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College Student Perceptions of Secondary Teacher Influence on the Development of Mathematical Identity

Kathryn Van Wagoner
Utah State University

COLLEGE STUDENT PERCEPTIONS OF SECONDARY TEACHER INFLUENCE ON THE DEVELOPMENT OF MATHEMATICAL IDENTITY

by

Kathryn Van Wagoner

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Approved:

Amy Bingham Brown, Ed.D. Major Professor	Patricia Moyer-Packenham, Ph.D. Committee Member
Amy Alexandra Wilson, Ph.D. Committee Member	Susan Turner, Ph.D. Committee Member
Yanghee Kim, Ph.D. Committee Member	Mark R. McLellan, Ph.D. Vice President for Research and Dean of the School of Graduate Studies

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ABSTRACT

College Student Perceptions of Secondary Teacher Influence on the Development of Mathematical Identity

by

Kathryn Van Wagoner, Doctor of Philosophy

Utah State University, 2015

Major Professor: Amy Bingham Brown, Ed.D.
Department: Teacher Education and Leadership

This phenomenological study explored how college students' perceptions of experiences with their secondary mathematics teachers affected their mathematical identities. The study was rooted in Wenger's notion that learning is an experience of identity and Dewey's theory that all experiences are inextricably linked to past and future experiences. Constructed narratives of eight college developmental mathematics students with high and low levels of mathematics anxiety were created from autobiographical essays and semistructured interviews. Analysis of the constructed narratives employed a deductive coding process using *a priori* themes related to experiences with secondary teachers and dimensions of mathematical identity.

The study answered three research questions: What kind of experiences did students recall having with their secondary mathematics teachers? How did students perceive that those experiences influenced their mathematical identities? What common student experiences positively or negatively affecting mathematical identity emerged

from the data? Two general factors that affect student mathematical identity emerged from the research: student-teacher interactions and student-mathematics interactions. Interconnectivity existed between positive student-teacher relationships, meaningful student-mathematics interactions, and strong mathematical identities. Positive student-teacher relationships were foundational to the overall connection.

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PUBLIC ABSTRACT

College Student Perceptions of Secondary Teacher Influence on the Development of Mathematical Identity

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Through interviews with college students, this qualitative study explored how the students' experiences with their secondary mathematics teachers affected their relationship with mathematics, known as mathematical identity. The study was rooted in the idea that learning is an experience of identity and in John Dewey's theory that all experiences are inextricably linked to past and future experiences. The eight college students' interview responses were written into biographical narratives and then analyzed within preselected themes related to experiences with secondary teachers and dimensions of mathematical identity. These themes were determined through a review of previously published studies on those topics.

The study answered three research questions: What kind of experiences did students recall having with their secondary mathematics teachers? How did students perceive that those experiences influenced their mathematical identities? What common student experiences positively or negatively affecting mathematical identity emerged from the data? Two general factors that affect student mathematical identity emerged from the research: student-teacher interactions and student-mathematics interactions. Positive student-teacher relationships were foundational to the overall connection. In

essence, students with poor mathematical identities had determined mathematics was not worth knowing because their teachers were not worth knowing, while students with positive identities had teachers who created safe and respectful learning environments. Additionally, meaningful mathematics learning experiences contributed to positive identities.

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CHAPTER I

INTRODUCTION

Although mathematics is a foundational skill in today's technological economy, the majority of Americans consider themselves bad at mathematics, many to the degree of being math phobic. In the U.S., this attitude is socially acceptable. Whether driven by myth or reality, this cultural acceptance has led to a shortage of quantitatively literate citizens (Steen, 1999). In addition to the need for increased numeracy in general, public policy leaders recognize a need for more students to graduate with degrees in science, technology, engineering, and mathematics (STEM; Varma & Frehill, 2010); at the same time, many college students, most studying in non-STEM fields, struggle to learn the mathematics they should have learned in high school so they can complete their college level general education mathematics course(s) (Stigler, Givvin, & Thompson, 2010). Traditional methods of mathematics instruction have done little to change this trend. For many students, the inability to learn mathematics prohibits college graduation. One solution to the growing problem of low student achievement in mathematics may be found in the construct of mathematical identity (Edwards, 2010; Grootenboer & Zevenbergen, 2008). This study explored how learning experiences in secondary mathematics classes affect a person's mathematical identity.

Overview of Mathematical Identity

Research in the affective realm of student mathematics learning led to a recognition of the connection between identity and mathematics learning. Boaler (2002)

first connected identity to mathematics learning as an extension of Wenger's (1998) work on a social theory of learning, and she found identity to be an important notion when considering the relationships students held with mathematics. Wenger saw learning as a process of becoming and described it as an "experience of identity" (p. 215). Grootenboer and Zevenbergen (2008) defined mathematical identity as the student's relationship with mathematics. Since its introduction, mathematical identity has been explored by researchers who are interested in socio-cultural aspects of mathematical learning (Anderson, 2007; Ben-Yehuda, Lavy, Linchevski, & Sfard, 2005; Black et al., 2010; Grootenboer & Zevenbergen, 2008; Heyd-Metzuyanim & Sfard, 2012). The research agreed that individuals develop a mathematical identity through their mathematics learning experiences. As students become mathematics learners they not only need to develop the skills necessary to solve mathematical problems, but they also need to develop the identity of a mathematics learner (Anderson, 2007).

For many decades, mathematics educators have sought the answer to the growing problem of low student achievement in mathematics. More current research has indicated that student achievement in mathematics is tied to mathematical identity (Edwards, 2010; Grootenboer & Zevenbergen, 2008). Axelsson (2009) identified a cyclical relationship between mathematics performance and identity development. Mathematical identity affects performance, which affects identity development, which then affects performance, and so on. Greater understanding about knowledge transfer and mathematical capacity can occur when viewed through a lens that focuses on the inter-relationships of knowledge, practice, and identity (Boaler, 2002).

Academic research has provided much literature about the nature and effects of mathematical identity, but has provided limited insight into the experiences contributing to mathematical identity development, particularly experiences with secondary school teachers. This literature will be explored in greater depth in chapter two. The relationship between identity and mathematics performance makes mathematical identity development an important area of research to provide a lens through which educators and administrators can better understand student learning.

Problem Statement

The teacher's role in facilitating the development of students' mathematical identity is significant. Grootenboer and Zevenbergen (2008) referred to this role as "bridging student and mathematics" (p. 246). Yet, little research existed that focused on the specific interactions between student and mathematics teacher and how those interactions affected student mathematical identity. If, as Grootenboer and Zevenbergen contended, "the goal of mathematics education is to develop students' mathematical identities" (p. 243), and if the major responsibility for facilitating this goal falls on the teacher, then more research is needed to clarify how teachers can help their students build positive mathematical identities. This study contributed to the literature by investigating students' perceptions of their past experiences with their secondary mathematics teachers and how those experiences contributed to their mathematical identity.

Definition of Terms

The following terms are used and operationalized in the context of this study and provided as a reference to the reader.

Developmental mathematics: Precollege-level courses taught at the college or university. These courses are often referred to as remedial mathematics, but in theory include more than just a reteaching of content. The term implies education that develops the whole student.

Mathematical identity: A person's relationship with mathematics.

Open enrollment university: A regional university that serves both a community college and a university mission. All applicants are accepted to the university.

Constructed narrative: A narrative essay constructed from multiple data sources. In this study the narrative essays are constructed from an autobiographical essay, the transcripts from semistructured interviews, and the researcher's reflective journal.

Autobiographical essay: A narrative data source written by the participant describing the individual's lived experiences in response to a writing prompt (Di Martino & Zan, 2009).

Semistructured interview: A qualitative data collection tool organized around a set of open-ended questions, which allow for more in-depth questioning to get to "a wider range of experience" (DiCicco-Bloom & Crabtree, 2006, p. 315).

Purpose and Design of the Study

This study employed a qualitative phenomenological research design in order to

explore and understand the phenomenon of mathematical identity development. The purpose of this phenomenological research study was to investigate college students' perceptions of the experiences they had with their secondary mathematics teachers and how those experiences influenced their mathematical identities. The population for the study was developmental (precollege level) mathematics students at an open enrollment university located in the Mountain West region of the U.S. Of the 26,500 students at the institution, approximately 3,000 students enrolled in developmental mathematics each semester. The participant selection process used two instruments, the Abbreviated Mathematics Anxiety Rating Scale (A-MARS; Alexander & Martray, 1989) and an autobiographical essay (Di Martino & Zan, 2009), to identify students with both strong and weak mathematical identities. Data were collected through semistructured interviews, then consolidated and analyzed to provide a rich description of the students' lived experiences. Chapter III describes the research design and methodology in greater detail.

Research Questions

The research questions that guided the study highlight the personal interactions between teacher and student that have a lasting effect on a student's mathematical identity. The study had three research questions.

1. What kind of experiences did students recall having with their secondary mathematics teachers?

2. How did students perceive that those experiences influenced their mathematical identities?

3. What common student experiences positively or negatively affecting mathematical identity emerged from the data?

Relationship of Study to Personal Experience and Knowledge

As a mathematics educator, I have worked with college mathematics students for 25 years. In this time, I have worked with students who demonstrated a variety of mathematical identities. I have also focused a great amount of effort on increasing student success in mathematics and found students who are challenged by mathematics are more likely to overcome those challenges when they address their affective issues related to mathematics learning. I initially set out to identify the origins of mathematics anxiety and found in the literature that most mathematics anxiety originates around grade nine. Through the literature review process, the idea of mathematical identity was introduced as a more complete means of understanding the affective realm of mathematics learning.

This study provided insight into the specific types of student-teacher interactions that have both positive and negative influence on the development of a person's mathematical identity. The identification of critical behaviors can inform efforts to improve student relationships with mathematics, while strengthening interest in mathematics and increasing success.

The report of this study continues in Chapter II with a review of the literature, discussing the major factors relating and contributing to mathematical identity, and the theoretical framework of the study. Chapter III describes the setting for this study, the instruments and processes used to identify participants and conduct the qualitative

research, and the limitations of the study. Chapter IV introduces the participants of the study, presents the themes, supports each theme with narrative excerpts, and explicitly answers the research questions. Finally, Chapter V concludes with a discussion of the findings within the theoretical framework and presents a model for developing strong mathematical identity. Also discussed are implications for educational practice and recommendations for future study.

CHAPTER II

DISCUSSION OF RELATED LITERATURE

This review of the literature discusses a selection of the major factors relating to and contributing to mathematical identity. The review produced four general categories to examine: (a) elements of mathematical identity development; (b) the relationship among anxiety, attitude, and mathematical identity; (c) teacher constructs that influence identity; and (d) discourse, learning, and identity.

Elements of Mathematical Identity Development

Mathematical identity plays an important role in forming an individual's long-term relationship with mathematics. Grootenboer and Zevenbergen (2008) asserted "The goal of mathematics education is to develop students' mathematical identities" (p. 243). Anderson (2007) concurred, explaining students need to develop the identity of a mathematics learner while in school. Many components make up an individual's mathematical identity (Axelsson, 2009; Bishop, 2012; Black et al., 2010; Hodgen & Askew, 2007).

The Experiential Continuum

To define what makes a worthwhile educational experience, Dewey (1938) developed a theory of experience that explained how past experience informs current experience, which in turn informs future experience. The experiential continuum explained "every experience both takes up something from those which have gone before

and modifies in some way the quality of those which come after" (Dewey, 1938, p. 13). Everyone who studied mathematics through childhood and adolescence has participated in a mathematical experiential continuum. "As students move through school, they come to learn who they are as mathematics learners through their experiences in mathematics classrooms; in interactions with teachers, parents, and peers; and in relation to their anticipated futures" (Anderson, 2007, p. 8). By understanding a student's prior experiences, a teacher can provide a better educational experience for the student and have a more positive effect on the student's long-term relationship with mathematics.

Qualitative studies of mathematical identity provided multiple examples of the mathematical experiential continuum. An analysis of an autobiographical interview and reflective writing of a preservice teacher showed "how her past experiences influenced her past and present mathematical identity and will also influence her future one" (Lutovac & Kaasila, 2011, p. 233). In another study, mathematical biographies created from the narratives of four preservice teachers contained a retrospective explanation that linked central events in each person's past and accounted for how each mathematical identity developed. By searching for clues, the author constructed an explanation for the participants' weak mathematical identity (Kaasila, 2007). Dewey's (1938) experiential continuum provided the foundation for the theoretical framework for this study.

The Four Faces of Identity for Mathematics Learning

Drawing from the social learning theories of Gee (2000) and Wenger (1998), Anderson (2007) developed four faces of identity for mathematics learning—

engagement, imagination, alignment, and nature—situated within Wenger's (1998) view that learning occurs through social participation. "Each face suggests different ways to describe how we see ourselves as mathematics learners although they are all part of the one whole" (Anderson, 2007, p. 11).

Engagement referred to the varying degrees of participation within the mathematics environment, with teachers, peers, and the mathematics itself. Some students saw themselves as capable mathematics learners who are an integral part of the learning environment. Others saw themselves on the periphery of the learning environment due to their inability to make valuable contributions to the classroom or make meaning of the mathematics within the learning environment (Anderson, 2007).

Imagination refers to the images a student has of herself "in relation to mathematics in everyday life, the place of mathematics in post-secondary education, and the use of mathematics in a future career" (Anderson, 2007, p. 9). This view of the broader context of mathematics contributes to either a positive or negative identity as a mathematics learner (Anderson, 2007).

Alignment relates closely to imagination, as a student comes to see himself as one who aligns his energies with the boundaries and requirements of educational institutions. For example, seeing oneself as the type of person who attends college, and therefore registers for college preparatory courses. Conversely, students who meet minimal graduation requirements for mathematics are less likely to see themselves as mathematics learners. Anderson (2007) further explained the relationship between alignment and imagination.

> When beginning high school, students are required to enroll in mathematics courses. This contributes to students' identity through alignment. As they participate in mathematics classes, the activities may appeal to them, and their identity is further developed through engagement. Similarly, students—like the one…who is interested in mechanics—may envision their participation in high school mathematics class as preparation for a career. Mathematics is both a requirement for entrance into the career and necessary knowledge to pursue the career. Thus, identity in mathematics is maintained through both imagination and alignment. (p. 9)

Nature refers to the level of belief that mathematics ability is related to genetics. In spite of research to the contrary, many students still cling to the fallacy that "learning mathematics requires special natural talents possessed by only a few" (Anderson, 2007, p. 10).

Knowledge, Ability, Motivation, and Anxiety

Using a person-oriented perspective, Axelsson (2009) studied the mathematical identity profiles of women with low levels of mathematical achievement and training who were enrolled in basic adult education in Sweden. From a review of the literature, Axelsson developed a theoretical model of mathematical identity containing components based on self-perceptions: self-perceived knowledge, self-perceived ability, self-perceived motivation, and self-perceived anxiety by quantitatively analyzing the relationships between the different self-concepts. Mathematical achievement, measured by high school mathematics grades, held the strongest relationship to mathematical identity. Axelsson was surprised to find that this relationship still existed well into adult life. High self-confidence and achievement correlated with positive mathematical identity and low self-confidence and low achievement correlated with negative identities.

Achievement and Mathematical Identity

More recent research explored causes of low achievement in developmental mathematics, a problem that has plagued higher education across the country. Because of the traditionally taught, sequential nature of mathematics curriculum, students placed in the lower-level developmental mathematics courses faced two full years of developmental mathematics before entering college level mathematics courses, or other college level courses requiring mathematics pre-requisites (Stigler et al., 2010). A very small percent of these students (16% for those needing three courses, 31% for those needing one or two courses) had the persistence to travel through this pathway to college level mathematics (Attewell, Lavin, Domina, & Levey, 2006; Bailey, 2009). Therefore, developmental mathematics, while intended to provide opportunity for students, has become a roadblock for access to a college degree. Some of this lack of persistence has been attributed to student avoidance. In one sample, the Achieving the Dream initiative, about 21% of students recommended for placement in developmental mathematics had not enrolled in a developmental mathematics course within three years of entering college (Bailey, 2009). Another study found that for more than half of those who did not complete the developmental mathematics sequence, the problem was that they never enrolled in the initial courses or in a subsequent course in the sequence (Bailey, Jeong, & Cho, 2010). The problems of avoidance and lack of persistence can be tied to mathematical identity.

Stevenson and Stigler (1994) determined U.S. students see struggle as an indicator of low ability, believing that smart people naturally understand everything and

do not struggle to learn. These students see errors as an indication of an inability to learn, rather than a place where more effort is needed to learn. Dweck (2006) concluded that when students were taught that effort makes a difference in ability to learn, they boost their motivation, participation, and academic performance. Graven (2003) revealed confidence as an important component of mathematical identity.

Anxiety, Attitude, and Mathematical Identity

Anxiety and attitude are the most commonly considered constructs relative to the affective domain of mathematics learning (Hembree, 1990). Mathematics attitude is often implied to be synonymous with mathematical identity, but not consistently. The elements of both are often interwoven, but mathematics identity implied a deeper and broader construct of an individual's relationship with mathematics. According to Malinsky, Ross, Pannells, and McJunkin (2006), "Mathematics anxiety has been the topic of more research than any other in the affective domain" (p. 274) and is rooted in teaching and teachers. Mathematics anxiety is one component of an overall mathematics attitude. Other components attributed to attitude included mathematics appreciation and self-confidence in mathematics (Hembree, 1990).

Recognizing mathematics anxiety as just one component of mathematics attitude and seeking a better construct for understanding student attitude toward mathematics, Di Martino and Zan (2009) produced a three-dimensional model to provide a better definition of attitude. Using a grounded-theory approach, they discovered a set of categories of how students described their own relationship to mathematics in student

essays on the subject “Me and Maths.” The first dimension, *emotional disposition*, paid particular attention to the use of the sentence “I like/dislike mathematics” and words such as “hate,” “love,” “fear,” and “anger,” which were found in 72.5% of the essays. The second dimension was the *vision of mathematics,* referring to the nature of mathematics, activities of mathematics, and/or what needs to be done to be successful in mathematics. The third dimension was the student’s *perceived competence* in mathematics. The second and third dimensions typically interacted with each other as causes of and results of the emotional dimension (see Figure 1).

A population that tends to have high levels of mathematics anxiety, thus providing large samples of mathematics anxious students, is preservice elementary teachers (Brady & Bowd, 2005; Cady & Reardon, 2007; Hembree, 1990). Another reason for a plethora of research on preservice elementary teachers is the concern that “mathematics-anxious teachers may serve to foster the early development of mathematics anxiety among their students” (Brady & Bowd, 2005, p. 39). There is a great interest and need to improve the mathematics attitudes of preservice teachers, and this study

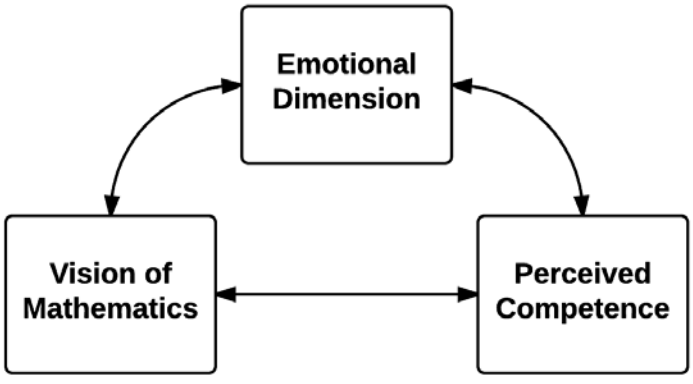

Figure 1. The three-dimensional model for mathematics attitude (Di Martino & Zan, 2009).

contributed to identifying possible sources of anxiety to better prevent it in the future. When considering the sources of mathematics anxiety, the research on preservice elementary teachers provided insight to multiple aspects of the problem, including when it develops. A single negative experience can spur a lengthy negative relationship with mathematics, causing a threat to mathematical identity (Hodgen & Askew, 2007). Only 7% of 157 participants in one study reported only positive experiences in their mathematics classes from kindergarten through college.

The middle grades were frequently identified as the critical time for students to develop a relationship with mathematics (Di Martino & Zan, 2009; Edwards, 2010; Kaasila, Hannula, Laine, & Pehkonen, 2005), and secondary teachers were frequently associated with personalization of mathematics failure (Bibby, 1999). Sixty percent of the preservice elementary teachers in Brady and Bowd's (2005) study of mathematics anxiety reported positive experiences in elementary school, and only 42% had positive experiences in secondary school. Another study indicated that elementary teachers generally had a positive effect on the participants' mathematics attitudes, and negative experiences began in middle school, high school or college (Cady & Rearden, 2007). A meta-analysis supports these results; it collected 10,428 measurements of anxiety by grade, from grade six through postsecondary school, and found "the levels increased through junior high school, peaked near Grades 9-10, and leveled off in upper high school and college" (Hembree, 1990, p. 41). Of additional interest is Cady and Reardon's finding. The high majority (96%) of their participants developed mathematics anxiety from experiences with their mathematics teachers. Based on these indicators, the

theoretical framework for this study identified experience with secondary school teachers as the focus of the research.

Teacher Constructs that Influence Identity

The classroom is a system of social practice in which mathematical identities are formed. In this construct, identity is situated in the context in which a student is participating and cannot be separated from what a student can ultimately do. Therefore, classroom structures and interactions with the teacher affect what students can do (Gresalfi, 2004). This section of the literature review explored teacher constructs that influence mathematical identity.

Student-Teacher Relationships

In her study of eighth-grade boys and girls, Edwards (2010) found the relationship with the teacher to be an important element of identity development that had not been discussed in previous research. While this element was not important for all students, it was a significant factor for many. While analyzing student narratives, she found frequent comments about their teachers. “The stories students remembered about their teachers, the ways in which they felt their teachers viewed them, and their overall opinions about their teachers affected the students’ views of themselves as mathematics students” (p. 230). Students were not interested in developing a social relationship with their mathematics teachers; rather they desired a working relationship to facilitate their mathematics learning.

The teachers in Edwards’ (2010) study tended to be more focused on students’

instructional needs than on relationship building, and in some cases the students' mathematical identities were negatively affected because of the lack of a connection. "The students had high expectations for their teachers, perhaps unrealistically so, but when those expectations were not met they took it personally, and it affected their beliefs about themselves as mathematics learners" (p. 242). Controlling this working relationship can be difficult for a teacher because student perceptions are "impossible to anticipate or control" (p. 236).

