in beliefs, self-perceptions, goals, and/or actions.</td>
<td>“Although I said that I think one’s interest in a subject is more influential in successful teaching, I am beginning to see that knowledge in the subject can fuel that interest.”</td>
</tr>
<tr>
<td>Experience in Class</td>
<td>Statements that describe a PST’s experience in the mathematics class.</td>
<td>“However, upon taking the quiz, I felt immensely bombarded. This is because the manner in which the wording of the questions were set up and the overall format of the test itself were foreign to me, quite different from not only the problem sets from homework, but also the previous quizzes that I had grown accustomed to.”</td>
</tr>
<tr>
<td>Prior Experience</td>
<td>Statements that describe a PST’s former experiences with mathematics.</td>
<td>“I did not learn anything from my teachers during my freshman and junior years of high school. After that, it was a downward spiral.”</td>
</tr>
<tr>
<td>Personal Background</td>
<td>Information about a PST’s personal background. For example, home life circumstances.</td>
<td>“My dad was a high school mathematics teacher and for some odd reason, he thinks I'm a mathematical genius. I constantly feel like I have to prove myself to him, and I dread getting bad grades in mathematics because he believes in me so much.”</td>
</tr>
<tr>
<td>---------------------</td>
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</tr>
<tr>
<td>Inverse Relationship</td>
<td>Statements that demonstrate an inverse relationship between a PST’s feelings towards mathematics and their hopes for his/her students’ relationship with mathematics.</td>
<td>“Even though I despise math, I will try my hardest to prevent my future students from hating it as well.”</td>
</tr>
<tr>
<td>Value</td>
<td>Statements that shed light on a PST’s perception of the value of the mathematics class or activities in the class.</td>
<td>“The more I thought about the explorations and the tasks we had to do for them the more I appreciated them. It is something that I could see using in the future when I teach, because it takes the lessons that we use and puts them in a different perspective.”</td>
</tr>
<tr>
<td>Exploration</td>
<td>Statements that indicate when a PST gathers information, questions, experiments, or reflects on their beliefs, abilities, and roles.</td>
<td>“This week’s class got me to start questioning myself as to who I am as a mathematics student and as a future early childhood teacher.”</td>
</tr>
<tr>
<td>Mathematics Anxiety</td>
<td>Statements that indicate a PST is experiencing mathematics anxiety.</td>
<td>“I get nervous and my palms sweat at the sight of algebra.”</td>
</tr>
</tbody>
</table>
| Perceived Relevance | Statements that indicate a PST perceives the content as relevant to his or her own life. | “I found the Exploration most interesting and relevant to my daily life. In a way, it was a positive representation of my schoolwork. Sometimes I feel guilty that I do not do a lot of schoolwork when I get home after 8pm, which I do three nights out of the week. However, drawing the graph on the
exploration made me realize that I just have a time period during the day where I am the most productive (afternoon/evening) and a time period where I relax and do other things.”

| Perceived Relevance – Teaching | Statements that indicate a PST perceives the content as relevant to his or her future as a teacher. | “Overall, knowing how to evaluate functions, locate values on a graph, and determine the flow of a graph is beneficial for elementary education teachers to help students understand how to apply mathematical concepts to real world scenarios.” |