Edwards (2010) identified four areas where this working relationship influenced student identity. The important components of the relationship included: student beliefs about how they felt known as learners; effectiveness of the teachers' instruction; positive and negative experiences with their teachers; and student perception of the teacher as nice or helpful. The first component, how the students felt known as learners, provided a unique look at the teacher-student relationship. This type of knowing went beyond the pedagogical content knowledge typically expected of teachers. It entailed knowing about each student's cognitive processing in order to recommend and use the most effective learning strategies for that student. As one student in the study said, "It's kind of a hard thing to ask that they [teachers] should understand each student, 'cause I know they try and they like try to learn names, but then they should try to learn brains" (p. 240).

In a study of teacher-student relationships and academic motivation of secondary school students, Opdenakker, Maulana, and den Brok (2012) found better student outcomes linked to higher degrees of influence (behaviors related to control relative to others) and proximity (interpersonal bonds and connections to others). The authors called

for teachers to be more aware of their behavior and pay more attention to their interpersonal approach to fostering student motivation. By observing teacher talk during small group instruction, Cohen and Lotan (1995) demonstrated that teachers played an important role in positioning students as competent.

To effectively inform and persuade students, teacher behaviors should confirm student identities, build rapport, and facilitate interpersonal relationships. Antisocial attempts to influence students tend to reduce cognitive and affective learning (Turman & Schrodt, 2006). In Jackson and Leffingwell's (1999) study of preservice elementary teachers, mathematics teachers were characterized as being either hostile or insensitive. Behaviors included embarrassing students in front of their peers, demonstrating impatience, or expecting students to grasp difficult concepts with just one explanation. Gender bias was also experienced by many of the subjects of this study. One of Kaasila's (2007) participants, Leila, had mostly negative memories of her mathematics teachers. One teacher favored the successful students, leaving the struggling students to feel inadequate. Leila perceived her teachers to not understand how many difficulties she had in learning. Most of Leila's teachers were negative role models of teaching mathematics. Kaasila et al. (2005) also spoke often of teachers who were negative role models.

Another element is confirmation, "The interactional phenomenon by which we discover and establish our identity as humans" (Turman & Schrodt, 2006, p. 267). Through teacher confirmation students come to understand that they are "endorsed, recognized, and acknowledged as valuable, significant individuals" (p. 266). In an extensive study of nearly 1,500 student essays, Di Martino and Zan (2009) identified the

teacher as a "crucial mediator in [the student's] relationship with mathematics" (p. 37). They called for teachers to reflect on their own vision of mathematics and on their theories of how competence is defined, so they could better work with students' emotions, visions of mathematics, and perceived competence. As Cady and Reardon (2007) pointed out, "Mathematics educators at all levels should be aware of the influence of the affective domain upon mathematics students" (p. 243).

Anderson (2007) asserted that teachers need to be aware of how students see themselves as mathematics learners, and can better situate students' experiences within an identity building framework, such as discussing college entrance requirements, making connections between school and practical mathematics, and dispelling myths about natural mathematics ability. According to Hodge (2008), teachers need to understand more than how competent students feel about learning mathematics and find out "how students think about what it means to learn and do mathematics" (p. 48). In this way teachers are aware of "what students are identifying with as they participate and learn in classrooms" (p. 48).

Kaasila et al. (2005) found that the view of mathematics of a task-oriented student was not usually affected by a bad teacher in a negative way, whereas a student with a socially dependent orientation had difficulty maintaining a positive view of mathematics after experiencing a bad teacher, in spite of experiencing other positive role models. "According to the psychological principle of centrality it seems that the beliefs related to their self are difficult to change. A negative view of the self seems to be embedded in the hard core of their view on mathematics" (p. 223).

Teaching Methods

The literature distinguished multiple outcomes associated with the way a teacher enacted mathematics curriculum. Di Martino and Zan (2009) found students' negative emotional disposition was almost always associated with either an instrumental vision of mathematics or with a low perceived competence. When a teacher has a history of difficulty with mathematics she can better empathize with and understand her students' difficulties, but this can lead to teachers protecting pupils from - or defending them against - mathematics. This is often manifested by making mathematics simpler, using a procedural emphasis which in turn makes learning mathematics boring and irrelevant (Hodgen & Askew, 2007).

Oppland (2010) found socially constructed meanings of experiences (cultural, racialized, classed, and gendered) played prominent roles in weakening students' identifications with mathematics. As students were able, through student-centered learning experiences, "to transform who they perceived as owning mathematical meanings, and to claim greater ownership of those meanings" (p. 447), they strengthened mathematics identities. The teacher's goal should be to help students to experience the same positive relationship with mathematics that the teacher already enjoys, thus bridging the student and mathematics (Grootenboer & Zevenbergen, 2008).

Discourse, Learning, and Identity

Even with the shift away from teacher-centered models in current research-based pedagogy (Walters et al., 2014), the teacher is still a critical element in the classroom,

particularly as a participant in the learning discourse. Teacher talk plays a much more important role in students' learning than is often considered. When teachers interject personal narrative into their mathematical explanations, they create a relationship of trust with their students. It also teaches students about sociocultural positioning by aligning the teacher according to race, gender, ethnicity, and class (de Freitas, 2008). When the teacher speaks mathematically, the students have the opportunity to learn how to speak mathematically.

> The words represent meanings that are waiting to be developed and eventually internalized. Therefore, which words are presented to the students and how they are developed are vitally important. Just as important is that students have opportunities to use these words in their talk and as they work. (Khisty & Chval, 2002, p. 155)

Discourse as Identity Development

Bishop (2012) identified classroom norms, tasks, teacher pedagogy, and curricula as important factors that influence identity on the macro level of learning. However, none of these factors perform in research studies in a consistent or predictable manner. "In fact, students in the same class, engaged in the same activity, abiding by the same classroom norms and participant structures can and do enact very different mathematics identities" (p. 43). In contrast, discourse happens at the micro level of learning, and thus, provides a lens through which the enactment of identity can be explored more richly. Through discourse, researchers can explore the role that others play in identity enactment and explore the variation in identities across the same classroom.

Bishop (2012) used discourse analysis to describe patterns in the interactions of two seventh grade students. The peer-to-peer discourse patterns explained how different

mathematics identities were enacted in the same context. In the case of the participants of the study, they "jointly enacted their mathematics identities through their positioning of each other" (p. 52). One participant spoke with authority and acted as decision maker, taking on the identity of mathematical expert. Simultaneously, the other participant willingly performed her role as dependent, mathematically helpless, and often unknowledgeable.

Teachers can listen to student talk and identify inequitable and unproductive ways that students talk during classroom discourse. "Initiation-response patterns, the distribution of turns of talk, how one is positioned, and whose ideas are taken up are all indicators of identity" (Bishop, 2012, p. 68). Additionally, when a teacher publicly values a student's comment, the student learns to respect his own thinking and begins to enact a strong mathematical identity. Anderson (2007) agreed that students whose ideas and explanations are positively received in classroom discussions come to recognize themselves as members of the community of mathematics learners.

Discourse as Reification

Anna Sfard conducted a series of extensive studies on the micro level about how discourse is used in creating mathematical identity (Sfard & Prusak, 2005a, 2005b). introduced the construct of defining identity as narrative, equating identities with stories about learners. This was different from finding identities expressed in stories. The authors posited that the identities were the stories. What made this construct work was the operational definition that was developed through this study. They defined identity as "a set of reifying, significant, endorsable stories about a person" (p. 14). Reification occurs

through the use of specific verbs that create a state of being: *be, have,* or *can*, but not *do.* These verbs are typically presented with adverbs that stress repeated actions or consistency: *always, never, usually,* and so forth. A story is endorsable if the person telling it "would say that it faithfully reflects the state of affairs in the world" (p. 16). Significance applies if the storyteller feels strongly about the story. "The most significant stories are often those that imply one's memberships in, or exclusions from, various communities" (p. 17).

Identifying stories can be told by the identified person (first person), to the identified person (second person), or about the identified person (third person). Different storytellers, called identity builders, do not always tell the same story. First-person stories tend to carry the most immediate impact on a person's actions. Although the stories are told individually, they work collectively to shape identity. The identified person can be susceptible to endorsing narratives, particularly those told by someone in a position of authority and power, such as a teacher, not realizing "that these are 'just stories' and that there are alternatives" (Sfard & Prusak, 2005a, p. 18).

Heyd-Metzuyanim and Sfard (2012) further refined this framework for studying discourse at the micro level. Building on the definition of identity as, "those narratives about individuals that are reifying, endorsable, and significant" (Sfard & Prusak, 2005, p. 16), they classified parts of discourse as being either mathematizing (about mathematics) or subjectifying (about the subjects doing the mathematics). The identity development occured through subjectifying, which is significant in the mind of the subject and has the power to reify. Subjectifying refers to the same action as telling identifying stories in the

previous study (Sfard & Prusak, 2005b).

Subjectifying occurred at three levels. The first level was about specific performance (“Oh, I forgot” “You said”). The second level was about routine performance (“I can’t” “It boggles my mind”). The third level was about subject of the discourse (“My brain is so slow” “She has a mathematical mind”). When the discourse described a permanent feature of the subject of the discourse (“I never understand fractions”), reification was most likely to occur.

Reification was an important element of this construct, and deserved further clarification. Heyd-Metzuyanim and Sfard (2012) defined reifying as “the discursive activity of rendering status of an object to something that was not necessarily treated this way so far” (p. 131). As an example, a statement about an action, such as, “she never tidies up after herself” (p. 131) reifies into a state of being, such as, “she is very disorganized” (p. 131), which attributes the subject with permanent qualities.

As described in Heyd-Metzuyanim and Sfard (2012), subjectifying can occur in first, second, or third person. Another important element to understand is that multiple lower level subjectifying utterances “can add up to form a coherent narrative, provided they are recurring and consistent” (p. 131). Any utterance that has the “power to reify” (p. 130) and has “significance in the eyes of the speaker” (p. 130) is classified as identifying.

Using this framework to analyze a small group instruction session, Heyd-Metzuyanim & Sfard (2012) discovered that “the learners’ identifying activity interfered with their mathematizing” (p. 143). Similar to the interaction between the students in Bishop’s (2012) study, the students in this group, as well as the teacher, reduced their

opportunities for learning due to frequent positioning of identities within the group. A circular process of adverse identifying ensued, trapping individuals in roles that prevented them from learning. This led to the conclusion that

> The way the learner chooses to participate in a mathematical discourse is affected not only, and perhaps even not mainly, by her mathematical competence and mathematical activity, but also by the question of whether the actions she and others perform are in concert with their self-told identities, with the identity others describe to them, and with the identities they ascribe to others. Finally, teachers' actions, as well-intended as they might, can harm the process of learning by prompting and then fueling counterproductive identifying interactions. Such harmful identifying may be responsible not only for students' failure to learn, but also for some learners' conviction on their "incapability," either mathematical or social. (Bishop, 2012, p. 144)

Although identities are just stories, they can get a life of their own and be very difficult to change. The struggle against mathematical failure may very well begin with perfecting our tools for conceptualizing, analyzing, and assessing students' discursive practices (Ben-Yehuda et al., 2005).

Thinking is an activity of communication and learning mathematics is an initiation to a certain type of discourse—the communicational approach to discourse. In their study of the arithmetical discourse of two 18-year-old girls with histories of learning difficulties, Ben-Yehuda et al., (2005) determined that almost anyone can learn to participate well in arithmetical discourse, and if success is not realized it is mainly because of poor practice by those leading the mathematical discourse.

Explanation of Theoretical Framework

Figure 2 shows the theoretical framework for this study. Dewey's (1938) experiential continuum is the foundation of the framework. Each current experience is

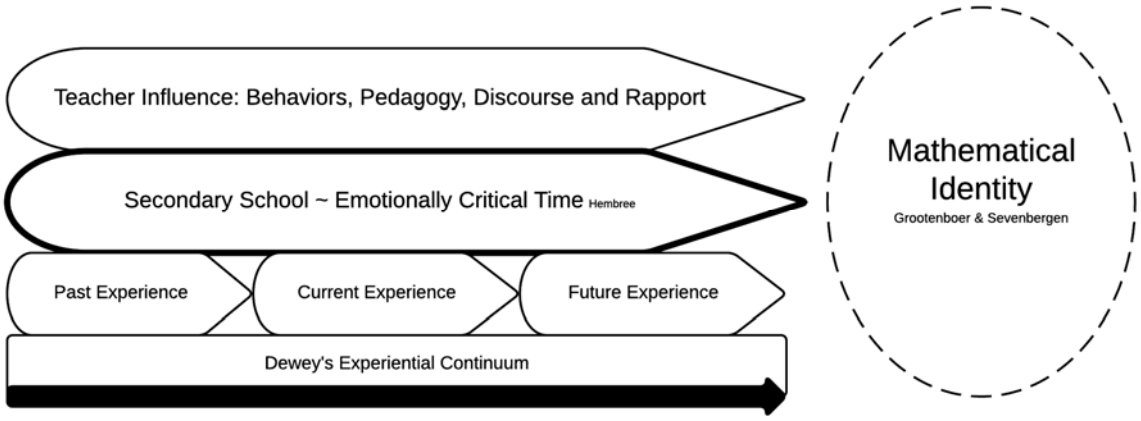

Figure 2. Theoretical framework for the development of mathematical identity.

both affected by past experience and will influence future experience. Hembree (1990) identified secondary school as an emotionally critical time in students' mathematics learning. As such, secondary school mathematics learning experiences have the potential of influencing future mathematics learning experiences and future mathematical identity. Stories that students remember about their teachers' view of them and the students' views of their teachers affect how students feel known as learners (Edwards, 2010) in current and future mathematics learning experiences. Grootenboer and Zevenbergen (2008) contended, "The goal of mathematics education is to develop students' mathematical identities" (p. 243). The dashed line around "mathematical identity" represents the idea that mathematical identity is not concrete and can always change (Ben-Yehuda et al., 2005).

The research questions for this study emerged from this theoretical framework. Question one looked at the experiences students had with secondary mathematics teachers, as secondary school was identified as an emotionally critical time in student development of mathematical identity. Those experiences become part of the student's

experiential continuum relative to their mathematical identity. The study considered graduation from high school, or equivalent, as the point along the continuum where the mathematical identity would be analyzed based on previous experiences. The elements of individual mathematical identity at that time were identified to answer research question two. The collective experiences of teacher influences during secondary school shaped the students' mathematical identities. Research question three sought to find commonalities in students' recalled experiences and subsequent perceptions of their identities for the purpose of identifying key experiences that either positively or negatively affect mathematical identity.

The literature supports the notion that the teacher plays a significant role in the development of mathematical identity. Chapter III outlines the methodology this study used to understand the phenomenon in more detail.

CHAPTER III

RESEARCH DESIGN AND METHODS

Teachers have significant influence on student mathematical identity, which Grootenboer and Zevenbergen (2008) defined as the student's relationship with mathematics. This qualitative phenomenological study explored the phenomenon of mathematical identity development through the recalled experiences participants had with their secondary mathematics teachers.

The qualitative study approach develops "an in-depth exploration of a central phenomenon" (Creswell, 2008, p. 213). Phenomenology uses qualitative methods to describe "the common meaning for several individuals of their lived experiences of a concept or a phenomenon" (Creswell, 2013, p. 76). This study was structured to allow students to look back along their mathematical experiential continuum (Dewey, 1938) and reflect upon those lived experiences that have affected the current phenomenon which, for the purposes of this study, was the development of the students' mathematical identity. While elementary school experiences with mathematics teaching and learning can have a reifying effect on mathematical identity, this study focused on secondary school experiences, as the research identified secondary school as an emotionally critical time in mathematics learning (Hembree, 1990).

This study asked participants to reflect upon their past experience and tell their personal stories. "The process of forming, recounting, and revising stories allows people to maintain a sense of continuity between their past, present, and future selves" (Edwards, 2010, p. 39). Recollection played an important role in this process because rather than

displacing objectivity, recollection can facilitate it. Recollection provided

> …distance and perspective needed for a more comprehensive appraisal of what has actually happened. If the task is to understand how the shape and subjective meaning of a person's life is created out of unfolding events, recollections may be best. (Freeman, Csikszentmihalyi, & Larson, 1986, p. 183)

Additionally, students "are able to identify specific aspects of instruction that help them succeed in both traditional and student-centered classrooms" (Walters et al., 2014, p. 36).

The phenomenological approach is well suited to exploring a research problem "in which it is important to understand individuals' common or shared experiences of a phenomenon" (Creswell, 2013, p. 81). Thus, the stories formed from recollected events were analyzed to answer the three research questions: (a) What kind of experiences did students recall having with their secondary mathematics teachers? (b) How did students perceive that those experiences influenced their mathematical identities? and (c) What common student experiences positively or negatively affecting mathematical identity emerged from the data?

Setting and Participants

This study was conducted at an urban, open enrollment university with a student population of approximately 26,500 students, located in the Mountain West region of the U.S. Over 60% of the students at this university fit within the institution's criteria for nontraditional students: over age 25; married, divorced, or widowed; and/or a parent. One third of the university's students were employed full-time. Only 23% of the students did not work full- or part-time jobs. Sixty percent of students were enrolled as full-time students. At this institution, approximately 3,000 students enrolled in developmental

(precollege level) mathematics classes each fall and spring semester, and approximately 1,100 enrolled during summer term. These students brought varying levels of previous mathematics achievement and self-efficacy to their developmental education experience. Some enrolled in developmental mathematics because they never learned basic mathematics and/or algebra in public school. Others enrolled due to an extended absence from academics and the need to refresh their mathematics skills.

Sampling Instruments

Two instruments were used to conduct purposeful sampling to identify the research participants. The first instrument was the Abbreviated Mathematics Anxiety Rating Scale (Alexander & Martray, 1989). The A-MARS, a 25-item adaptation of the original 98-item Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972), has become the most commonly used measure of mathematics anxiety, in part, due to extensive reliability and validity data. The MARS survey was "constructed to provide a unidimensional measure of anxiety associated with the manipulation of numbers and the use of mathematical concepts" (Capraro, Capraro, & Henson, 2001, p. 376). Participants respond to "short descriptions of real-world and academic situations that may stimulate mathematics anxiety" (p. 376) on a 5-point Likert-type scale. The responses indicate the level of anxiety the participant associates with each statement ranging from 1 (*none at all*) to 5 (*very much*). A number of instruments exist to measure mathematics anxiety, but the MARS has become very popular. Multiple revisions of the MARS have been created including versions for elementary and adolescent students, as well as shortened versions

(Alexander & Martray, 1989; Plake & Parker, 1982; Suinn & Winston, 2003). This study used the A-MARS (see Appendix A) because of its length and appropriateness for the population of the study.

The second instrument used for sampling purposes was an autobiographical essay responding to the essay prompt: "Me and Math: My Relationship with Mathematics Up to Now." This essay prompt allowed the narrator to write about what he considered relevant to his personal experience with mathematics. As part of an Italian national research project, Di Martino and Zan (2009) administered the essay prompt, "Me and Maths: My Relationship with Mathematics Up to Now" to approximately 1,500 students in primary and secondary grades in order to better define the construct of attitude toward mathematics in a grounded theory study. What emerged was a multidimensional characterization of student attitude toward mathematics, which indicated a need for mathematics educators to provide a better diagnosis than simply labeling a student as having a positive or negative attitude. The essay prompt was modified from "Me and Maths" to "Me and Math" for the U.S. context.

Selection of Participants

Participants were selected from the population of developmental mathematics students at an open enrollment university using purposeful sampling to identify those students whose mathematical identity was influenced by interactions with one or more secondary mathematics teachers. Done well, purposeful sampling provides "the most information-rich data possible" (Morrow, 2005, p. 255) and identifies participants who

are ideal examples of the phenomenon. The construct of mathematical identity emerged in part from research on mathematics anxiety; therefore, the first stage of sampling was to identify students with very high and very low anxiety. The second stage identified, within the first sample, students whose mathematical identity was influenced by teachers. Two instruments identified prospective participants for this study—the A-MARS (Alexander & Martray, 1989), and an autobiographical essay. Nine developmental mathematics instructors teaching 19 sections of developmental mathematics assigned 379 students the A-MARS survey and the autobiographical essay in their summer semester developmental mathematics classes, and the teachers invited the students to contribute their survey and essay to this research study. Instructors were provided instructions for how to administer the instruments, but the researcher was not present when the survey and essay were administered. Ninety-eight students contributed their work to the study, although eight of them had not written an essay. Each packet of student work was given a unique identifying number. The A-MARS surveys were scored, and identifying numbers and survey scores were recorded in a spreadsheet. The scores on the A-MARS ranged from 26 (low anxiety) to 108 (high anxiety) from a possible 125 points.

The original study proposal planned for the A-MARS to identify 15 students with the highest levels of anxiety and 15 students with the lowest levels of anxiety. These 30 students' autobiographical essays would be read, for sampling purposes only, to identify 16 students for whom teacher interaction played a significant role. These 16 participants were to be invited to participate in semistructured interviews. Expected indicators of significant teacher influence included both positive and negative behaviors. Descriptions

of the ways in which students felt their teacher viewed them and the student's overall opinion of the teachers indicated how teacher interactions affected the students' views of themselves as mathematics learners (Edwards, 2010). Positive behaviors included building rapport and confirming students' identities as mathematics learners (Turman & Schrodt, 2006). Negative behaviors included embarrassing students in front of their peers, demonstrating impatience, and gender bias (Jackson & Leffingwell, 1999).

Because of the small number of willing participants and the brevity of most of the essays, all 98 essays were read and scored for mention of teacher influence, either implied or explicit, on a scale of 0 to 2. An essay with any mention of a teacher was scored as 2, any mention of secondary school was scored as 1, and no mention of secondary school or a teacher was scored as 0. These scores were added to the sampling spreadsheet, as shown in Figure 3. While reading the essays, the researcher looked for statements that implied a relationship between the teacher behaviors and the student's current relationship with mathematics. For example, "Mrs. C. made learning mathematics so much fun that I have always loved mathematics since she was my teacher." Or "Ms. Smith convinced me that I would never be able to learn math."

Most of the student essays were 100 to 300 words in length with only a few providing more in depth information. Most mentions of teacher influence were brief and very few indicated a connection between previous experience and current feelings about mathematics. The following examples are typical of the statements about teachers found in the essays.

	A	B	C	D	E	F	G	H
1		Purposeful Sampling Record						
2								
3		Document #	MARS Score	Essay				
4								
5	A.1	11437-1	74	0				
6	A.2	11437-2	39	0				
7	A.3	11437-3	74	2				
8	A.4	11437-4	83	0				
9	A.5	11439-1	80	1		0 = nothing about school or teacher		
10	A.6	11439-2	84	0		1 = mentioned secondary school		
11	A.7	11439-3	79	0		2 = mentioned teacher		
12	A.8	11439-4	67	0				
13	A.9	11439-5	101	2				
14	A.10	11439-6	69	1				
15	A.11	11439-7	46	1				
16	A.12	11439-8	57	0				
17	A.13	11442-1	61	0				
18	A.14	11442-10	26	2				
19	A.15	11442-11	68	1				
20	A.16	11442-2	71	0				
21	A.17	11442-3	35	2				

sort by ID | sort by MARS | sort by IDMARS | Tracking | +

Figure 3. Screenshot of researcher's record of participant information.

> I think a lot of the problem was I did not have the best teacher. (Student A.62).
>
> Through hard work and effort on mine, teachers, and parents parts I was able to get by alright and pass my classes with mostly B's. (Student A.14)
>
> Teachers are a huge benefit or hindrance for math. Some can teach and make it easy and enjoyable. Others, well, it can be really hard to enjoy and even understand the math. (Student A.82)
>
> …when I had to take Algebra II my teacher was not a personable man and told me that I would never get it. From then on I have been extremely afraid of it. (Student A.78)
>
> …my teacher was great and really took the time to help me understand the concepts and equations in her class. (Student A.23)

In total, 18 students mentioned teachers in their essays. These students' scores on the A-MARS ranged from 26 to 108 out of a total of 125 points. All 18 students were

invited to participate in semistructured interviews. Each student was emailed up to 4 times, and those who provided phone numbers were contacted by telephone. Some students were encouraged by their instructor to respond to the email invitation. After six weeks, 14 students agreed to be interviewed. Eight of the 14 completed both interviews and member checking.

Data Collection

Constructed Narratives

Edwards (2010) described narrative structuring as "an essential part of being human" (p. 11). As humans, we "make sense of random experience by the imposition of story structures" (Bell, 2002, p. 207). The original conceptualization of narrative inquiry arose from John Dewey's notion that life is education. This led to the idea of investigating lived experience (Clandinin, Pushor, & Orr, 2007). When people tell their own stories, they often uncover information they did not consciously know themselves (Bell, 2002), which sheds light on the identities of individuals (Creswell, 2013). The data source for this study was constructed narratives created from the autobiographical essays used in the sampling process and transcripts from semistructured interviews.

Semistructured Interviews

Data for this study were collected in two semistructured interviews. The first interviews lasted up to 1 hour in length and were conducted face-to-face on the university campus in a small group study room in the university library or in an empty classroom at the satellite campus. Due to the difficulty of scheduling the first interviews and the

richness of the data received in the first interviews, the second interviews were conducted by telephone. This was a variation from the original proposal to meet face-to-face for both interviews. Creswell (2013) recommended between 5 and 25 participants for a phenomenological study. The goal was to interview between eight and ten participants, ensuring enough participants to be able to fully investigate the range of common experiences while allowing sufficient time to spend with each participant to gather a rich data set. In the end, nine participants participated in first interviews. Eight completed the entire data collection process.

The first interview allowed each participant to reflect upon lived experience and tell his/her personal story of learning mathematics in secondary school. Details of the structure of these interviews are in a later paragraph. After the first interview, a narrative was constructed from the participant's essay and interview transcript. While writing the constructed narratives, the researcher embedded additional questions to ask in the second interview. These questions ranged from a missed detail such as the participants rank in college to a request to elaborate on a specific experience that was not fully discussed in the first interview. At the second interview, the embedded questions were asked of the interviewee. The interviews were recorded using two instruments, the Voice Recorder app on a cell phone and the Recorder app on an iPad. The researcher transcribed the interviews using the software *Transcribe*, shown in Figure 4, which allowed the user to control the audio file and type the transcript in the same browser window. After the second interview, the constructed narrative was updated and emailed to the participant for review and member checking. Nine students participated in the first interview. Eight

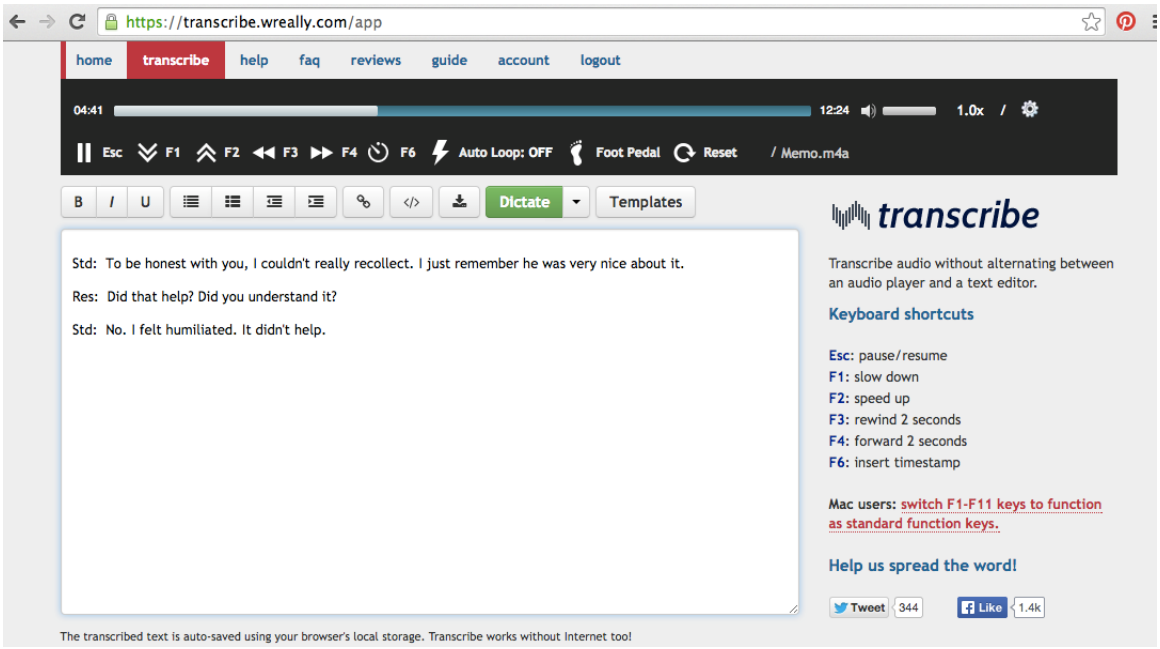

Figure 4. Screenshot of Transcribe webpage.

participants followed up with the second interview and the request for member checking. All but one agreed that the narrative was accurate. That one provided a correction on the use of a teacher's name.

The researcher kept a reflective journal to record "ideas, reactions, and conclusions" (Howard, 2008) during the interview stage of the project. The journal was used to jot down thoughts during the interview and to manage researcher bias. Notes from the journal were integrated into the writing of the constructed narratives, but the journal did not provide significant content for the constructed narratives.

Phenomenological studies seek to find an overall essence of the lived experience and "fully describe how participants view the phenomenon" (Creswell, 2013, p. 81). This is best facilitated through in-depth interviews that are guided by two broad questions that ask participants what they have experienced in terms of the phenomenon and what

situations influenced or affected the experiences of the phenomenon (Creswell, 2013). Following this recommended procedure, the first interviews focused on two general questions: (a) Describe the experiences you have had with your junior or senior high school mathematics teachers, and (b) How have these experiences influenced your relationship with mathematics today? Asking very broad questions provided room for the participants to tell their own story, but further questioning led to a more detailed description of the phenomenon. Therefore, the first interview followed an interview protocol (see Appendix B) that included the two general questions as well as open-ended questions that encouraged participants to further share the details of their experience. The creation of the questions was informed by the literature on elements of mathematical identity and teacher constructs that influence identity.

Data Analysis

Constructed narratives were created from the autobiographical essays, the semistructured interview transcripts, and the researcher's reflective journal. The constructed narratives were analyzed through a deductive coding process. Typically, this coding process uses *a priori* codes derived from a theoretical model or existing literature on the topic of interest (Kodish & Gittelsohn, 2011). For this study deductive coding was done within the framework of the literature review. Additionally, Creswell, (2013) recommended researchers using deductive coding be open to additional codes or dimensions of codes emerging during the analytic process to avoid limiting the findings.

Coding for research question one (What kind of experiences did students recall

having with their secondary mathematics teachers?) addressed the following themes found in the literature: Behaviors of teachers (Jackson & Leffingwell, 1999; Kaasila, 2007; Turman & Schrodt, 2006), relationship building (Edwards, 2010; Opdenakker et al., 2012), effectiveness of pedagogy (Di Martino & Zan, 2009; Grootenboer & Zevenbergen, 2008; Hodgen & Askew, 2007; Oppland, 2010; Walters et al., 2014), and discourse and subjectifying (Ben-Yehuda et al., 2005; Bishop, 2012; Heyd-Metzuyanim & Sfard, 2012; Sfard & Prusak, 2005b). The researcher looked for statements that fit within each theme. Table 1 provides examples of the types of statements that might fit each theme. The coding system was open to any unanticipated themes that may have emerged. However, the *a priori* themes were broad and contained all the statements in the data.

The four themes were divided into positive and negative categories. Each category was assigned a color, and text in the narratives was highlighted to indicate

Table 1

Example Statements that Fit Themes from the Literature Related to RQ 1: What Kind of Experiences did Students Have with Their Secondary Teachers?

Theme	Positive and negative examples
Behaviors of teachers	"She was very patient with me when I didn't understand." "She just yelled the entire time we were doing our work."
Relationship building	"My teacher liked me."
	"My teacher didn't care if I showed up."
Effectiveness of pedagogy	"She brought in sticks and materials that we used to understand the math."
	"The teacher always did all the work so all we had to do was copy it down."
Discourse and subjectifying	"He always would say to me 'there's my star student.' "
	"My teacher told me, 'you're not very good at this, are you?' "

occurrences of each theme. See Appendix L for a sample of color-coded text. For example, positive (noninstructional) behaviors of teachers and negative (noninstructional) behaviors of teachers were each assigned a distinct color. Positive theme categories were assigned a bright highlight color, and negative theme categories were assigned a coordinating dark highlight color (see Table 2). The theme of effective pedagogy included teacher knowledge of mathematics as well as mathematical knowledge for teaching.

Coding for the research question two (How did students perceive that those experiences influenced their mathematical identities?) followed a similar pattern using the following themes from the literature: perceived competence (Axelsson, 2009; Di Martino & Zan, 2009, Hembree, 1990), motivation (Axelsson, 2009; Cohen & Lotan, 1995; Opdenakker et al., 2012), anxiety (Brady & Bowd, 2005; Cady & Rearden, 2007; Hembree, 1990; Hodgen & Askew, 2007), emotional disposition (Di Martino & Zan, 2009), and vision of mathematics (Anderson, 2007; Di Martino & Zan, 2009; Hodge, 2008). Coding for the second question was done on a clean document of the constructed

Table 2

RQ 1 Color Coding Scheme

Theme	Assigned color
Positive behaviors of teachers	Turquoise
Negative behaviors of teachers	Royal blue
Positive relationship building	Pink
Negative relationship building	Purple
Effective pedagogy	Light green
Ineffective pedagogy	Dark green
Positive discourse and subjectifying	Yellow
Negative discourse and subjectifying	Brown

narrative, so every statement was equally visible for coding. Table 3 provides examples of the types of statements that might fit each theme.

These themes were color coded for their positive and negative instances, similar to the teaching themes. Each category was assigned a color, and text in the narratives was highlighted to indicate occurrences of each theme as indicated in Table 4.

Table 3

Example Statements that Fit Themes from the Literature related to RQ 2: How Did Those Experiences Influence Their Mathematical Identities?

Theme	Positive and negative examples
Perceived competence	"Math was always easy for me." "No matter how hard I try, I can't get it."
Motivation	"I worked hard so I could get good grades." "I tried to avoid doing math."
Anxiety	"I would do mathematics homework to help me relax." "I had panic attacks every time I had to take a test."
Emotional disposition	"I love math." "I hate math."
Vision of mathematics	"Math is everywhere." "I think mathematics is useless."

Table 4

RQ 2 Color Coding Scheme

Theme	Assigned color
High competence	Pink
Low competence	Purple
High motivation	Yellow
Low motivation	Brown
Low anxiety	Turquoise
High anxiety	Teal
Positive disposition	Light Gray
Negative disposition	Dark Gray
Positive vision	Light Green
Negative vision	Dark Green

After the narratives were color coded, each narrative excerpt was inserted into a spreadsheet and labeled with the participant's name, the research question, and the theme the excerpt related to. The spreadsheet was used to sort, separate, and organize the narrative excerpts for reporting and analyzing the data. See Figure 5 for a screenshot of the spreadsheet.

Limitations and Validity

"Narrative research issues claims about the meaning life events hold for people. It

	A	B	C	D
1	Participant	RQ	Theme	Excerpt
2	B	1	IP	he never found his math classes to be terribly exciting. You went to class, learned what you had to learn, and did the homework. "Math wasn't as much about learning the subject as it was completing the homework because all that matters is what grade you got on your assignments and tests. Not whether you understand it or not."
3	B	1	EP	He gained an appreciation for math in a high school engineering program. In that class he enjoyed math a lot more because they were able to immediately apply the math they learned in a real world application. He found he liked math a lot more when it was actually useful. It was a lot easier to focus and pay attention to math and to want to do it on his own when there was a reason behind why he was learning it.
4	B	1	IP	In these classes students typically filled out guided notes pages while the teacher was teaching, After the lecture, they had about 10 minutes to work on a set of practice problems on their own and ask questions of the teacher while they were working. Sometimes they had worksheets that had a game-like activity, such as solving a word puzzle by getting the right answers to a set of math problems. Braden liked math, even though it "wasn't super interesting, not something you'd go out and just do for fun." He didn't have a problem doing it and he didn't dread doing it. It was just school. And he did enjoy it more than his English classes.
5	B	1	EP	the teacher was really good. She would write a problem on the board and the students would each work it on a small square of whiteboard. The teacher used this method to check understanding of the concept. Students could erase and rework incorrect problems. When the teacher identified a common misunderstanding she would explain it in more detail to the entire class.
	B	1	IP	Another teacher wasn't as helpful. She did more lecturing and left students to figure out the math on their own. It was a lot harder for Braden to understand since they didn't do as much practical work, mostly lectures.

Figure 5. Screenshot of the spreadsheet used to organize narrative excerpts.

makes claims about how people understand situations, others, and themselves" (Polkinghorne, 2007, p. 6). Limitations are inherent in any study and existed for this study. One limitation was the self-selective nature of the sampling process. While the survey and essay identified appropriate participants for the study, the students had the option of whether or not to participate. Most of those who chose to participate had weak mathematical identities, which could have been due to selecting participants from a population of only developmental mathematics students. This limited the data about students with healthy mathematical identities. The lack of diversity of the population was a limitation. An additional limitation was the possibility of nonobjective reporting, commonly characteristic of autobiographical storytelling. Many of the participants had been away from secondary school for a number of years, so they lacked the more recent recollections that a younger college student would have. However, as phenomenological research, this study did not seek historical truth, rather narrative truth (Di Martino & Zan, 2009). The narrative truth in this study was rich with the social and psychological perceptions that made up the participants' individual identities.

The reflective journal is one of the precautions and preventive measures taken to verify the data of this study. Creswell (2013) recommended the use of at least two of the following eight possible verification procedures in qualitative studies: prolonged engagement and persistent observation, triangulation, peer review or debriefing, negative case analysis, clarification of researcher bias (reflexivity), member checking, rich and thick description, and external audits. The reflective journal provided clarification of researcher bias. Additionally, this study employed triangulation by using three sources of

data: autobiographical essays, face-to-face semistructured interviews, and the reflective journal. A third verification procedure was member checking. Participants were asked to read drafts of the narratives developed from their essays and interview transcripts and provide feedback regarding the accuracy of the narrative. The combination of these methods elicited a rich and thick description of the phenomenon.

Positionality of the Researcher

As a mathematics educator of over 25 years, I brought my own experiences and ideas to this research experience. Students commonly attribute their success or failure in mathematics to teachers. Although teachers play a relatively small role in the student's ability to learn (Nolting, 2002), I do believe strongly in the ability of a teacher's words to affect a student's mathematical identity through subjectifying (Sfard & Prusak, 2005b). My subjective lens created some expectations for the findings of this study. I expected to have no problem finding students who attributed their relationship with mathematics to their teachers. I did not expect students to understand the idea of a mathematical identity and its influence on their mathematical achievement. To manage my subjective lens I kept a reflective journal for recording my own values and perceptions, keeping them separate from the transcribing of the interviews. The journal served as an "ongoing record of [the researcher's] experiences, reactions, and emerging awareness of any assumptions or biases that come to the fore" (Morrow, 2005, p. 254).

Summary

Through the use of rigorous qualitative methods, this study identified the experiences students had with secondary teachers that influenced the students' mathematical identity. Edwards (2010) cited a need for more studies about how students, particularly those with difficulties with mathematics, relate to mathematics. By identifying the experiences that affect this relationship with math, mathematics educators can take measures to improve individual's mathematical identities.

CHAPTER IV

RESULTS

The purpose of this study was to explore and understand the phenomenon of mathematical identity development and how it is affected by student experiences with secondary mathematics teachers. This study was constructed to answer three research questions: (a) What kind of experiences did students recall having with their secondary mathematics teachers? (b) How did students perceive that those experiences influenced their mathematical identities? and (c) What common student experiences positively or negatively affecting mathematical identity emerged from the data? These questions are explicitly answered in this chapter. Discussion of these results will continue in Chapter V.

For this phenomenological study, eight developmental mathematics students from a 4-year, open enrollment university were selected purposefully based on responses to the A-MARS mathematics anxiety survey (Suinn & Winston, 2003) and an autobiographical essay. The students ranged in age from 19 to 38. Four of the participants were males and four were females. All were Caucasian. To understand the common and shared experiences of mathematics students, this study allowed students to look back along their mathematical experiential continuum (Dewey, 1938) and reflect upon those lived experiences that affected the development of their mathematical identity. As was explained to students in the informed consent forms (see Appendix C) and in the interview, students received a pseudonym for the report of the study to protect their privacy and assure anonymity. The names used in this report reflect nothing other than

the gender of each participant.

Brief Introduction of Each Participant

This section includes a brief summary of each participant's constructed narrative. The full narratives were constructed from autobiographical essays and semistructured interviews. These are in Appendices D through K. Table 5 summarizes key characteristics of each of the eight participants and serves as a resource to the reader. Additional information about the students' anxiety and relationship with mathematics is provided in the summaries following the table.

Blake was a 19-year-old freshman majoring in mechanical engineering. He had a low anxiety score of 35 and a positive relationship with mathematics. He never felt the need to develop relationships with his mathematics teachers. He saw them purely as a source of information. In general, he learned from them that he could usually solve any

Table 5

Summary of Participant Descriptions

Name	Age	Rank	Major	Anxiety	Relationship w/math
Blake	19	Freshman	Mechanical engineering	Low	Positive
Cody	28	Sophomore	Psychology	Low	Weak
Devin	22	Freshman	Pre-med	Low	Positive
Heather	30	Freshman	Visual communications	High	Negative
Joel	38	Junior	Field service operations	Moderate	Negative
Kayla	21	Freshman	English	High	Medium
Lauren	23	Junior	Business management	High	Love-Hate
Sadie	36	Sophomore	Social work	High	Negative

problem if he worked at it hard enough. He did not find his mathematics classes to be terribly exciting. He gained an appreciation for mathematics in a high school engineering program where he learned to apply the mathematics in a real-world application. He found he liked mathematics a lot more when it was actually useful. He highly valued mathematics, recognizing that we cannot really do anything without mathematics. He believed mathematics was good to know, even if one never really used it.

Cody was 28-year-old sophomore majoring in psychology. He had a low anxiety score of 37 and a weak relationship with mathematics. Cody did not develop relationships with any of his secondary school teachers. He preferred to keep a low profile—did not perform too well or too poorly to draw attention to himself. His negative experience with a teacher in fifth and sixth grade had a significant impact on him. Most of his high school teachers were good. They spoke encouraging messages to the classes as a whole, and once in a while they would work closely with and provide extra encouragement to those who were struggling. However, he never felt personally encouraged. The lack of encouragement eventually led to his giving up with each class. Cody established a consistent pattern of doing well at the beginning, then giving up and quitting when the course became more challenging. Cody had no motivation to learn mathematics because he didn't see that mathematics had any value to him. In eleventh grade Cody's family moved to Western Samoa, where he took the GED instead of graduating from high school.

Devin was a 22-year-old freshman who planned to become a doctor. He had a lower anxiety score of 42 and a positive relationship with mathematics. Devin had very

positive experiences with his secondary mathematics teachers. He highly valued their willingness to work individually with him. If he could not figure something out, he asked his teachers for help and was very satisfied with all of his teachers. This helped Devin develop confidence in his ability to learn mathematics. He also had a strong appreciation for the value of mathematics, which began in eighth and ninth grade engineering classes.

Heather was a 30-year-old freshman majoring in visual communications. She had a high anxiety score of 77 and a negative relationship with mathematics. At the time she entered seventh grade, Heather already did not like mathematics and struggled to learn it. She had leukemia as a child and missed a lot of mathematics instruction because of her illness. With one exception, Heather described her junior and senior high school teachers as uncaring. Heather avoided building any kind of relationship with those teachers. The one positive exception in Heather's secondary experiences was her 11th grade teacher who developed a positive rapport with the students, made herself available to help, and explained the concepts behind the procedures. Heather had no confidence in her ability to learn mathematics when she completed high school. She also believed her problems with mathematics were genetic. Heather never saw the value of mathematics in her personal life, but recognized its value in the world in general. Fear of mathematics deterred her from going to college to pursue a degree.

Joel was a 38-year-old junior majoring in field service engineering operations. He had a moderate anxiety score of 51 and a negative relationship with mathematics. Joel had a demeaning experience with his sixth grade teacher that killed his motivation to learn mathematics. He struggled with learning in general and had a very weak support

system at home. There was no one to motivate him to do anything. Those factors, combined with the bad experience in sixth grade, led to him not caring about school. After sixth grade, Joel never participated in a mathematics class. He began working nights and sleeping in class. A lot of his teachers in general would pay no attention to him or tell him he was a waste of time. A guidance counselor told him he should quit school. He dropped out of school soon after starting high school. Mathematics was a non-entity for Joel when he was a teenager. He believed he would grow up and never use mathematics. Joel later earned his GED through a university program.

Kayla was a 21-year-old freshman majoring in English. She had a high anxiety score of 73 and an average relationship with mathematics. Kayla placed her ability to succeed in mathematics squarely on her teachers. She always believed that if she could work hard enough and get a good teacher, then she could understand it. Fortunately, most of her teachers were good, by her standards. They explained things step by step, often providing visual cues or other techniques to help students memorize formulas and processes. They gave positive encouragement and were willing to answer her questions. When she had a good teacher, she had a positive attitude toward learning mathematics. When she understood the mathematics, she felt motivated to work hard. While she recognized that mathematics had value in the world and that it enhanced her life, she saw mathematics more as a milestone to be achieved so she could go on with life. She did not expect to ever actually apply mathematics in her life, particularly the things she learned in algebra.

Lauren was a 23-year-old junior majoring in business management. She had a

high anxiety score of 88 and a love-hate relationship with mathematics. Lauren's relationship with her teachers was based on how she perceived them as a mathematics teacher. If the teachers were able to help her understand mathematics, then she loved them. If she did not understand what they were trying to teach, she did not like them. Lauren's relationship with mathematics was also dependent on whether or not she understood. If she did not understand a concept she did not like it, but if she understood a concept she liked it. She did not see the point of algebra, so she generally did not like it. Typically she found it easier to do mathematics that she could equate to money because that made more sense to her. Lauren recognized the value of mathematics in the world, but if it had no value in her own life, she did not like it. Good grades were really important to her, so she was motivated to learn the mathematics to get a good grade. Mathematics was simply a requirement to be met.

Sadie was a 36-year-old sophomore majoring in social work. She had a high anxiety score of 71 and a negative relationship with mathematics. Sadie hated mathematics all through secondary school. She was always in the lower mathematics classes for slower or troubled students. She had mostly male teachers who were generally tough athletics coaches. These teachers intimidated her. She was quite sensitive to the classroom environment and unwilling to ask questions. Sadie's one positive experience was her eleventh grade mathematics class. She passed the class because the teacher's philosophy was if the student tried the student got credit. He created a positive learning environment, so Sadie was more willing to try to learn and ask questions. When Sadie finished high school she did not think she was capable of learning mathematics, and she

wanted to stay as far away from it as possible. In spite of her dislike of mathematics, she recognized that it was used all the time.

Narrative Excerpts

To gain an understanding of the lived experiences of the participants in this study, the phenomenological analysis of the data were deductively coded using the themes that emerged in the literature review. These themes were categorized based on the first two research questions: experiences students recalled having with secondary teachers, and elements of mathematical identity. This section presents excerpts from the constructed narratives related to the categorized themes for research questions one and two. Some excerpts are relevant to and included in more than one category. For example the following excerpt is included in the categories of effective pedagogy and high motivation.

> It was a lot easier to focus and pay attention to math and to want to do it on his own when there was a reason behind why he was learning it. (Blake, lines 17-18)

For formatting consistency and ease of reading, each excerpt is presented and punctuated as a complete sentence in this section, even though many are phrases or parts of complex sentences in the actual constructed narratives. Quotation marks indicate the actual words of the students as quoted in the constructed narrative.

RQ 1: Experiences with Secondary Teachers

The literature produced the following themes relevant to research question one: behaviors of teachers, relationship building, effectiveness of pedagogy, and discourse and

subjectifying. Students described positive and/or negative experiences within each of these themes. The following narrative excerpts answer research question one: What kind of experiences did students recall having with their secondary mathematics teachers?

Behaviors of teachers. All except two of the participants described either positive or negative behaviors of teachers. These exclude specific behaviors directly focused on relationship building or representing pedagogy. The following narrative excerpts reflect positive behaviors.

> He mostly remembers this teacher was always willing to work with students (Devin, lines 22-23).
>
> She was "very willing to work with you. I remember going in a lot for tutoring and getting that extra help" (Devin, lines 29-30).
>
> A lot of times they would teach you in class, but if you sat down and talked to them they would show you an easier way, a better way for doing it than the original pattern that they teach (Devin, lines 53-55).
>
> She was willing to help during class (Heather, line 45).
>
> Instead of going to lunch with the other teachers, she would eat lunch in her classroom and be available to help students (Heather, lines 55-57).
>
> They knew she struggled with math and always put it in a way that she would understand it (Kayla, lines 39-40).
>
> She would get one-on-one help from the teacher (Lauren, lines 24-25).
>
> The teacher worked with the students "a little bit more" and she appreciated that environment (Sadie, lines 43-44).
>
> The philosophy of her junior year high school math teacher (who was also a coach) was if the student tried, the student got credit (Sadie, lines 42-43).
>
> They were understanding of how busy life could be and how dreary homework was, but still pushed you to completing it anyway (Blake, lines 51-53).
>
> If he tried something and did it wrong, the teacher wasn't going to get mad about

> it and would be willing to work with him to understand. Because of this he was willing to attempt to solve any problem (Blake, lines 76-78).
> The 12th grade teacher was friendlier with the students and a lot easier to talk to, so it wasn't intimidating to ask her questions (Blake, lines 59-60).
>
> He was energetic (Kayla, line 26).
> They were always happy and smiling (Kayla, line 35).
>
> This particular teacher had a sense of humor and joked around with the students (Sadie, lines 27-28).
>
> "The guy was funny" (Devin, line 37).

The following narrative excerpts reflect negative behaviors of secondary teachers.

> Heather described most of her junior and senior high school teachers as "there because that was their job" not because they cared about it (Heather, lines 14-15).
>
> Her 7th grade prealgebra teacher taught a little bit during class but didn't seem to be very committed to teaching (Heather, lines 17-18).
>
> Her 8th grade experience was even worse because the teacher didn't want to be there (Lauren, lines 21-22).
>
> There didn't seem to be any emphasis on helping the students to actually learn math. "It was kind of—get us in and get us out. There wasn't a lot of one-on-one" (Sadie, lines 13-15).
>
> Her 8th grade teacher ridiculed students for giving wrong answers. Homework was corrected orally in class with students row-by-row reading aloud their answers. "Everyone got nervous when it came to be their turn because . . . he loved to make a joke out of you. So I just really didn't love it (Heather, lines 21-24).
>
> When this teacher returned papers to students, she would nicely place the papers on the desks of her good students. For the others, she would throw the paper and "hopefully it would land on your desk and some kids thought it was funny and they would make a contest of being able to grab it before it hit the ground. But she was not doing it as a game" (Heather, lines 79-82).
>
> I didn't feel that the teachers really cared if I came in for help." Heather recalled going in for extra help a few times, but "didn't particularly feel like they really wanted to be there to help me.… I kind of felt they had an attitude like 'what aren't you getting about this?... how can you not see this?' … I got very

> discouraged very quickly. And I just would give up very quickly" (Heather, lines 84-91).
>
> The teacher told them if they couldn't understand he would put them in the 5th grade math class for the day, which he did in a "really mean and demeaning" way (Joel, lines 11-13).
> "He was mean. I think he would get frustrated very easy, you know. With math I would kind of space off, and then when I come back I'm lost. And I'm too afraid to ask a question, especially when the teachers were agitated that you'd wandered off" (Sadie, lines 25-27).
>
> He was also very tough. He had a sign on the classroom door that said something to the effect of: "I am the lawnmower and you are the grass. If you mess with me I'll cut you down to size." He had a spray bottle of water that he would spray on students if they fell asleep (Sadie, lines 28-31).
>
> She did recall that when he taught at the board he would spit on people. Sitting on the front row was not preferred (Heather, lines 18-19).
>
> The 9th grade teacher was "a bumbling idiot." He was very disorganized and stumbled over his words a lot. He became the brunt of students' jokes (Heather, lines 34-35).
>
> She replaced the wrestling coach who was fired due to drinking alcohol on the job (Heather, lines 50-51).
>
> Her teacher was "a big guy and would yell at us a lot or yell at --- because kids were getting into trouble. And he had a fake eye so you never knew who he was yelling at" (Sadie, lines 11-13).

Relationship building. These excerpts relate to behaviors affecting the student's ability to develop a personal working relationship with a teacher. Not all of the students indicated an interest in building relationships with their teachers. Those who were interested in having a relationship had positive and negative experiences. The following narrative excerpts related to positive relationship building.

> "I think the teachers I spent the most time with, cared the most, were the ones that I liked and remember" (Devin, lines 55-56).
>
> The new teacher developed a positive rapport with the students. "She seemed to

> care [about] what we were doing in life. She liked to joke around with us and I felt that she genuinely cared for the students" (Heather, lines 51-54)
>
> "I could tell that she truly cared if I succeeded or didn't succeed, and I knew it, so it was more motivating" (Heather, lines 68-69).
>
> Some teachers in junior high tried to reach him (Joel, lines 28-29).
>
> The teacher was strict, but likeable (Kayla, lines 12-13).
>
> She always felt comfortable with these teachers. If she had a question she was never afraid to ask. She never felt like they were too smart for her, or that they thought she wasn't smart enough (Kayla, lines 37-39).
>
> She also showed interest in the students' lives outside of math class (Lauren, line 48).
>
> "If they were a good teacher then I absolutely loved them" (Lauren, line 78).

The following excerpts related to negative relationship building:

> He was a "really crusty old man." Heather was the sixth child in her family to be in his class. He gave Heather a silly nickname based on her last name (Heather, lines 30-32).
>
> You could tell he wasn't particularly interested in the students (Heather, line 36).
>
> This teacher felt her lunch and after school time was her personal time and she didn't want to spend that time with students (Heather, lines 44-45).
>
> As for her teacher, "I really didn't like her and she really didn't like me…. She was too cool to be there.... She had this authoritative, I am better than everyone, kind of vibe." With many of her teachers, Heather felt like there came a certain point in time when they "stopped looking at you." This was especially the case with this teacher. "I remember times where I remember thinking, 'she just totally skipped right past me, like I'm just not even here'" (Heather, lines 73-78).
>
> Heather avoided building any kind of relationship with her teachers. "I was not comfortable with math. I was not comfortable with my math teachers. I was not comfortable with any of it.… I just tried to stay as invisible as possible throughout my math experience" (Heather, lines 94-98).
>
> One challenge in eleventh grade was that Lauren missed class often due to athletics. She would try to get help with what she missed, but the teacher wasn't

> very accommodating.… "If you missed class, then you missed class, and she wouldn't help you as much." Even with Lauren's efforts to get help she doesn't recall having any meaningful conversations with this teacher (Lauren, lines 63-68).
>
> "If they were a bad teacher and I didn't understand what they were saying, I absolutely did not like them" (Lauren, lines 78-79).
>
> Therefore she didn't like those teachers because "I didn't like feeling dumb" (Lauren, lines 86-87).
>
> "They just seemed like they didn't really care. They were frustrated. There were a lot of kids that were in trouble. They just wanted to get you in and out. Get it over with, is what it felt like" (Sadie, lines 20-22).

Effectiveness of pedagogy. These excerpts relate to behaviors related to instruction, as well as comments about curriculum. Participants placed greatest emphasis on how well teachers explained mathematics procedures. They spoke less about other aspects of pedagogy such as assessment, worthwhileness of tasks, lesson organization, etc. (Anthony & Walshaw, 2009). The following narrative excerpts related to what the participants considered effective pedagogy, not necessarily what research considers effective pedagogy.

> He gained an appreciation for math in a high school engineering program. In that class he enjoyed math a lot more because they were able to immediately apply the math they learned in a real-world application. He found he liked math a lot more when it was actually useful. It was a lot easier to focus and pay attention to math and to want to do it on his own when there was a reason behind why he was learning it (Blake, lines 13-18).
>
> The teacher was really good. She would write a problem on the board and the students would each work it on a small square of whiteboard. The teacher used this method to check understanding of the concept. Students could erase and rework incorrect problems. When the teacher identified a common misunderstanding she would explain it in more detail to the entire class (Blake, lines 33-37).
>
> They also had a strong enough understanding of the subject to be able to teach it

well to those who didn't understand the subject. And would spend time working on one subject, ignoring what would normally have been required by the district that day, and focusing on helping the entire class understand a difficult concept (Blake, lines 53-56).

She worked closely with students. She reviewed homework with the class before grading it, allowing students to ask questions and improve their understanding of the exercises (Blake, lines 57-59).

It was because of his engineering program. This is where he learned that math was used for something other than just doing homework. An example of the kind of assignments he had in the program was building truss bridges. They had to calculate how much weight could be distributed on each of the beams and how much weight the whole bridge could hold. He found this application of math highly interesting. He wanted to learn math so he could do more things like that. He took engineering classes all three years of high school and completed a capstone project during his senior year. He decided he wanted to do something engineering or math related as a career due to this experience (Blake, lines 61-69).

The teacher did a "typical whiteboard presentation and then if we had questions, we just sat at her desk and she would work with us until we figured it out" (Devin, lines 20-22).

She gave students a notes worksheet to fill out as they followed her lecture. She also created a fun and relaxing atmosphere that made it easier to deal with any struggle in learning math. She took the stress out of learning math by using songs, pictures and clever ways to remember rules and formulas. "It was just really relaxing having the struggle, but having it fun, too." In 11th grade Precalculus, Devin had this same teacher. The math was more challenging, but the environment and attitude made it a positive learning experience (Devin, lines 27-35).

He also created a different learning environment, providing the students with the opportunity to be more independent learners. In his lecture he would "make sure you understood how to do the basics," but he didn't show students how to work every type of problem in the homework. Students had to figure out how to apply the basic understanding to more complicated exercises. Another thing that made this class more interesting was working with practical applications (Devin, lines 37-42).

Learning practical applications helped him learn it better. In Trigonometry, "we got into vectors and I really enjoyed that. I climb. So we did one problem that was all related to rock climbing and it just clicked after that. Familiarity with the idea outside really made those lines and equations make sense afterwards. A lot of

times it's kind of abstract and it's just formulas and ideas, but having a practical application for it really -- I remember that one 'cause it just clicked" (Devin, lines 44-49).

The personalities of the teachers varied, but even if the teacher's personality was "a little on the dull side, they could still explain it really well" (Devin, 59-60).

"She had a different way of explaining things. She would say … this is why we do it. Not just 'here's the steps.' At least for me, it makes more sense for me to remember it if I know why I'm doing it, and I can apply it that way instead of just memorizing the steps of things. And I'm just not a mathematical person to begin with, so I have to know why I'm doing all this stuff that I hate doing" (Heather, lines 57-61).

She put it in a way that I could understand (Joel, line 20).

This teacher would put stories into learning math. For example, she taught them to "rise before you run" and taught songs to help learn formulas. Through her facial features and actions in teaching, as well as her love of the subject, she kept students' attention and interest. When students had a question about a concept, she would show different examples until students understood. She did a lot of group activities and made things into games. For a math class, it was kind of fun, more fun than other math classes she'd had (Kayla, lines 17-23).

Showed a lot of examples (Kayla, line 27).

She was also registered in a lab class with four or five other people who were also struggling with math. They were able to help each other as they worked together. They also used a computer-based math program that adapted based on their individual understanding and knowledge of the math to review prerequisite skills and build Prealgebra skills (Kayla, lines 28—32).

She trusted that they could explain the math well (Kayla, line 40).

The geometry class followed a different classroom structure. Each day the teacher did a little review of what was taught in the previous class period and connected it to what was going to be taught that day. Instead of group activities students were partnered up with someone for the entire quarter to work together (Kayla, lines 44-48).

He explained things pretty well, starting at step one. He included stories in the explanations and used visual cues to help the students remember. Most of his instruction was lecture and individual work, but sometimes he included group work. Typically the class would correct the homework together, then go on to the

> day's lesson. This teacher integrated tips on how to learn math in his lessons (Kayla, lines 51-55).
>
> It also helped when a teacher made it into a story that is related to her personal life, or used techniques to help with memorizing and using formulas (Kayla, lines 70-71).
>
> Sometimes students would correct each other's work in this class, but "it really didn't matter because most of the kids in that class really stunk at math, too. So I made a few friends in that class because we'd say, 'Oh, it's ok. I missed that question, too' " (Lauren, lines 26-29).
>
> She had the best math teacher she ever had because she explained each concept "three different ways" (Lauren, lines 40-41).
>
> The teacher did many things to help the students learn, including group activities, making worksheets, and demonstrating math principles using "toys and stuff"—small items such as marbles and handy objects such as pencils, pieces of paper (Lauren, lines 42-45).
>
> The teacher showed a lot of real life connections using concrete objects to demonstrate the geometry concepts and explaining how geometry is used in real life. One class period they went outside and worked an exercise with a tree and the shadow. Lauren's family was also building a new house that year, and Lauren saw a lot of geometry applications in the construction of the house (Lauren, lines 52-57).
>
> In her view, a good teacher was one who would explain math in different ways until she was able to understand (Lauren, lines 79-81).
>
> This teacher tried to make math fun. "He wasn't so serious about it. More laid back. It wasn't such a big deal if you made a mistake" (Sadie, lines 45-46).

The following narrative excerpts related to ineffective pedagogy.

> He never found his math classes to be terribly exciting. You went to class, learned what you had to learn, and did the homework. "Math wasn't as much about learning the subject as it was completing the homework because all that matters is what grade you got on your assignments and tests. Not whether you understand it or not" (Blake, lines 8-12).
>
> In his eighth and ninth grade classes students typically filled out guided notes pages while the teacher was teaching, After the lecture, they had about 10 minutes to work on a set of practice problems on their own and ask questions of the

teacher while they were working. Sometimes they had worksheets that had a game-like activity, such as solving a word puzzle by getting the right answers to a set of math problems. Blake liked math, even though it "wasn't super interesting, not something you'd go out and just do for fun." He didn't have a problem doing it and he didn't dread doing it. It was just school. And he did enjoy it more than his English classes (Blake, lines 18-27).

Another teacher wasn't as helpful. She did more lecturing and left students to figure out the math on their own. It was a lot harder for Blake to understand since they didn't do as much practical work, mostly lectures. He had trouble keeping up. The class was more difficult as a whole and the instructor didn't explain the math as well as Blake would have liked (Blake, lines 38-42).

The substitute would give a lecture then sit at her desk while the students worked on homework for half the class period. Again. Not a very impactful experience with math (Blake, lines 44-46).

Class time consisted of a lecture followed by homework time. "Here's the presentation. Do the math" (Devin, lines 57-58).

However she only provided an explanation of the steps for the specific problem without any kind of reasoning or foundational explanation (Heather, lines 45-47).

She did not relate well to their teaching methods. "It was just like this is the first thing you do, this is the second thing you do, this is the third. You'll get your answer. That was it. … But if I could understand why it was done this way, why this step was done before this step, then it helps me to remember" (Heather, lines 98-102).

The structure of the class was fairly traditional. The teacher taught the material. The students worked problems in class, asking for help as needed. They completed assigned homework at home (Kayla, lines 10-12).

In spite of having a good teacher, she struggled some with the algebra due to the abstract nature and the need to memorize and apply formulas (Kayla, lines 55-57).

He wasn't so good at explaining concepts from the beginning, "jumping in somewhere like five steps into the process" (Kayla, lines 61-63).

Classmates graded quizzes and tests (Lauren, line 10).

When the teacher presented the class lecture, he would not stop to check for student understanding, and Lauren didn't understand what was going on (Lauren, lines 23-24).

> This same teacher was her math lab tutor. She didn't really talk to the students. She sat at her desk and students needing help had to walk to her desk. She did frequently tell the students to "be quiet." This was also typical of the 11th grade algebra class. After presenting the material for the day, the teacher sat at her desk and students came to her to ask questions (Lauren, lines 69-73).

> A bad teacher was one who would "just say this is the way to do it and this is the only way to do it" (Lauren, lines 81-82).

> A single explanation that was repeated over and over, … The repetitive approach to teaching made her feel "really dumb," (Lauren, lines 83-86).

> In these classes, which last about forty-five minutes, most of the time was spent with the teacher lecturing. Homework was to be completed at home. "I remember hating to do the homework" (Sadie, lines 16-18).

Discourse and subjectifying. These excerpts relate to the non-cognitive related conversations that occurred in the classrooms. The participants rarely recalled specific words spoken to them or about them (subjectifying), but many did remember general messages they received from their teachers. The following narrative excerpts related to positive discourse and subjectifying.

> They were understanding of how busy life could be and how dreary homework was, but still pushed you to completing it anyway (Blake, lines 51-53).

> The message that he got from all of his teachers was that you can usually solve anything if you work at it hard enough. He learned that even if you don't understand a problem immediately, if you do what you know, you can often figure it out (Blake, lines 72-74).

> He remembers his teachers being very supportive of him. "The entire time they spoke to me or were helping me they made it really stick out in my mind that 'you can do math,' that it is possible, even with this section where you really struggled. It just takes time, practice, and is a whole different thinking mindset. It's just going to [require] applying yourself." Devin internalized this message. "I think one of the biggest lessons that I learned throughout that education is just that you can do it. It's nothing you need to panic about. If you panic, you stress out about it, it just doesn't work out for you. Your mind's just not in that set where you can learn at your best level (Devin, lines 65-73).

> Additionally, this teacher did not allow students to talk negatively about their ability to do math. “If someone were to be frustrated—“Ugh. I’m just so stupid” or “I’m horrible at this” she would [say] “No, we don’t talk like that!” She was the type who said, “not everyone’s good at math, but everyone’s good at something and this might not be your forte but that doesn’t mean you can’t do it. You just need to put more effort into it than some other people” (Heather, lines 61-66).
>
> Her eighth and ninth grade teachers encouraged her to work hard. They never downgraded her in spite of her struggles. They were always happy and smiling, saying things like “you can do this” and “if we work on it a little bit more, I know you can do this” (Kayla, lines 34-36).
>
> This teacher provided encouragement telling Lauren things such as “You can do this. You’re not dumb. You’re not stupid. You’re a smart girl.” She would say these things to the class as a whole, as well as directly to Lauren (Lauren, lines 45-47).
>
> He “was always very positive about math and about teaching. I don’t remember anything specific [he said] to me, but I remember it being positive” (Sadie, lines 46-48).

The following narrative excerpts related to negative discourse and subjectifying.

> She would frequently hear comments such as: “You got all of them wrong, it’s amazing!” or “Lauren stunk at this quiz again” (Lauren, lines 11-12).
>
> While the teacher never verbally critiqued her, Lauren felt put down by having her peers correct her quizzes and tests. “I felt stupid. It reminded me [that] the kid behind you knows what grade you got. The kid two people in front you knows what grade you got. Eventually, the whole row knows what grades you get, so that perception carries outside of the classroom. The other kids are like ‘she’s bad at math’ “ (Lauren, lines 15-20).
>
> “When it would be your turn to say your answer and you’re kind of shakin’ in your boots and you say your answer and you get it wrong. He would put his hands down (slapping hands on the table) and just “ohhhh,” and roll his eyes and say [sarcastically] ‘Really? How’d you get that one? Where’d you pull that one from?’ Stuff like that. … He made her feel like “a complete idiot.” He didn’t say those words, “but it was just there” (Heather, lines 24-33).

The following narrative excerpt related to both positive and negative discourse and subjectifying:

> Kayla recalls this teacher encouraging her to work hard in math, complimenting her for trying hard, but the teacher also pointed out to her that she would likely always struggle with math (Kayla, lines 23-25).

RQ 2: Dimensions of Mathematical Identity

The literature produced the following themes relevant to research question two (How did students perceive that those experiences influenced their mathematical identities?): Perceived Competence, Motivation, Anxiety, Disposition and Vision of Mathematics. Students positioned themselves in positive and/or negative ways relative to these dimensions of mathematical identity. The following narrative excerpts address research question two.

Perceived competence. The theme of perceived competence includes a participant's ability, achievement, and confidence. Most of the participants addressed these aspects. The following narrative excerpts reflect high perceived competence.

> Lauren passed with an A, her first (Lauren, lines 48-49).
>
> She got A's and A-'s without really having to study (Lauren, lines 50-51).
>
> She had done well in math, compared to the 16 other students in her class (Lauren, lines 8-9).
>
> She helped other students in the class and earned extra points on tests and assignments because she always got the bonus questions right (Lauren, lines 51-52).
>
> Typically she found it easier to do math that she could equate to money because that made more sense to her (Lauren, lines 62-63).
>
> Algebra made a lot more sense to Blake than geometry. He attributes that to being "just how my brain works" (Blake, lines 28-29).
>
> Blake always did fairly well in math (Blake, line 8).
>
> He learned that even if you don't understand a problem immediately, if you do

> what you know, you can often figure it out. Some of this confidence in his ability to learn was an internal thing and some of it came from being in a safe learning environment. If he tried something and did it wrong, the teacher wasn't going to get mad about it and would be willing to work with him to understand. Because of this Blake was willing to attempt to solve any problem (Blake, lines 73-78).
>
> Cody was able to succeed in spite of the lack of teaching (Cody, line 16).
>
> Cody rarely asked any questions because he was always able to complete his assignments without difficulty (Cody, lines 23-24).
>
> Math was never a great struggle for him, and he just "plugged along" and went through it all (Devin, lines 14-15)
>
> Learning practical applications helped him learn it better. In Trigonometry, "we got into vectors and I really enjoyed that. I climb. So we did one problem that was all related to rock climbing and it just clicked after that. Familiarity with the idea outside really made those lines and equations make sense afterwards (Devin, lines 44-47).
>
> It's just this kind of preset idea that math is hard and you're not good at it. So I think that was one of the biggest things—just breaking out of that traditional mindset that holds people back." This understanding helps Devin's confidence in his ability to learn math. Even though there were times he wondered if he would ever get through a class—Trigonometry in particular—he knew that with time he could catch on (Devin, lines 74-78).
>
> "Deep down I'm going to know I have what it takes, but at the same time there are going to be those times where it's 'Oh boy. What did I get myself into? I don't know if I can figure this out in time for my grade.' I always have that attitude that eventually I will catch on, but will it be in time for a good grade? Will I figure it out before the test" (Devin, lines 79-83)?
>
> "It makes more sense for me to remember it if I know why I'm doing it, and I can apply it that way instead of just memorizing the steps of things" (Heather, lines 58 -60).
>
> Kayla had confidence in her ability to learn math, but knew that it comes only after a lot of hard work (Kayla, lines 66-67).

The following narrative excerpts are related to low perceived competence.

> Joel felt he honestly tried to understand the math, but it didn't make sense (Joel, lines 13-14).

Joel struggled with learning in general (Joel, line 16).

He started struggling with math in fourth and fifth grade (Joel, lines 18-19).

“It just made me feel really dumb, and it made me feel mad because I didn’t get what they were saying.” The repetitive approach to teaching made her feel “really dumb” (Lauren, lines 84-86).

She didn’t understand what was going on (Lauren, line 24).

Lauren felt put down by having her peers correct her quizzes and tests. “I felt stupid” (Lauren, line 16).

She didn’t do well in Prealgebra (Lauren, lines 9-10).

Her relationship with math was also dependent on whether or not she understood. If she didn’t understand a concept she didn’t like it, but if she understood a concept she liked it (Lauren, lines 87-89).

She thought she would be good at math, but when she got to algebra, “Oh, I’m not good at it” (Lauren, lines 92-93).

She always had a hard time passing the tests (Sadie, line 49).

Sadie passed her eleventh grade math class. “I don’t think I really learned a whole lot” (Sadie, lines 51-52).

She “never passed a math class.” She never felt like she was learning something and moving forward (Sadie, lines 18-19).

Additionally, Sadie didn’t think she could learn math. “Doing math, I feel like a block goes up, like a wall. I can’t get past the wall to get to the numbers. Sometimes I feel like I’m banging my head against the wall trying to get to it” (Sadie, 62-64).

It’s almost like they are speaking a totally different language and I can only make out a few random words and ideas (Sadie, lines 8-9).

He never was able to understand proofs. They made no sense regardless of how many times they were explained to him (Blake, lines 29-30).

It was a lot harder for Blake to understand since they didn’t do as much practical work, mostly lectures. He had trouble keeping up (Blake, lines 39-40).

> "I'm not the brightest child, so I didn't really stay up with my class in math" (Cody, 25-26).
>
> "I kind of know it and do well for the first little bit, but when it gets harder I just kind of lose it, and I don't do much after that. I just give up on it" (Cody, lines 42-44).
>
> The teaching in high school was very procedural. "This is how you do it, just do it." Teachers would show the problem once, not explain anything, and then "your turn" Cody needed more than that, especially in higher math. For him, it made more sense to understand why to do certain steps. "Explain it a little bit more to me instead of just running through it, and I'll have a better understanding of it" (Cody, lines 65-69).
>
> Without a thorough understanding of the math, Heather eventually fell too far behind and gave up (Heather, lines 47-48).
>
> At the time she entered seventh grade, Heather already did not like math and "felt very inadequate in math" (Heather, lines 6-7).
>
> I would get lost really quickly (Heather, line 84).
>
> Reflecting back, she realized her biggest problem was a weak foundation in prerequisite skills—so she was always behind. At the time, she didn't understand why she was struggling so much. She just thought she was stupid (Heather, lines 91-93).
>
> After graduating from high school, Heather had no confidence in her ability to learn math (Heather, lines 103-104).
>
> She typically had to work harder at it than most people (Kayla, line 67).
>
> If she tried hard to understand an idea and can't, she chalked it up to the fact that, "Math is just one thing, I probably won't understand unless something miraculous happens" (Kayla, lines 77-79).

Motivation. The theme of motivation relates to a participant's willingness to try to learn and achieve. Most of the participants addressed motivation in their interviews. Some participants expressed being differently motivated at times because of differing experiences. The following narrative excerpts reflect high motivation.

> Good grades were really important to her, so she was motivated to learn the math to get a good grade. Math was simply a requirement to be met (Lauren, lines 94-96).
> Sadie was more willing to try to succeed in this class (Sadie, lines 48-49).
>
> It was a lot easier to focus and pay attention to math and to want to do it on his own when there was a reason behind why he was learning it (Blake, lines 17-18).
>
> He wanted to learn math so he could do more things like that [engineering] (Blake, lines 66-67).
>
> He was highly motivated to learn math for gaining a career in engineering (Blake, lines 89-90).
>
> She attributed her success to the teacher taking time to provide real help. In return for the teacher's efforts, Heather was more motivated and put forth more effort to learn. "I could tell that she truly cared if I succeeded or didn't succeed, and I knew it, so it was more motivating" (Heather, lines 67-69).
>
> She "would really try to start out doing what I thought I should and tried to be really motivated, but I would get lost really quickly. I didn't feel that the teachers really cared if I came in for help" (Heather, lines 83-85).
>
> When she understood the math, she felt motivated to work hard (Kayla, line 77).

The following narrative excerpts address low motivation.

> There was no one to motivate him to do anything. Combined with the bad experience in sixth grade, those factors led to him not caring about school (Joel, lines 24-26).
>
> "I honestly stopped paying attention. Because I was working and had a lot going on, my mind wasn't in school at all" (Joel, lines 26-27).
>
> He never participated in a math class. Some teachers in junior high tried to reach him, but "my mind wasn't in school at all" (Joel, lines 28-29).
>
> When Sadie finished high school she wanted to stay as far away from math as possible (Sadie, lines 57-58).
>
> He wasn't overly engaged with learning math (Cody, lines 31-32).
>
> As the course became more challenging it "kind of turned me off to it, and I didn't want to deal with it anymore" (Cody, lines 40-41).

> Cody had no motivation to learn math (Cody, lines 61).
> "I'd kind of know it and do well for the first little bit, but when it gets harder I just kind of lose it, and I don't do much after that. I just give up on it" (Cody, lines 42-44).
>
> The lack of encouragement eventually led to his giving up with each class (Cody, lines 59-60).
>
> "If I don't [understand] then I tend to procrastinate and get frustrated" (Kayla, line 90).
>
> And I'm just not a mathematical person to begin with, so I have to know why I'm doing all this stuff that I hate doing (Heather, lines 60-61).
>
> "Part of it was my fault in that I didn't really push myself, I wasn't super motivated, but at the same time, I didn't feel like my teachers really tried to motivate me either" (Heather, lines 15-17).
>
> "I got very discouraged very quickly. And I just would give up very quickly" (Heather, lines 90-91).
>
> Because she was often frustrated, she tended to not try as much as she had in other classes (Kayla, lines 63-64).

Anxiety. The theme of anxiety covers any strong negative emotion, outside of a general like or dislike of mathematics that affects a student's relationship with mathematics. Low anxiety was rarely mentioned, as it is typically the absence of the negative emotion. The following narrative excerpts reflect high anxiety.

> "I felt humiliated…. I really did not do any math after that" (Joel, lines 14-15).
>
> Lauren had this class after lunch and because she hated to go to class, she often had a stomachache from the anxiety of having to go. She often considered skipping class, but didn't have any place to go, other than hiding in the bathroom, and she didn't want to do that. The physical reaction to the anxiety worsened. Soon around the time of the first test, she began to have "night terrors." She would wake up in the middle of the night and have no control over her body. She would have bad nightmares dealing with numbers and not being able to balance equations. This would happen every time she had a math test during the entire year, or greatly struggling to understand specific concepts. They occurred more

than ten times during the year (Lauren, lines 29-37).

She had a job as a teller, and "I was scared to death that I'd have to do the math because I couldn't. I think I got yelled at a couple times because I couldn't, the thing was down, and I miscounted or I did it wrong. I hated working as a teller. It scared me—because I couldn't do the math" (Sadie, lines 59-62).

"With math I would kind of space off, and then when I come back I'm lost. And I'm too afraid to ask a question, especially when the teachers were agitated that you'd wandered off'" (Sadie, lines 25-27).

She was quite sensitive to the classroom environment and unwilling to ask questions. "I never asked questions. I was too scared to ask questions. I didn't want to be dumb and I didn't want to let them know I wasn't paying attention" (Sadie, 33-35).

Overall, Sadie was intimidated by this tough teacher and intimidated by male teachers in general (Sadie, 35-36).

Fear of math deterred her from pursuing a degree (Heather, lines 111-112).

The following narrative excerpts mentioned low anxiety.

"It was just really relaxing having the struggle, but having it fun, too" (Devin, line 33).

"I think one of the biggest lessons that I learned throughout that education is just that you can do it. It's nothing you need to panic about. If you panic, you stress out about it, it just doesn't work out for you (Devin, lines 70-72).

Emotional disposition. Statements that indicated a like or dislike of mathematics or the learning experience were coded for emotional disposition. The following narrative excerpts indicated positive emotional disposition.

She loved geometry (Lauren, line 50).

In high school, Blake liked math even more than in junior high, but it was because of his engineering program (Blake, lines 61-62).

Blake liked math, even though it "wasn't super interesting, not something you'd go out and just do for fun." He didn't have a problem doing it and he didn't dread doing it. It was just school. And he did enjoy it more than his English classes

(Blake, lines 24-27).

In junior high 8th and 9th grade he enrolled in engineering classes. “I started to enjoy figuring out puzzles, so math become more enjoyable once I started taking that” (Devin, lines 17-18).

He generally enjoyed math (Devin, line 8).

Devin enjoyed working on his math homework alone. He enjoyed the challenge of trying to solve problems, “It was hard, but enjoyable at the same time” (Devin, lines 50-51)

Also, she related better to geometry because it was more visual (Kayla, lines 42-43)

Kayla liked math when she understood it (Kayla, line 73).

When she had a good teacher, she had a positive attitude toward learning math, saying, “Yeah, I can do this” (Kayla, lines 75-77).

The following narrative excerpts indicated a negative disposition about mathematics.

Joel remembered always not liking math (Joel, line 8).

Her strongest memory of the class was that she hated it (Lauren, lines 7-8).

Eleventh grade was algebra again, and she hated it (Lauren, line 58).

If it had no value in her own life, she didn’t like it (Lauren, line 93-94).

“If I don’t see a point to the math, I don’t necessarily like it” (Lauren, lines 89-90).

In spite of her dislike of math at that time, she recognized the value of math, “that you use it all the time” (Sadie, lines 58-59)

“My relationship with math can be summed up in one word. Hate! I hate math!” (Sadie, lines 5-6).

At the time she entered 7th grade, Heather already did not like math and “felt very inadequate in math” (Heather, lines 6-7).

When she took the ACT and SAT in high school, she didn’t bother trying on the math section. “I was so frustrated with it, and I hated it so much that I would just

> go a-b-c-d-a-b-c-d all own the math part" (Heather, lines 108-110).
>
> It's not really a subject she would personally choose to study (Kayla, lines 73-74).
>
> "There wasn't anything drastic in my high school or life that makes me say 'yeah, math is awesome.' I mean, I'm sure it's awesome, just not awesome for me" (Kayla, lines 84-86).
>
> "Math and I have never gotten along" (Kayla, lines 87-88).

The following narrative excerpts indicated a mixed disposition about mathematics.

> In algebra there are some concepts that she loved and understood, others she couldn't understand and hated, and they were often foundational ideas. She really enjoyed solving systems of three equations in three variables. But simplifying square roots was confusing (Lauren, lines 59-62).
>
> In junior high his attitude about math was neither positive nor negative. "Math was math. It was just one of those classes you had to take. It wasn't bad. It wasn't good" (Devin, lines 16-17).

Vision of mathematics. Participants' perceptions of the nature, value and activities of mathematics and/or what is required to learn or be successful in mathematics were coded for vision of mathematics. The following narrative excerpts related to a positive vision of mathematics.

> Lauren recognized the value of math in the world (Lauren, line 93).
>
> This is where he learned that math was used for something other than just doing homework. An example of the kind of assignments he had in the program was building truss bridges. They had to calculate how much weight could be distributed on each of the beams and how much weight the whole bridge could hold. He found this application of math highly interesting (Blake, lines 62-66).
>
> He gained an appreciation for math in a high school engineering program. In that class he enjoyed math a lot more because they were able to immediately apply the math they learned in a real-world application. He found he liked math a lot more when it was actually useful (Blake, lines 13-17).
>
> Blake saw himself as a numbers kind of person. When he thought about anything

> in life, it was more the numbers or the logistics behind it rather than the emotional or language side of it. He was able to see how the different parts of math fit together (Blake, lines 82-85).
>
> He felt his math classes influenced his development in understanding math, although he didn't have very many experiences in his math classes that introduced the value of or practical uses of math. He highly valued math, recognizing that we can't really do anything without math. He believed math was good to know, even if one never really uses it (Blake, lines 85-89).
>
> It became clear to him that there were different ways of doing a problem and still come to the same solution (Cody, lines 37-38).
>
> Devin also developed a strong appreciation for the value of math, algebra in particular. Even math that seems to only be of academic value is "very practical because it teaches you a new way to think—how to be very organized and systematic about things. So I think even that academic application can be very practical throughout your life. You can always pull a good learning experience in every subject in more than just facts and figures. I think math is one that really stands out how it does that—that systematic thinking. How beneficial that is for everything…Honestly, there's just too many applications for algebra in life not to say, 'yeah, I have to know this . . . Having a good understanding of math is definitely a requirement to get through anything in today's world" (Devin, 84-92).
>
> She always believed that if she could work hard enough and get a good teacher, then she could understand it (Kayla, lines 67-69).
>
> She recognized that math has value in the world and that it enhances her life—"you wouldn't have your laptop if there wasn't math...we are an advancing world in technology and science" (Kayla, lines 80-82).

The following narrative excerpts related to a negative vision of math

> I have never truly understood math concepts unless I had an extremely good professor that explained the concepts well (Kayla, lines 88-89)
>
> Math was a non-entity for Joel when he was a teenager. His attitude was "I'm going to grow up and not use math. The closest I came to using math was doing wheel alignments of the front end of automobiles and trucks. That's the closest thing I've come to math, but for the most part the machine would do the calculations for me, so I still had that old cliché of grow up and not use math" (Joel, lines 35-40).
>
> She didn't see the point of algebra (Lauren, line 89).

> "Math wasn't as much about learning the subject as it was completing the homework because all that matters is what grade you got on your assignments and tests. Not whether you understand it or not" (Blake, lines 10-12).
>
> This was mostly because math had no value to him. "I knew you used math every day for random stuff, but [not] algebra or Prealgebra. I didn't really care . . . Why should I learn math I'm never going to use" (Cody, lines 61-63)?
>
> At the time he finished his high school education, he didn't see that math had any value to him (Cody, lines 63-64).
>
> Her father was attending college and struggling with math at the same time, so she was certain her problems with math were genetic (Heather, lines 104-105).
>
> Heather never saw the value of math in her personal life, but recognized its value in the world in general (Heather, lines 105-106).
>
> "One of my struggles with math is that I am not a rule follower, and I like things that fall into the gray area. This is not possible with math—you're either right or you're wrong and that is a struggle for me" (Heather, lines 112-115).
>
> She saw math more as a milestone to be achieved so she can go on with life. She did not expect to ever actually apply math in her life, particularly the things she learned in algebra (Kayla, 82-84).
>
> "I have never truly understood math concepts unless I had an extremely good professor that explained the concepts well" (Kayla, lines 88-89).

The following narrative excerpts related to mixed vision of mathematics

> He believed knowing basic math was highly valuable in our every day lives, but not algebra, calculus or higher math (Cody, lines 70-72).
>
> She expected to have to work hard in college and felt she would be successful if she had a good teacher to explain the math to her (Kayla, lines 86-87).

Summary of Narrative Excerpts

Students' lived experiences as presented in the autobiographical narratives provided a rich data source relative to research questions one and two: students' recalled experiences with secondary teachers and perceived dimensions of their mathematical

identity. Students' experiences—their interactions with teachers, parents, and peers—affected how students came to know themselves as mathematics learners (Anderson, 2007). This identity development in secondary schools has the potential to affect individuals' long-term relationships with mathematics.

Effect of Experiences on Mathematical Identity

The participants shared their perceptions of how their experiences with their teachers influenced their relationship with mathematics. These influences were coded into themes or dimensions of mathematical identity. This section of the results answers the second research question: How did students perceive that those experiences influenced their mathematical identities? A summary of their dimensions of mathematical identity is in Table 6.

Blake and Devin had healthy mathematical identities. Lauren, Heather, Sadie, Cody, Joel, and Kayla had weak mathematical identities. This section presents each

Table 6

Summary of Participant Dimensions of Identity

Dimensions	Blake	Cody	Devin	Heather	Joel	Kayla	Lauren	Sadie
Vision of mathematics	High	Low	High	Low	Low	Low	High	Low
Motivation	High	Low	High	Low	Low	High	Mixed	Low
Perceived competence	High	Low	High	Low	Low	Low	Low	Low
Emotional disposition	Positive	Negative	Positive	Negative	Negative	Mixed	Mixed	Negative
Anxiety	Low	Low	Low	High	Med	High	High	High

dimension of mathematical identity for each student based on the students' descriptions of themselves at the point of high school graduation (or the equivalent).

Blake

Vision of mathematics. The strongest element of Blake's mathematical identity was his vision of mathematics. However, had his experience with mathematics been limited to his mathematics classes, he may not have had this positive vision. His descriptions of mathematics classes reflected an *instrumental* view of mathematics, what DiMartino and Zan (2009) called a belief that success in mathematics relies on memorizing a set of unrelated rules. For Blake, the purpose of school mathematics was "to learn it because you are supposed to learn it." In junior high, "math wasn't as much about learning the subject as it was completing the homework because all that matters is what grade you got on your assignments and tests. Not whether you understand it or not." His high school mathematics classes did little to change that perspective.

A 3-year engineering program in high school provided Blake with a strong understanding of the uses of mathematics and a reason to learn it. Assignments such as building a truss bridge caused him to want to learn more mathematics, so he could do more engineering activities. He was able to see how the different parts of mathematics fit together. DiMartino and Zan (2009) called this a *relational* view of mathematics. Blake highly valued math, recognizing that we can't really do anything without math. He believed mathematics was good to know, even if one never really used it. "It makes you think more logically about things."

Motivation. Blake's positive vision of mathematics enhanced his motivation to

learn. He found learning easier when he saw a reason behind why he was learning it. Blake's engineering experiences fueled his motivation to learn mathematics. His desire to be better at engineering and able to solve more engineering problems motivated him to succeed in the mathematics classes in spite of how uninteresting they were to him. He was motivated to continuing learning mathematics in college because he wanted to pursue a career in engineering.

Perceived competence. Blake had some areas where he lacked competence, but his overall perceived competence was high. He never understood how to do proofs, so he struggled in Geometry. In Precalculus, he passed all the tests without doing the homework. Unfortunately, homework was worth more credit than tests, so he failed the class. He saw himself as someone who always did well in math. He developed confidence in his ability to learn, particularly because his teachers provided a safe learning environment where he was allowed to make mistakes without fear of being punished. Because of these experiences, Blake was willing to attempt to solve any problem. "I think I'm pretty good at learning math because I'm able to understand how what you've learned before applies to it. Even if it's a more difficult concept, it makes sense because it is just these different parts going together."

Emotional disposition. Blake maintained a positive disposition about mathematics and he positioned himself positively relative to mathematics. Blake saw himself as a numbers kind of person. When he thought about anything in life, it was more the numbers or the logistics behind it rather than the emotional or language side of it.

Anxiety. Blake scored very low (35) on the anxiety rating scale. His confidence

in his ability to figure out how to solve mathematics problems was a strong factor in eliminating anxiety. Having a positive disposition allowed Blake to overcome feelings of stress that could be associated with learning mathematics or taking tests.

Summary. Blake had a strong, positive identity with mathematics in spite of having some negative experiences with his teachers. His motivation to learn engineering helped him overcome those negative experiences. Blake exhibited what Kassila et al (2005) called being task-oriented. Students who are task-oriented, as opposed to being socially-oriented, have coping strategies that prevent them from being negatively affected long term by the occasional negative experience. Consistent with DiMartino and Zan's (2009) findings, Blake's relational vision of mathematics was accompanied by a positive disposition and high perceived competence. Much of the credit for Blake's strong mathematical identity would go to his engineering courses, which helped him develop his relational vision of mathematics through learning real-world applications of mathematics.

Cody

Vision of mathematics. Cody had a low vision of mathematics. He believed everyone should know basic arithmetic for use in daily life, but beyond that mathematics had no value to him. The instructional focus on procedural understanding without conceptual or contextual understanding did nothing to broaden his vision of mathematics. He did not expect to use mathematics in his career, so he saw no point in learning it.

Motivation. Cody had no motivation to learn mathematics, mostly because of his low vision of mathematics. He had no motivation to learn any mathematics that he would not personally use. In school, he never felt any encouragement from his teachers. As the

mathematics became more challenging he did not have the persistence or support to stick with it, so he easily gave up in his classes.

Perceived competence. Cody's actions indicated he had a very low perceived competence. In fifth and sixth grade his teacher's subjectifying indicated Cody was "stupid" and "dumb." These were truly reifying messages for Cody. He did "as well as anyone else" in seventh and eighth grade, but in the more difficult high school classes, he did not succeed. By the time he finished high school he had given up trying to learn.

Emotional disposition. Cody disliked math. He saw no use for it and no reason to learn it.

Anxiety. Cody did not really care much about his mathematics learning experience and his anxiety score was very low (37). By positioning himself separately from mathematics he was able to protect himself from any harm that could be inflicted by the experience.

Summary. Cody had a weak mathematical identity. Cody blamed his lack of persistence on not receiving encouragement from his teachers, which indicated he had a socially dependent orientation. He lacked the skills to overcome negative experiences and focus on the task of learning mathematics. He said he preferred to keep a low profile and not develop relationships with his teachers, most likely to avoid the disappointment he would feel if they did not meet his needs. He had an instrumental view of mathematics due to the strictly procedural instruction he received.

Devin

Vision of mathematics. Through much of secondary school, Devin seemed to

have a more instrumental view of mathematics, but it did not affect his mathematical identity negatively. He saw mathematics as a puzzle and loved the challenge of solving it. While most students relied heavily on teacher explanations of the mathematical procedures, Devin liked the challenge of not having every type of problem demonstrated in class and trying to figure things out on his own. By the time he graduated from high school, Devin knew applications for algebra existed, but he hadn't been exposed to many of those applications or how to apply algebra to real-world problems. Even his experience with junior high school engineering classes was described as being exposed to "solving puzzles." Devin found value in learning algebra because it taught "systematic thinking." Learning practical applications became important for Devin when he struggled to understand trigonometry. The real-world applications helped his mind grasp the abstract. In the Precalculus and Trigonometry class his teacher challenged the students to do more of their own thinking, which likely helped Devin make connections between mathematical ideas and thus move toward having a relational view of mathematics by the time he finished high school.

Motivation. Devin's motivation came from his love of doing hard things. He loved the challenge of trying to figure out a difficult problem. The strong support he felt from his teachers who taught him effort makes a difference in one's ability to learn, (Dweck, 2006), empowered him to persevere through difficulty. He was also motivated by his belief that "having a good understanding of math is definitely a requirement to get through anything in today's world."

Perceived competence. At the start of his interview, Devin said, "Math was

never a problem for me." But he did struggle some with Trigonometry. Overall, he developed so much confidence in his ability, that he did not see the struggle as a problem. Devin liked the struggle of learning math. He attributed his confidence to an internal belief in himself, as well as the encouragement of teachers. When he struggled to understand, his concern was not if he could learn, but whether or not he would understand it in time for the test. He said gaining confidence in his ability to learn mathematics was one of the most valuable lessons he learned through his education.

Emotional disposition. In junior high school his attitude about mathematics was neither positive nor negative. "Math was math. It was just one of those classes you had to take. It wasn't bad. It wasn't good." Then in eighth and ninth grades, Devin took engineering classes and his emotional disposition became more positive. He came to appreciate the game of solving puzzles and each mathematics problem was just another puzzle to solve. He also had "amazing teachers" whom he credits for creating a positive environment for learning.

Anxiety. Devin scored low (42) on the A-MARS, indicating he had low anxiety. He refused to buy into the popular belief that mathematics is hard and most people can't learn it. His high confidence prevented stress and anxiety about learning. Unlike any other participant, Devin articulated the negative relationship between mathematics anxiety and performance (Hembree, 1990; Richardson & Suinn, 1972). Devin said, "If you panic, you stress out about it, it just doesn't work out for you. Your mind's just not in that set where you can learn at your best level."

Summary. Devin had a strong mathematical identity by the time he entered high

school and his subsequent experiences strengthened that identity. Unlike the other students in this study he did not have a single bad teacher. He spoke highly of their willingness to help. Devin demonstrated the qualities of having Dweck's (2006) growth mindset throughout high school, if not sooner. People with a growth mindset believe their abilities can be improved through dedication and hard work. This meta-perspective creates a love of learning and a resilience needed to persist through difficulty. Devin may have had great teachers because he made each of them great for himself. They may have all been willing to help because he was willing to ask for help. Devin experienced a wide variety of pedagogical practices and considered all of them effective: standard lecture followed by homework time, fill-in-the-blank lecture notes, procedural explanations, real-world applications, clever songs and mnemonic devices, hands-off teaching, and active whole class practice. He used each experience to his advantage.

Heather

Vision of mathematics. Heather had a poor vision of mathematics all through secondary school. She had an instrumental view of mathematics. "One of my struggles with math is that I am not a rule follower, and I like things that fall into the gray area. This is not possible with math—you're either right or you're wrong, and that is a struggle for me." This instrumental view was fed by the procedural nature of the instruction she experienced through most of her school years. "It was just like 'this is the first thing you do, this is the second thing you do, this is the third. You'll get your answer.' That was it.… But if I could understand why it was done this way, why this step was done before this step, then it helps me to remember." Ironically, she labeled herself as "not a

mathematical person" because she was unable to learn from a procedural approach, and she needed a conceptual understanding in order to be successful. She had an incorrect perception that mathematics is about memorizing random facts. When she was shown a relational view of mathematics, in her eleventh grade class, she was successful. Additional evidence of her poor vision of mathematics was her belief that her struggles with mathematics were genetic. She recognized the value of mathematics in the world in general, but never saw personal value in using or learning mathematics.

Motivation. Heather had a socially dependent orientation (Kaasila, 2005) that controlled her motivation. She expected her teachers to motivate her. She started out each year motivated to do well in her mathematics class, but in nearly every case, her teachers let her down socially and pedagogically, so she became discouraged and lost her motivation. She had little internal motivation. Socially, she couldn't connect to her teachers because they were mean, aloof, or disinterested in her success. When Heather had the one teacher who she felt genuinely cared about students, Heather was more motivated and made more of an effort to learn.

Perceived competence. Heather thought she was stupid throughout her secondary years. Her difficulties with mathematics started in elementary school and contributed to this perceived lack of competence. Only with the perspective of looking back during her interview, did she realize the real problem was her weak prerequisite skills due to missing a lot of elementary school while being treated for leukemia. Most of her experiences with her teachers confirmed her low opinion of her abilities. The mean eighth grade teacher who ridiculed students made her feel like an idiot. Other teachers were not willing to

provide explanations that truly helped her understand. Heather's low competence contributed to her lack of motivation. She developed a fixed mindset (Dweck, 2006). She came to believe that no amount of effort would change her ability to do mathematics. After graduating from high school she had no confidence in her ability to learn mathematics.

Emotional disposition. Heather did not like mathematics when she entered seventh grade and she hated it by the time she graduated. Her one positive learning experience did not do much to change her disposition.

Anxiety. Hembree (1990) found mathematics anxiety to be a learned condition with behavior similar to general anxiety, in that mathematics anxiety is a state of fear and dread about mathematics. Heather scored high (77) on the A-MARS. She described experiences of fear and dread in the classroom of the demeaning seventh grade teacher. Later when she took college admission tests her frustration with mathematics stopped her from trying any of the problems in the mathematics section of the test. She postponed going to college because she was afraid of taking mathematics again.

Summary. Heather had a very weak mathematical identity due to a combination of lacking foundational skills for learning secondary mathematics and a socially dependent orientation with teachers who did not meet her expectations. This affected her view of herself as a mathematics learner. When she was unable to find success either mathematically or socially, she gave up trying. Anderson (2007) referred to this as *engagement*, the degree with which a student participates within the mathematics-learning environment. Like those in Anderson's study, Heather found herself on the

periphery of the learning environment because of her inability to make valuable contributions within the classroom or make meaning of the mathematics being enacted. Heather also exemplified Anderson's notion of *nature*, the belief that mathematics ability is genetic.

Heather's emotional disposition—hating mathematics—was both a contributing factor to and a result of how she positioned herself relative to mathematics. The combination of a poor vision of mathematics and low perceived competence typically associate with a negative emotional disposition (Di Martino & Zan, 2009). Heather had a positive experience with her eleventh grade teacher because the teacher met Heather's socially dependent needs. She also taught conceptually, which Heather found easier to understand and more enjoyable to study. Finally, this teacher was attentive to classroom discourse and the reifying effect it can have. She curbed unproductive discourse (Bishop, 2012) and replaced it with productive subjectifying (Sfard & Prusak, 2005b). Had Heather had more teachers like this, she may have graduated with a stronger mathematical identity, but one positive year was not enough to counter the negative experiences over many years.

Joel

Vision of mathematics. Joel had a low vision of mathematics. Mathematics was a non-entity for Joel as a teenager. He used a little bit of mathematics in doing automotive work, but he had machines to do most of the required calculations. He never believed he would use math. He did not recall ever being taught a practical use for mathematics.

Motivation. Joel lacked motivation for school in general, due to his family and

personal circumstances. This led to his dropping out of school.

Perceived competence. After third or fourth grade, Joel had difficulty understanding any mathematics instruction. By the time he entered seventh grade, he had already mentally checked out from doing mathematics. By not participating, he avoided the risk of looking like he did not know anything (Bibby, 1999).

Emotional disposition. Joel never recovered from being humiliated by his sixth grade teacher who ridiculed him in front of the class and sent him to the fifth-grade mathematics class. He did not participate in any mathematics instruction through the rest of his time in school, until he dropped out.

Anxiety. Because mathematics was a nonentity for Joel as a teenager, he likely had little anxiety over math. He was unable to recall anything about the mathematics required to earn his GED. It was neither a positive nor negative enough experience to make an impression. When he took the A-MARS for this study, he had had some positive mathematics learning experiences in college and scored moderately (51) on the scale.

Summary. Joel did not have a secondary education experience to analyze, but his sixth-grade experience showed the long-term threat to mathematical identity that can come from a single negative experience (Hodgen & Askew, 2007). Joel's sixth-grade experience led him to disengage from mathematics. He disconnected himself from mathematics, so he would no longer see mathematics as anything to do with himself. Disengagement stopped him from identifying as a failure in relation to mathematics (Bibby, 1999). Likely, this psychological response extended to his entire education.

Kayla

Vision of mathematics. A key component of vision of mathematics is a person's belief in what it takes to learn mathematics (Di Martino & Zan, 2009). What stood out most in Kayla's interview was her strong belief that her success depended on having a good teacher. Unlike Heather, Kayla was less interested in developing relationships with her teachers and more interested in what they did to make mathematics accessible to her. She also recognized the need for hard work on her own part, but never indicated she could rely on her own merits to learn mathematics. Because all of her instruction was procedural, Kayla liked teachers who explained everything step by step. She referred often to liking teachers who started at "step one." Kayla had no inclination that algebra could be of any value in her life, but she recognized that mathematics had value to the world in general, particularly in technology and science. She said, "I'm sure it's awesome. Just not awesome for me." She had a low vision of mathematics.

Motivation. Kayla saw mathematics as a milestone, or a hoop to jump through, on her way toward her academic goals. She looked forward to not having to take any more mathematics classes. She was motivated to work hard when she was able to understand what she was doing. When she was frustrated by a teacher who did not explain mathematics well—starting at "step one"—she got frustrated and did not try as hard as she had with better teachers.

Perceived competence. Kayla entered seventh grade having "never been really talented at math." Her eighth-grade teacher told Kayla mathematics was something she was always going to struggle with. This turned out to be true. She eventually developed

some confidence in her ability to learn mathematics, but accepted the fact that she would always have to work harder at it than most people. She needed concepts explained in multiple ways and relied on teachers to provide clever tricks and mnemonics to help her memorize the steps. With certainty she said, “Math is just one thing, I probably won’t understand unless something miraculous happens.”

Emotional disposition. Kayla liked mathematics when she understood it. She had a positive attitude toward learning when she had a good teacher.

Anxiety. Kayla scored high (73) on the A-MARS, but provided very little indication of its cause in her interview. A closer look at her survey showed Kayla’s anxiety is centered on the factor of mathematics test anxiety. This fear of testing was consistent with Kayla’s procedural approach to learning mathematics. In her interview she said she repeatedly worked each problem from the beginning in order to always remember how to do it. She did not have confidence in her ability to figure out a problem she hadn’t seen and practiced several times.

Summary. Kayla had relatively positive experiences with her teachers, yet came away disliking and feeling anxiety over mathematics. This could be explained by a result in a study comparing highly effective teachers in traditional and student-centered classrooms. The students in more traditional classrooms felt the instruction increased their confidence and made mathematics easier to manage; however, “Although these students felt better about mathematics, they did not go so far as to say they actually enjoyed the subject. On the other hand, students in more student-centered classrooms said that they no longer dreaded mathematics and some even enjoyed it” (Walters et al., 2014,

p. 31). Kayla's success in and appreciation for geometry indicated she might have had a more positive experience with algebra if the instruction had been less procedural and traditional. Kayla often received identifying messages about her dedication and hard work. Just as her eighth-grade teacher told her, Kayla was resigned to the fact that mathematics would always be difficult for her. Kayla became a very hard working student who struggled to learn math.

Lauren

Vision of mathematics. Lauren recognized the value of mathematics in the world. As for her own life, she valued what she could make real life connections to, particularly financial mathematics and geometry. She excelled in geometry due to the real life applications. Her family built a new house the same year she was taking geometry, and Lauren made connections between their home construction and the geometry she was learning.

Motivation. Lauren's motivation to do mathematics was to get good grades. She would have been a 4.0 student in high school if it hadn't been for mathematics. Her motivation was socially dependent (Kaasila, 2005). If she liked how a teacher taught and respected her she was more motivated to participate.

Perceived competence. Lauren believed she was "really dumb." She believed she was the only student not able to understand the single explanation repeated over and over. This perspective was reinforced by the subjectifying in her seventh-grade class where peers graded quizzes and tests. The stories told by her classmates—"You got all of them wrong!"—collectively shaped her belief about her ability. The next year, Lauren

experienced intense anxiety over mathematics. In ninth grade, Lauren had a teacher who worked to change the stories Lauren heard about herself. She told Lauren she was smart and capable. This created some improvement in her confidence to learn math. The next year she was very successful in Geometry. In spite of two successful years of math, Lauren maintained a fairly low perceived competence of math.

Emotional disposition. Lauren had expected to like mathematics because she had enjoyed money-related games, such as Monopoly. When mathematics became irrelevant—algebra in particular—she had difficulty enjoying it. Lauren liked mathematics when she understood it and did not like what she couldn't understand. She could list and categorize very specific concepts as liked or not. Some algebraic concepts made sense to her, so she liked them. But, mostly, she best related to financial and business mathematics. She also did very well in geometry because the teacher made it relevant for Lauren.

Anxiety. Lauren's anxiety score (88) was higher than all the participants in the study. Her narrative described the peak of her mathematics anxiety when, in junior high, Lauren's anxiety over mathematics testing was so intense she had physical manifestations of the anxiety including seizure-like spasms called night terrors. She got a reprieve from the anxiety with more positive experiences in ninth and tenth grades. Fortunately, the anxiety never reached the previous level of intensity, but she was never able to completely overcome it.

Summary. Lauren had a weak mathematical identity due to high anxiety and low perceived competence. She fought hard through her secondary years to overcome the

horrible anxiety she suffered in eighth grade; and in the process she built up resilience and tenacity toward learning mathematics. Yet she kept mathematics safely separated from her by maintaining careful control of her relationship with it. She established boundaries, allowing herself to like helpful teachers and understandable mathematics concepts, without fully embracing mathematics as a whole.

Sadie

Vision of mathematics. Sadie recognized that mathematics was used "all the time," but she had no reason to make it a part of her life. She wanted to stay as far from mathematics as possible once she graduated from high school. Her teachers did nothing to help her find value in it.

Motivation. The only time Sadie was internally motivated to learn mathematics was when she had a teacher who created a less stressful environment and showed more interest in student success. He was positive about mathematics and about teaching. Even though the mathematics was still difficult for her, Sadie put forth more effort in this class.

Perceived competence. Sadie did not think she could learn math. "Doing math, I feel like a block goes up, like a wall. I can't get past the wall to get to the numbers. … It's almost like they are speaking a totally different language and I can only make out a few random words and ideas." Sadie was assigned to the lowest level mathematics classes through her secondary education. Even when she passed a mathematics class, she did not think she really learned anything.

Emotional disposition. Sadie summed up her relationship with mathematics with one word—Hate!

Anxiety. Sadie scored relatively high (71) on the A-MARS. She spoke about feelings of anxiety throughout her secondary education. She was quite intimidated by her teachers, especially the men. She was afraid to ask questions in class when the teachers were intimidating. She worked as a bank teller and was "scared to death" of making a mistake with counting money or doing anything mathematical.

Summary. Considering the experiences Sadie had in high school, it is no wonder she avoided mathematics as much as possible. The teacher is a "crucial mediator" (Di Martino & Zan, 2009) between student and mathematics, and Sadie's teachers were poor emissaries for mathematics. The mean shop teacher who sprayed students with water and posted a darkly humorous sign on his door about cutting down anyone who messes with him was using antisocial tactics to influence his students. This approach is rarely productive and generally reduces cognitive and affective learning (Turman & Schrodt, 2006). Sadie had a very weak mathematical identity.

Conclusion

Identities are just stories constructed from experiences (Ben-Yehuda et al., 2005). They can be changed (Howard, 2008), but as is evident in the identities of these students, years of experiences are deeply rooted into identities and can be difficult to uproot and regrow. These students' identities show the interconnectivity of the individual dimensions. Each dimension is both affected by and affects other dimensions. For example, anxiety increases as perceived competence decreases and high anxiety reduces motivation to participate in learning activities.

In spite of the many negative influences described by the students, a teacher

positively affected each dimension in many experiences. Vision of mathematics was high for Blake and Devin whose teachers helped them understand the value of mathematics beyond the classroom. Teachers who were positive about mathematics and about teaching positively motivated Sadie. Lauren's perceived competence increased when she had a teacher who told her she was smart and capable. Kayla had a positive emotional disposition when she had a teacher who explained processes clearly. Devin was taught how to manage the stress related to learning mathematics, thus he had very low mathematical anxiety.

Common Experiences Positively or Negatively Affecting Identity

Research question three asked: What common student experiences positively or negatively affecting mathematical identity emerged from the data? In this study, clear relationships emerged between teacher's actions and student's identity.

Blake and Devin had the strongest mathematical identities in the group of participants. They both experienced positive relationships with their teachers. Devin's relationships tended to be more personal, but while Blake was not interested in developing personal relationships, his teachers were similar to Devin's in being kind, encouraging, and willing to help. These findings are consistent with those of Walter et al. (2014) in their study of highly regarded teachers. The other key common experience was their engineering classes, which helped them gain a positive vision of mathematics due to learning mathematics in context.

One particular experience was common to the remaining participants, who had

weak mathematical identities. They all talked about how most of their instruction was focused on memorizing procedures without any explanation of why the procedures were used. As a result of this procedural instruction, these participants all developed an instrumental view of mathematics, a belief that success in mathematics relies on memorizing a set of unrelated rules. Many of those students indicated having a more positive experience in the rare occurrences of learning math in context. They also indicated a desire to be taught conceptually, to learn the "why?" of doing mathematics. Blake and Devin also experienced procedural instruction, but were able to succeed. Blake's success was due to his task-oriented nature and being in a safe learning environment. As capable as Devin was at memorizing procedure, he spoke highly of the few conceptual and contextual learning experiences he had, which made learning and understanding easier for him.

Also common to students with weak mathematical identities, with the exception of Kayla, was experiencing multiple or significant negative behaviors of teachers, including negative subjectifying, antisocial behavior, and apathy about students and/or teaching mathematics. Even if well-intended, negative actions caused counterproductive identifying interactions which harmed the process of learning (Bishop, 2012). In the minds of these students, mathematics was inextricably connected to the teacher, and if the teacher was not worth knowing, neither was mathematics.

An analysis of the data identified two general factors that influenced student mathematical identity—interactions with teachers and interactions with mathematics. In general, positive interactions with teachers and meaningful interactions with mathematics

contributed to the development of a healthy mathematical identity. The results also showed positive interactions with teachers were foundational to having positive interactions with the mathematics. Like the experiences of the subjects in Heyd-Metzuyanim and Sfard's (2012) study where identifying (talking about the people doing the math) interfered with mathematizing (talking about the mathematics), so did student-teacher interactions interfere with student-mathematics interactions.

CHAPTER V

DISCUSSION

This phenomenological study sought to examine college students' perceptions of past experiences with secondary mathematics teachers and how those experiences affected their mathematical identities. This phenomenon was explored through constructed narratives created from autobiographical essays and semistructured interviews of eight college developmental mathematics students with high and low levels of mathematics anxiety. The four males and four females between the ages of 19 and 38 were from a 4-year, open enrollment university in the mountain west region of the U.S.

Figure 6 revisits the theoretical framework revealed in Chapter II. The specific

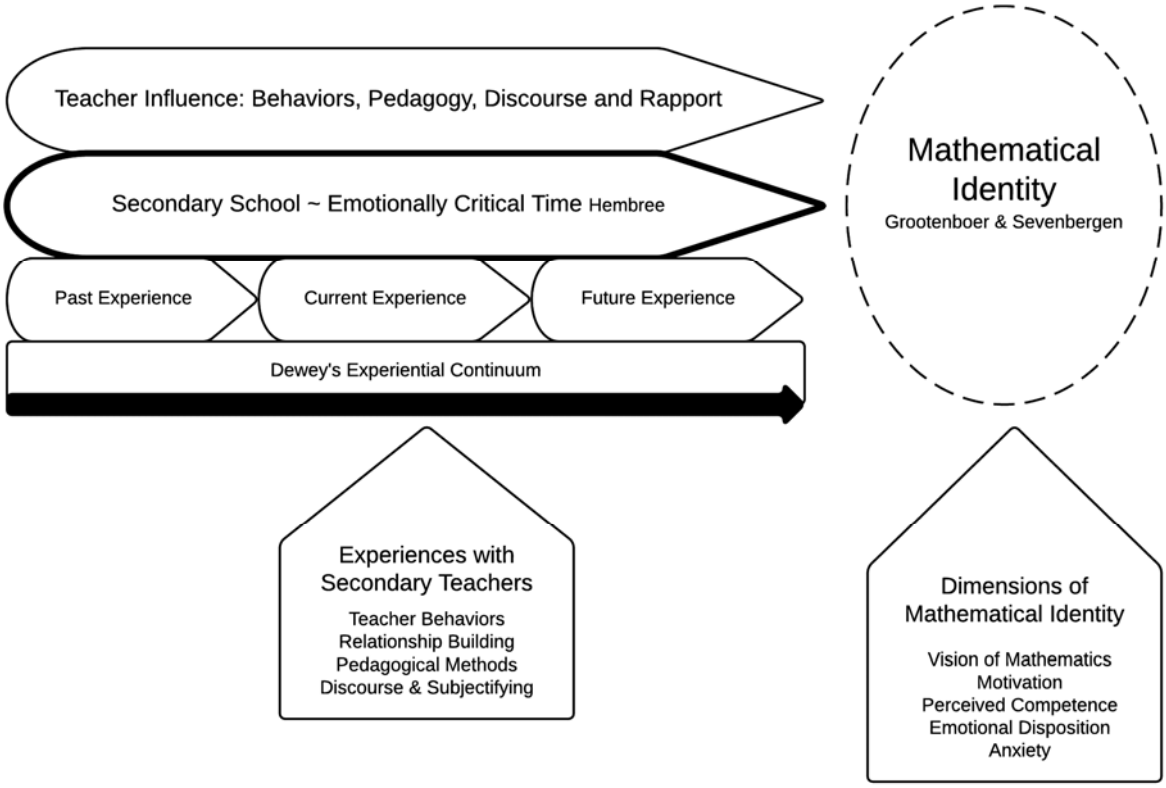

Figure 6. Theoretical framework with *a priori* themes.

themes from the data analysis have been added to show how the data were organized relative to the theoretical framework. The collected data confirmed the *a priori* themes for the analysis. While exploring research question two: how recalled experiences with teachers influenced student mathematical identity, all of the dimensions of mathematical identity were exhibited in each of the students. No additional dimensions emerged. While exploring research questions one and three the themes for experiences with secondary teachers began to diverge into two general factors: interactions with teachers and interactions with mathematics. For the remainder of this discussion, the interactions with teachers are referred to as student-teacher relationships, and the interactions with mathematics are referred to as student-mathematics interactions. Positive student-teacher relationships positively influenced mathematical identity. The student-mathematics interactions that positively influenced mathematical identity were those that made mathematics meaningful to the student. While the most compelling examples from the students' experiences demonstrated negative student-teacher relationships and meaningless interactions with mathematics, this discussion will focus on how the positive and meaningful interactions build strong identities.

Figure 7 shows the interconnected relationship that exists between positive student-teacher relationships, meaningful student-mathematics interactions, and strong mathematical identities. Positive student-teacher relationships are the foundation for meaningful student-mathematics interactions because meaningful interactions require an emotionally safe learning environment. These two factors work together to develop strong mathematical identities. As mathematical identities strengthen, students contribute

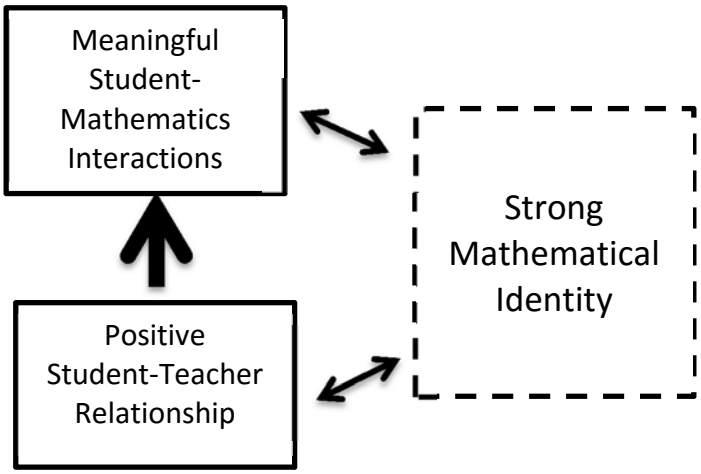

Figure 7. Model for building strong mathematical identity.

more to the student-teacher relationship and to the mathematics interactions. The remainder of this chapter discusses in more detail this interconnectivity and the elements of each factor.

Positive Student-Teacher Relationships

The classroom community has been shown to be an important factor contributing to achievement in mathematics and the development of students' mathematical identities. In particular, a caring classroom community encourages students to expend effort to achieve the learning goals of the classroom (Muller, 2001, p. 252; Ryan & Patrick, 2001; Zhu, 2013) The teacher creates this caring environment through building positive relationships that demonstrate genuine concern for the student as a learner and as an individual. In this study, students favored the teachers whom they believed demonstrated a sincere attitude of caring. When teachers were supportive and helpful, students were more likely to actively participate in learning activities and in

developing their abilities as students. Heather described this experience with one of her teachers. “I could tell that she truly cared if I succeeded or did not succeed, and I knew it, so it was more motivating” (lines 68-69). Sadie described being willing to ask questions of a caring teacher, when she had never felt comfortable asking questions of her other teachers due to their intimidating demeanor.

Teachers often use antisocial strategies in a misguided attempt to influence students to participate in the classroom and learning activities. Antisocial behaviors do not motivate students to stay on task and avoid disruptive behavior. They typically cause students to retreat within themselves, thus closing themselves off from the opportunity to learn. Heather, Lauren, and Sadie, three students who struggled immensely with learning mathematics, based their academic efforts on how caring they perceived their teachers to be. Heather aptly described why students avoided building relationships with teachers and how that related to their relationship with mathematics. “I was not comfortable with math. I was not comfortable with my math teachers. I was not comfortable with any of it. … I just tried to stay as invisible as possible throughout my math experience” (lines 95-98). Uncooperative students generally want to be successful students. They simply need the opportunity to be cooperative while maintaining their personal dignity. This could be seen in the narratives of many students with weak mathematical identities. Heather started each year intending to do well and work hard, but she experienced regular negative interactions with her teachers, which caused her to lose her motivation to participate. Lauren attempted to keep up with her work when she missed class due to athletic trips, but her teacher was not helpful in Lauren’s efforts to make up the work.

Sadie had questions but was too afraid to ask them of her easily agitated teachers. These students made attempts at becoming part of the learning environment, but when they encountered what they perceived to be antisocial responses to their efforts, they chose to protect themselves by disengaging from the learning relationship, thus reducing cognitive and affective learning.

Students often feel vulnerable when trying to learn mathematics. They want and need to learn in an environment that makes everyone feel included and valued. Positive student-teacher relationships create an emotionally safe environment in which students can think for themselves, ask questions, and take intellectual risks (Anthony & Walshaw, 2009). The meaningful student-mathematics interactions described in the next section are possible once students know the classroom is an emotionally safe environment.

Meaningful Student-Mathematics Interactions

The vast majority of mathematics instruction described by the participants in this study was traditional and procedural. Traditional mathematics instruction is "a teacher lecture followed by student practice, with a focus on the application of procedures" (Walters et al., 2014, p. 3). Procedural mathematics instruction is the practicing of routine procedures with little emphasis on understanding concepts (Stigler, Gallimore, & Hiebert, 2000). The majority of instruction in this study focused on memorization of procedures, often including clever tricks and techniques to enhance memorization. Students spoke favorably of teachers who implemented these techniques, but these techniques did little to improve students' dispositions toward mathematics and

only reinforced the image of mathematics as a set of unrelated and meaningless ideas. Even the successful students, Blake and Devin, indicated the procedural instruction did little to inspire their interest in mathematics. Blake's perspective was the typical by-product of procedural instruction: "Math wasn't as much about learning the subject as it was completing the homework because all that matters is what grade you got on your assignments and tests. Not whether you understand it or not" (lines 8-12). Heather and others came to believe they were incapable of learning mathematics when they were, in fact, incapable of memorizing random processes.

Students in this study spoke positively about their opportunities to learn real-world applications of mathematics. Devin explained how a practical application helped him learn Trigonometry better.

> We got into vectors and I really enjoyed that. I climb. So we did one problem that was all related to rock climbing and it just clicked after that. Familiarity with the idea outside really made those lines and equations make sense afterwards. A lot of times it's kind of abstract and it's just formulas and ideas, but having a practical application for it really—I remember that one 'cause it just clicked. (lines 45-49)

Working with mathematics in context of real-world situations helped students learn mathematics is more than the exercise of producing right answers and helped them recognize the value of mathematics in their lives and in society in general. Learning real-world uses of mathematics was highly valued by those students who recalled that type of instruction. Blake and Devin gained their interest and appreciation for math in engineering classes through real-world experiences such as Blake's experience with building truss bridges. They calculated how much weight could be distributed on each of the beams and how much weight the whole bridge could hold. He found this

application of math highly interesting. He wanted to learn math so he could do more things like that. Students who struggled with algebra often found more success in geometry due to the frequent real-world applications.

The students in this study who had difficulty learning procedurally expressed a need for conceptual understanding. Heather said, "It makes more sense for me to remember it if I know why I'm doing it, and I can apply it that way instead of just memorizing the steps of things. And I'm just not a mathematical person to begin with, so I have to know why I'm doing all this stuff that I hate doing" (lines 58-61). Cody struggled with the "This is how you do it. Just do it." approach to teaching. He found it made more sense to understand why to do certain steps. Even though learning procedurally was not difficult for Blake, he valued an instructor who took time to ensure students understood concepts, rather than focusing on staying on schedule. Another of Blake's teachers monitored student understanding and explain concepts in more depth when she found common errors in student work. Lauren found greater success with a teacher who demonstrated concepts using small items such as marbles, pencils, and scraps of paper.

The selection of appropriate mathematical tasks determines the way a student knows mathematics. "Tasks should involve more than practicing taught algorithms; they should provide opportunities for students to struggle with important mathematical ideas" (Anthony & Walshaw, 2009, p. 155). Students in this study found the addition of conceptual and contextual instruction made the mathematics instruction more meaningful. Truly meaningful mathematics instruction occurs when teachers pose

experientially real situations, observe students' activity and ask questions about their work. Then students feel they are being listened to, that their ideas are valued, and they are being understood as mathematics learners (Hackenberg, 2005).

Dimensions of Strong Mathematical Identity

Strong mathematical identity results from positive student-teacher relationships and meaningful student-mathematics interactions, as shown in Figure 7. A better understanding of mathematical identity development encourages teachers to enact pedagogy that considers the mathematics student holistically.

> Identities are important because they affect whether and how we engage in activities, both mathematical and otherwise, and also because they play a fundamental role in enhancing (or detracting from) our attitudes, dispositions, emotional development and general sense of self. (Bishop, 2012. p. 1)

The following descriptions of the dimensions of mathematical identity were used and refined during the data analysis of this study. The five dimensions consider multiple aspects of a student's relationship with mathematics and interrelate thoroughly for a holistic view of the student.

Vision of Mathematics

Perceptions of the nature, value and activities of mathematics and/or what is required to learn or be successful in mathematics make up a person's vision of mathematics. A student with a healthy vision of mathematics understands mathematics is more than an unrelated set of rules to be memorized, and thus has had conceptual and contextual experiences in understanding mathematics. None of the students in this study

fully understood this nature of mathematics. Heather mistakenly assumed she was not a "mathematical person" because she could not memorize all the rules. While most of the participants knew math had practical value, Blake, Devin and Lauren understood more broadly the uses of mathematics in the world. This enhanced their vision of mathematics, yet they still had strongly procedural views of what it means to know mathematics. A student with a healthy vision of mathematics also knows mathematical ability is not based on gender or genetics, but on an ability to persevere through struggle. Devin understood this more than any of the other participants, saying, "It just takes time, practice, and is a whole different thinking mindset. It's just going to [require] applying yourself" (lines 68-9)

Perceived Competence

A student's perceptions of her ability, achievement, and confidence make up the dimension of perceived competence. In simple terms the student with healthy perceived competence knows she is good at mathematics and capable of learning it. This knowledge comes from having successful learning experiences through meaningful interactions with mathematics. Blake attributed some of his confidence to having teachers who provided a safe learning environment. He was willing to attempt to solve any problem because he knew the teachers would not get upset when he made mistakes and they would be willing to help him understand. Heather and Sadie had particularly low perceived competence. Neither had confidence in her ability to learn mathematics. Students with low perceived competence were more likely to correlate their ability to succeed with their perceived quality of the teaching. Kayla always credited her success to good teachers. She never

considered herself capable of learning independent of having a teacher who could explain math step by step.

Motivation

A student's willingness to try to learn mathematics and achieve understanding is closely tied to his vision of mathematics and perceived competence. When students understand that time, practice, and steady effort will pay off they are more motivated to participate in learning activities. Knowing effort will change ability increases motivation to persist through difficulty (Dweck, 2006). Additionally, students who understand the value of mathematics are also more motivated to learn it, particularly when they know how to apply in their own lives. Cody had no interest in learning math when he was convinced he wouldn't use it his own life. Devin's view was the opposite of Cody's he understood the value of mathematics in "today's world" and had the confidence to persevere through difficulty. Kayla felt motivated to work hard when she understood the math. Heather and Sadie were socially dependent and their motivation depended on their relationships with their teachers.

Emotional Disposition

This is typically referred to as attitude toward mathematics. A student with a healthy emotional disposition likes, or even loves, mathematics. A positive disposition is usually associated with a positive vision of mathematics and high perceived competence. Lauren was an interesting example of this. She liked mathematics when it was relevant to her, particularly financial math. She liked math when she understood it and did not like

what she could not understand. Devin and Blake showed that positive disposition usually leads to high motivation.

Anxiety

Anxiety, while similar to emotional disposition is a separate dimension due to its prevalence in mathematics students and its potential to affect cognition. Anxiety is a strong emotional response to mathematics and mathematical activity. Anxiety has the potential to negatively affect ability, as it interferes with the brain's ability to function (Smilkstein, 1993). As Devin explained, "If you panic, you stress out about it, it just doesn't work out for you." A student with a healthy mathematical identity has low mathematics anxiety. It is not uncommon for a student with healthy mathematical identity to feel moments of stress and anxiety, but he has the ability to manage those emotions so they did not interfere with learning and performance. Lauren provided an example of the potential of anxiety to debilitate a student in her experiences with night terrors and being physically ill when expected to perform mathematically.

As indicated in Figure 7, mathematical identity influences how students participate in the student-teacher relationship and the student-mathematics interaction. The interconnectivity has the potential of creating very effective educational experiences for students. This opportunity relies directly on teachers. The construct of mathematical identity builds a broad view of a student that enhances teachers' understanding of their students and serves as a reminder of the complexities associated with learning mathematics.

Implications for Practice

As owners of mathematics in the classroom, teachers influence how students position themselves relative to mathematics, and become the most important resource for building students' mathematical identities (Cobb & Hodge, 2002). Teachers will be most effective in their role as mediator or identity builder when they create positive student-teacher relationships and facilitate meaningful student-mathematics interactions.

Teachers may believe student learning and behavior is out of their control. To a degree this is true. No student can be forced into any particular behavior. However, uncooperative students will often respond to an opportunity to be cooperative when teachers offer respectful and caring attempts to build positive relationships. It follows that positive student-teacher relationships are the responsibility of the teacher. These relationships begin when a teacher uses a happy, positive, and energetic approach to the learning and teaching of mathematics. Kindness and respect must permeate all interactions with students. These behaviors make students comfortable in the learning environment and willing to engage with the teacher and with the mathematics. When students believe the teacher cares about their learning and is willing and available to help them learn, positive student-teacher relationships can then be formed. Meaningful mathematics instruction can be an emotionally risky experience for the student. When the student feels safe in the learning environment, meaningful student-mathematics interactions are possible.

Meaningful mathematics instruction engages students with mathematics through appropriate mathematical tasks that cause students to reason mathematically,

communicate their thinking to others, and engage in reciprocal critique of mathematical ideas. They use mathematical reasoning to understand "why" and "how" as they make connections between and among mathematical concepts. They persevere through solving difficult problems, which require more than the rote application of procedures, and often tie to real-world contexts. Meaningful mathematics instruction makes room for students to understand mathematics procedurally, conceptually, and contextually. These meaningful student-mathematics interactions strengthen students' mathematics identities by transforming their perception of who owns mathematic and allowing them to claim ownership of mathematical meanings (Oppland, 2010).

The Rest of the Story

The purpose of this study was to consider the influence of secondary school teachers on student mathematical identity. The data analysis of this study focused on the identity of the student at the time of leaving high school. However, mathematical identity is not concrete (Ben-Yehuda et al., 2005), and the reader may be interested in knowing the rest of the story. The interviews took place while the participants were enrolled in procedurally taught developmental mathematics courses in college. None of the participants experienced a major change in their mathematical identity after leaving high school, but some of the students with weak identity were able to make improvements.

After completing high school, Heather avoided college because of her fear of math. In her late 20s, Heather decided the importance of gaining an education outweighed her fear of math. She started in prealgebra and successfully completed all

three developmental mathematics classes in 1 year without failing a single class. She said it was the greatest accomplishment in her life so far, aside from beating cancer and having three children. It was not easy, and many times she wanted to give up, but she persevered. She still did not like mathematics, but she developed confidence in her ability to learn it and to help her children with their mathematics homework.

With some life experiences behind him, Joel gained a greater appreciation for the value of mathematics. He found success in his developmental mathematics classes. His teachers were helpful and encouraging, which motivated him to work very hard. As a father, he was careful about how he talked about his struggles with mathematics in front of his daughters. He wanted them to know they can work hard and learn math, too.

As a peer mentor at a community college, Lauren learned strategies that helped her manage her mathematics anxiety. Lauren placed into Intermediate Algebra, higher than the majority of developmental mathematics students at her institution. With less stress and a determination to persevere, she did very well in the course. In spite of these successes, she still did not think she was very good at algebra.

Sadie avoided mathematics as long as she could due to her fear and hatred of it. She successfully completed a prealgebra class, and entered the next class with more confidence. In a resource-rich, computer-based, mastery course, Sadie realized she could eventually understand each concept. If one source of explanation did not work for her, she could turn to other resources for help. “There’s so many ways to keep trying,” she said. This method of learning improved Sadie’s relationship with mathematics and her motivation to try to learn.

Kayla struggled with developmental mathematics in college. At the time of this writing, she had been unable to succeed after two attempts in the mastery, computer-based Prealgebra course. She decided to postpone taking mathematics for the time being.

Very little changed for the other participants. Blake and Devin continued to enjoy learning mathematics in their college classes. Cody dropped out of his mathematics class and eventually stopped out of college.

Recommendations for Future Research

This study connected research about teacher-student relationships and effective mathematical pedagogy to research on mathematical identity. The results indicated many possible directions for future research. The methodology of this study could be replicated with a number of different populations in order to broaden the findings of this research. A study with a larger sample of students would contribute a greater amount of data for analysis. Research could focus specifically on students with high or low anxiety to better identify the common experiences contributing to strong or weak mathematical identities. In this study all the women participants had high anxiety and weak mathematical identity. A more in depth study of females' experiences could yield valuable information. Students who were recent high school graduates would have richer memories of their high school experiences to contribute. Students from a more ethnically diverse school would provide perspectives that may have been missing from the all-Caucasian sample in this research study. Finally, this study should be replicated in several years, after students have had multiple years of instruction in the Common Core Curriculum to see if the change in

curriculum has done much to change students' experiences with secondary teachers.

The conclusions drawn in this study came from data based on participants' remembered experiences and their perceptions of those experiences. In order to more fully understand the relationships between secondary teachers and student mathematical identity more work needs to be done through classroom observation and follow up interviews with students and teachers. Additionally, further research about changing teacher behaviors is needed to answer the question of how teachers will change when they learn the importance of building positive student-teacher relationships. Finally, while this research targeted common dimensions of mathematical identity, no single theory of mathematical identity exists. A grounded theoretical study of mathematical identity could improve our understanding of the construct and develop an inclusive model of mathematical identity.

Conclusion

As I entered my doctoral program I was deeply concerned about the high mathematics anxiety of the preservice elementary teachers I worked with in the university mathematics tutoring center I managed at that time. I wondered how society could ever hope to improve mathematics achievement and attitudes if those who were laying mathematical foundations for school children feared mathematics. As I approached my study, I discovered a plethora of research on mathematics anxiety of preservice elementary teachers (Brady & Bowd, 2005; Cady & Rearden, 2007; Malinsky et al., 2006). I also discovered the construct of mathematical identity. In this construct, I found

the opportunity to gain understanding that was broader than anxiety. Mathematical identity both included and explained anxiety. Mathematical identity provided a holistic approach to mathematics education.

The most significant finding of this study was how crucial the positive student-teacher relationship was in facilitating a strong mathematical identity, especially for struggling students. I was particularly struck by the realization that in the minds (and hearts) of these struggling students, if the teacher was not worth knowing, neither was the mathematics. I expected student-teacher interactions to influence mathematical identity. I did not expect them to be foundational to being able to create meaningful interactions with mathematics.

The good news is that mathematical identity can be improved (Ben-Yehuda et al., 2005; Howard, 2008). The findings in this study contribute to an understanding of the dimensions of mathematical identity and the factors that need to exist in order to improve it. While I did not focus specifically on preservice elementary teachers, as I had originally intended, I am gratified that my research has produced information that can inform the preparation of preservice teachers in multiple ways. In addition to addressing mathematical knowledge and pedagogical skills of preservice teachers, preservice elementary teachers need preparation that addresses their mathematical identity, and preservice secondary mathematics teachers need preparation that addresses their ability to create emotionally safe classroom environments through positive student-teacher relationships. By improving classroom environments we can improve mathematical identities and achievement in our society.

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APPENDICES

Appendix A

Abbreviated Mathematics Anxiety Rating Scale (A-MARS) Questionnaire

From: <Alexander>, Livingston <lalexand@pitt.edu>
Date: Tuesday, November 24, 2015 7:04 AM
To: Kathryn Van Wagoner <kathryn.vanwagoner@uvu.edu>
Subject: RE: A-MARS reprint permission

Dear Dr. Wagoner:

I hereby grant permission for you to reprint the A-MARS in the appendix of your dissertation.

Livingston Alexander

Livingston Alexander
President
University of Pittsburgh at Bradford and Titusville Campuses
300 Campus Drive
Bradford, PA 16701
814-362-7501
814-362-7690 (Fax)
lalexand@pitt.edu

Abbreviated Mathematics Anxiety Rating Scale (A-MARS) Questionnaire

Please indicate the level of your anxiety in the following situations. Please choose ONE box on each line.

		Not at all	A Little	A Fair Amount	Much	Very Much
1	Studying for a math test					
2	Taking math section of the college entrance exam					
3	Taking an exam (quiz) in a math course					
4	Taking an exam (final) in a math course					
5	Picking up math textbook to begin working on a homework assignment					
6	Being given homework assignments of many difficult problems that are due the next class meeting					
7	Thinking about an upcoming math test 1 week before					
8	Thinking about an upcoming math test 1 day before					
9	Thinking about an upcoming math test 1 hour before					
10	Realizing you have to take a certain number of math classes to fulfill requirements					
11	Picking up math textbook to begin a difficult reading assignment					
12	Receiving your final math grade in the mail					
13	Opening a math or stat book and seeing a page full of problems					
14	Getting ready to study for a math test					
15	Being given a "pop" quiz in a math class					
16	Reading a cash register receipt after your purchase					
17	Being given a set of numerical problems involving addition to solve on paper					
18	Being given a set of subtraction problems to solve					
19	Being given a set of multiplication problems to solve					
20	Being given a set of division problems to solve					
21	Buying a math textbook					
22	Watching a teacher work on an algebraic equation on the blackboard					
23	Signing up for a math class					
24	Listening to another student explain a math formula					
25	Walking into a math class					

Appendix B

Interview Protocol

Interview Protocol

Before the interview begins, the students will be informed that:

- The interview will be digitally recorded.
- Their identity will remain confidential during the whole course of the study and in the written report of the study.
- They can discontinue their participation at any time.

The following questions will be asked:

General Question 1: Describe the experiences you have had with your junior or senior high school mathematics teachers.

Additional open-ended questions:

- What other experiences do you remember?
- What do you remember about the teachers you liked/disliked?
- How would you describe the relationships you had with your teachers?
- What do you remember about the ways your teachers ran their classes?
- What do you remember about the ways your teachers explained mathematics concepts?
- What do you remember about how your teachers spoke to you or about you?
- (Clarifying questions as needed)

General Question 2: How have these experiences influenced your relationship with mathematics today?

Additional Questions:

- How would you describe your present attitude toward learning mathematics?
- What value does mathematics have in the world?
- What value does mathematics have in your life?
- How would you describe your ability to learn math?
- How would you describe your motivation to learn math?
- (Clarifying questions as needed)

Closing thoughts: What else would you like to say about your mathematics learning experiences and your relationship with mathematics?

Appendix C

Informed Consent Forms

UtahState University
School of Teacher Education and Leadership
6700 Old Main Hill
Logan UT 84322-6700
Telephone: (435) 797-3085

INFORMED CONSENT
Doctoral Research Study on Mathematical Identity
Initial Sampling

Introduction/Purpose USU education professor Amy Brown and Kathryn Van Wagoner, a doctoral candidate at Utah State University in the school of Teacher Education and Leadership, are conducting a research study to learn more about the factors affecting college students' relationship with mathematics, known as mathematical identity. You have been asked to take part because you are a developmental mathematics student at this university. There will be approximately 100 total participants in this study.

Procedures If you agree to be in this study, the researcher will use your score on the Abbreviated mathematics Anxiety Scale survey and read your narrative essay on "Me and Math: My Relationship with Mathematics Up to Now" to identify some participants to invite to be interviewed.

Risks There are minimal risks involved in this study. Sharing personal experiences with the researcher may cause some discomfort. There is a small risk of loss of confidentiality, but we will take steps to reduce this risk.

Benefits There will not be any direct benefit to you from this study. An indirect benefit is that the study may provide information that can assist educators and administrators in improving mathematics education. You will assist in advancing educational research in the field of mathematical identity.

Voluntary Participation and Right to Withdraw Participation in this study is entirely voluntary. You may withdraw at any time, or refuse to participate without consequence.

Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigator and graduate student researcher will have access to the data which will be kept in a locked file cabinet or on a password protected computer in a locked room. To protect your privacy, personal, identifiable information will be removed from study documents and replaced with a study identifier. Identifying information will be stored separately from data and will be kept secure. Written documents and data will be shredded within 12 months of completing the study.

IRB Approval The Institutional Review Board (IRB) for the protection of human

subjects at Utah State University and at Weber State University has approved this study. (Pending). If you have any questions or concerns about your rights and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Reporting of Results The results of this study will be reported in a doctoral dissertation at Utah State University. Other articles may be published in educational journals and findings may be reported at educational conferences. It is anticipated that the dissertation will be available by April 2015.

Copy of Consent You have been given two copies of this Informed Consent. Please sign both copies and retain one copy for your files.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Signature of Researchers

_____	_____
Amy B. Brown, Ed.D.	*Kathryn Van Wagoner*
Principal Investigator	Student Researcher

Signature of Participant By signing below, I agree to participate.

_____	_____
Participant's signature	Date

The best way for the researcher to contact me, if needed, for further participation:

☐ Email: _____

☐ Phone: _____

INFORMED CONSENT
Doctoral Research Study on Mathematical Identity
Participant interviews

Introduction/Purpose USU education professor Amy Brown and Kathryn Van Wagoner, a doctoral candidate at Utah State University in the school of Teacher Education and Leadership, are conducting a research study to learn more about the factors affecting college students' relationship with mathematics, known as mathematical identity. You have been asked to take part because you are a developmental mathematics student at this university and you were a participant in the first part of this study. There will be approximately 8—10 total participants in this stage of the study.

Procedures In this stage of the study, the researcher will conduct two one-hour interviews in which she will ask you open-ended questions about your experiences with learning mathematics. Each interview will be audio-recorded and will last approximately one hour. Interviewees will be given the opportunity to read a narrative biography constructed from the collected data and provide feedback about its accuracy.

Risks There are minimal risks involved in this study. Sharing personal experiences with the researcher may cause some discomfort. There is a small risk of loss of confidentiality, but we will take steps to reduce this risk.

Benefits There will not be any direct benefit to you from this study. An indirect benefit may be that by reflecting on your past experiences with learning mathematics, you may gain insights about yourself that will positively affect your ability to learn mathematics now. The study may provide information that can assist educators and administrators in improving mathematics education. You will assist in advancing educational research in the field of mathematical identity.

Compensation Those who participate in two interviews will receive a $20.00 gift card to your university bookstore as compensation for participation in this study. The Internal Revenue Service (IRS) has determined that if the amount you get from this study, plus any prior amounts you have received from participating in research studies at USU since January of this year, total $600 or more, USU must report this income to the federal government. If you are a USU employee, any payment you receive from this study will be included in your regular payroll.

Voluntary Participation and Right to Withdraw Participation in this study is entirely voluntary. You may withdraw at any time, or refuse to participate without consequence.

Confidentiality Research records will be kept confidential, consistent with federal and state regulations. Only the investigator and graduate student researcher will have access to the data which will be kept in a locked file cabinet or on a password protected computer in a locked room. To protect your privacy, personal, identifiable information

will be removed from study documents and replaced with a study identifier. Identifying information will be stored separately from data and will be kept secure. Persons quoted in any publication of the research will be given pseudonyms, as it is anticipated that some statements from essays and/or interviews will be quoted in the final report. Written documents and data will be shredded within 12 months of completing the study and audio recordings will be destroyed within 6 months of completion of the project.

IRB Approval The Institutional Review Board (IRB) for the protection of human subjects at Utah State University and at Weber State University has approved this study. (Pending). If you have any questions or concerns about your rights and would like to contact someone other than the research team, you may contact the IRB Administrator at (435) 797-0567 or email irb@usu.edu to obtain information or to offer input.

Reporting of Results The results of this study will be reported in a doctoral dissertation at Utah State University. Other articles may be published in educational journals and findings may be reported at educational conferences. It is anticipated that the dissertation will be available by April 2015.

Copy of Consent You have been given two copies of this Informed Consent. Please sign both copies and retain one copy for your files.

Investigator Statement "I certify that the research study has been explained to the individual, by me or my research staff, and that the individual understands the nature and purpose, the possible risks and benefits associated with taking part in this research study. Any questions that have been raised have been answered."

Signature of Researchers

_____	_____
Amy B. Brown, Ed.D.	*Kathryn Van Wagoner*
Principal Investigator	Student Researcher

Signature of Participant By signing below, I agree to participate.

_____	_____

Appendix D

Participant Narrative—Blake

Participant Narrative—Blake

At the time of his interview, 19-year old Blake was enrolled in Prealagebra in the developmental mathematics program. While he did well in his secondary math classes, he worried he might have some gaps in his understanding, so he dcided to start at the lowest math class to refresh his basic math skills. He declared mechanical engineering as his major because of his enjoyment of designing and building.

Blake always did fairly well in math. However, he never found his mathematics classes to be terribly exciting. His experience was that you went to class, learned what you had to learn, and did the homework. "Math wasn't as much about learning the subject as it was completing the homework because all that matters is what grade you got on your assignments and tests. Not whether you understand it or not." The purpose of junior and senior high school math was "to learn it because you are supposed to learn it." He gained an appreciation for math in a high school engineering program. In that class he enjoyed math a lot more because they were able to immediately apply the math they learned in a real-world application. He found he liked math a lot more when it was actually useful. It was a lot easier to focus and pay attention to math and to want to do it on his own when there was a reason behind why he was learning it.

His junior high math classes were fairly consistent in how they operated. In his eighth and ninth grade classes students typically filled out guided notes pages while the teacher was teaching. After the lecture, they had about ten minutes to work on a set of practice problems on their own and ask questions of the teacher while they were working. Sometimes they had worksheets with a game-like activity, such as solving a word puzzle by getting the right answers to a set of math problems. Blake liked math, even though it "wasn't super interesting, not something you'd go out and just do for fun." He didn't have a problem doing it and he didn't dread doing it. It was just school. And he did enjoy it more than his English classes.

Algebra made a lot more sense to Blake than geometry. He attributed that to being "just how my brain works." He never was able to understand proofs. They made no sense regardless of how many times they were explained to him. The teaching methods in his geometry class were similar to algebra but required a different method of thinking. Where some students excelled, he seemed to lag behind.

According to Blake, the teacher was really good. She would write a problem on the board and the students would each work it on a small square of whiteboard. The teacher used this method to check understanding of the concept. Students could erase and rework incorrect problems. When the teacher identified a common misunderstanding she would explain it in more detail to the entire class.

Another geometry teacher wasn't as helpful. She did more lecturing and left students to figure out the math on their own. It was a lot harder for Blake to understand

since they didn't do as much practical work, mostly lectures. He had trouble keeping up. The class was more difficult as a whole, and the instructor didn't explain the math as well as Blake would have like.

Tenth grade math was not a great experience. The teacher was gone on maternity leave for a long time. The substitute gave a lecture then sat at her desk while the students worked on homework for half the class period. Again, this was not a very impactful experience with math. Up to this point, Blake earned A's and B's in his math classes.

In 11th grade Blake took precalculus. Personal life challenges prevented him from keeping up with the homework. Although he performed well on the tests, the homework was a significant enough part of the grade that he ended up failing the class. He repeated the class in 12th grade and passed it.

The 11th and 12th grade teachers were pretty good. "They were understanding of how busy life could be and how dreary homework was, but still pushed you to completing it anyway. They also had a strong enough understanding of the subject to be able to teach it well to those who didn't understand the subject. And would spend time working on one subject, ignoring what would normally have been required by the district that day, and focusing on helping the entire class understand a difficult concept."

His 12th grade teacher worked closely with students. She reviewed homework with the class before grading it, allowing students to ask questions and improve their understanding of the exercises. The 12th grade teacher was friendlier with the students and a lot easier to talk to, so it wasn't intimidating to ask her questions.

In high school, Blake liked math even more than in junior high, but it was because of his engineering program. This is where he learned that math was used for something other than just doing homework. An example of the kind of assignments he had in the program was building truss bridges. They had to calculate how much weight could be distributed on each of the beams and how much weight the whole bridge could hold. He found this application of math highly interesting. He wanted to learn math so he could do more things like that. He took engineering classes all three years of high school and completed a capstone project during his senior year. He decided he wanted to do something engineering or math related as a career due to this experience.

Blake never really felt the need to develop relationships with his teachers. Sometimes he would ask a question about the math, but he found his friends to be equally helpful. The message that he got from all of his teachers was that you can usually solve anything if you work at it hard enough. He learned that even if you don't understand a problem immediately, if you do what you know, you can often figure it out. Some of this confidence in his ability to learn was an internal thing and some of it came from being in a safe learning environment. If he tried something and did it wrong, the teacher wasn't going to get mad about it and would be willing to work with him to understand. Because of this Blake was willing to attempt to solve any problem. "I think I'm pretty good at

learning math because I'm able to understand how what you've learned before applies to it. Even if it's a more difficult concept, it makes sense because it is just these different parts going together."

At the time of his interview, Blake saw himself as a numbers kind of person. When he thought about anything in life, it was more the numbers or the logistics behind it rather than the emotional or language side of it. He was able to see how the different parts of math fit together. He felt his math classes influenced his development in understanding math, although he didn't have very many experiences in his math classes that introduced the value of or practical uses of math. He highly valued math, recognizing that we can't really do anything without math. He believed math was good to know, even if one never really uses it. "It makes you think more logically about things." He was highly motivated to learn math for gaining a career in engineering.

Appendix E

Participant Narrative—Cody

Participant Narrative—Cody

Cody never planned to go to college, but at the time of his interview he was a 28-year-old sophomore majoring in psychology and enrolled in Prealgebra.

In elementary school, Cody had a teacher who strongly influenced his future math learning experiences. He had this same teacher for 5th and 6th grades. He was very negative and would say things like, "you will never get this. Don't even worry about it." The teacher wouldn't give him tests because he knew Cody wouldn't pass it. It wasn't in an effort to be nice. The message was "You're stupid. You're dumb. It wasn't to help me out in any way. He just didn't care. He didn't want to deal with it. . . . That kind of stuck with me. That kind of resonated with me."

Cody recalled doing as well as anyone else in 7th and 8th grade. He didn't really like his 7th grade teacher or the way he taught. The teacher's personality was "crass and rude. He was mean all around. Not a friendly person. Not a people person." The teacher didn't really teach much, but expected students to understand the math and do their assignments on their own. Cody was able to succeed in spite of the lack of teaching. Interactions between students and the teacher were rarely on a personal basis. While students were working on math individually, the teacher waited until someone asked a question before teaching anything. Each question was answered on the board in front of the entire class. "If you were already way ahead of that you wouldn't pay attention to it. If you were far behind it, you needed to catch up. It really wasn't that great of a teaching style and it wasn't really one-on-one. It was more of like 'you have a problem?'—Put it up on the white board. Figure it out." Cody rarely asked any questions because he was always able to complete his assignments without difficulty. He doesn't remember anything about 8th grade math.

In 9th grade he ended up in a remedial math class. "I'm not the brightest child, so I didn't really stay up with my class in math." This was the case in most of his math classes. He also had personal challenges that interfered with his ability to succeed because he was "kind of a troubled youth." The 9th grade class taught practical math, such as medication dosing. He doesn't remember much else about the class or the teacher. In junior and senior high school, he was consistently in self-paced classes, "do it yourself and if you have any problems go to the teacher." While he wasn't overly engaged with learning math, he was able to finish with B's or better in junior high.

Cody started his high school experience with a "pretty good" teacher in 10th grade. She was "on top of it" and very willing to help students one-on-one. Class time was focused on working through exercises sets individually, but when a student had a question the teacher worked multiple problems thoroughly and showed multiple approaches to solving a problem in order to meet the different learning styles of the students. It became clear to him that there were different ways of doing a problem and

still come to the same solution. Sometimes there would be a whole class activity that was typically kind of fun. One such day they did a math activity with playing cards. As the course became more challenging it "kind of turned me off to it, and I didn't want to deal with it anymore." He earned grades of D or C. By this time, Cody had established a consistent pattern in his math classes. "I'd kind of know it and do well for the first little bit, but when it gets harder I just kind of lose it, and I don't do much after that. I just give up on it."

Cody took a math class in 11th grade that was also independently structured. The teacher worked one-on-one with students to answer questions as they came up. He had a very outgoing personality, really wanting to help students to learn and tried to get all the students on the same assignment, not too far ahead, not too far behind. Every morning they would start class with a page of arithmetic drills, or have a quiz. Half way through the school year Cody's family moved to Western Samoa. He took the GED right after he arrived in Samoa. And that was the end of his public school experience.

Cody didn't develop relationships with any of his teachers. He preferred to keep a low profile—didn't perform too well or too poorly to draw attention to himself. He wasn't interested in connecting with his teachers. He recalled they were all good, positive people. They spoke encouraging messages to the classes as a whole, and once in a while they would work closely with and provide extra encouragement to those who were struggling. "They kind of stayed with the kids they knew would do all right. And the other ones they just kind of figured either they'd figure it out or they won't." He never felt personally encouraged. "No "you can do it." Nothing like that." The lack of encouragement eventually led to his giving up with each class.

Cody had no motivation to learn math. This was mostly because math had no value to him. "I knew you used math everyday for random stuff, but [not] algebra or Prealgebra. I didn't really care. . . . Why should I learn math I'm never going to use?" At the time he finished his high school education, he didn't see that math had any value to him.

The teaching in high school was very procedural. "This is how you do it, just do it." Teachers would show the problem once, not explain anything, and then "your turn" Cody needed more than that, especially in higher math. For him, it made more sense to understand why to do certain steps. "Explain it a little bit more to me instead of just running through it, and I'll have a better understanding of it."

Cody did not expect to use a lot of math in his career, particularly no algebra. He believed knowing basic math was highly valuable in everyday life, but not algebra, calculus or higher math. He believed everyone should know basic math. He had no motivation to learn any math that he would not personally need to know.

Appendix F

Participant Narrative—Devin

Participant Narrative—Devin

Devin was 22 years old, a freshman and planned to become a doctor. At the time of his interview, Devin had recently dropped an Intermediate Algebra class due scheduling issues. Devin took math each of the four years of high school, completing concurrent enrollment College Algebra and Trigonometry in 12th grade. He was a little disappointed to be placed in Intermediate Algebra, but not surprised because a few years had passed since he graduated from high school. Devin generally enjoyed math, but found classroom experiences could be frustrating depending on the teacher and how the class was managed. He had more positive experiences in higher level classes that had students who "actually wanted to participate in class." The small number of students in the classes make it easier to work with the teacher and "get those inside tips on math."

Devin started junior high math in prealgebra and followed the traditional sequence through high school. math was never a great struggle for him, and he just "plugged along" and went through it all. In junior high his attitude about math was neither positive nor negative. "Math was math. It was just one of those classes you had to take. It wasn't bad. It wasn't good." In junior high 8th and 9th grade he enrolled in engineering classes. "I started to enjoy figuring out puzzles, so math become more enjoyable once I started taking that."

Devin had very positive experiences in junior high and high school and had "amazing teachers." In 7th grade prealgebra the teacher did a "typical whiteboard presentation and then if we had questions, we just sat at her desk and she would work with us until we figured it out." He mostly remembers this teacher was always willing to work with students. He "lucked out" and had this same math teacher in 8th grade Algebra I and 9th grade Geometry, so he had a consistently positive experience with learning math all through junior high.

One of his favorite teachers was Mrs. H in 10th grade with Algebra 2. Her teaching varied a little from the typical lecture style, as she gave students a notes worksheet to fill out as they followed her lecture. What made her a favorite was the way she related with students. Like his other teachers, Mrs. H was "very willing to work with you. I remember going in a lot for tutoring and getting that extra help." She also created a fun and relaxing atmosphere that made it easier to deal with any struggle in learning math. She took the stress out of learning math by using songs, pictures and clever ways to remember rules and formulas. "It was just really relaxing having the struggle, but having it fun, too." In 11th grade Precalculus, Devin had this same teacher. The math was more challenging, but the environment and attitude made it a positive learning experience.

Another favorite teacher was Mr. S in 12th grade College Algebra and Trigonometry. "The guy was funny." He also created a different learning environment, providing the students with the opportunity to be more independent learners. In his

lecture he would "make sure you understood how to do the basics," but he didn't show students how to work every type of problem in the homework. Students had to figure out how to apply the basic understanding to more complicated exercises. Another thing that made this class more interesting was working with practical applications. Devin didn't recall any of his other teachers explaining the practical uses of math, but Mr. S did frequently. Devin struggled with trigonometry, but learning practical applications helped him learn it better. In Trigonometry, "we got into vectors and I really enjoyed that. I climb. So we did one problem that was all related to rock climbing and it just clicked after that. Familiarity with the idea outside really made those lines and equations make sense afterwards. A lot of times it's kind of abstract and it's just formulas and ideas, but having a practical application for it really—I remember that one 'cause it just clicked."

Devin enjoyed working on his math homework alone. He enjoyed the challenge of trying to solve problems, "It was hard, but enjoyable at the same time." If he couldn't figure something out, he asked his teachers for help and was very satisfied with that experience with all of his teachers. "A lot of times they would teach you in class, but if you sat down and talked to them they would show you an easier way, a better way for doing it than the original pattern that they teach. I think the teachers I spent the most time with, cared the most, were the ones that I liked and remember."

Devin found little distinction in the way his classes were structured. Class time consisted of a lecture followed by homework time. "Here's the presentation. Do the math." The personalities of the teachers varied, but even if the teacher's personality was "a little on the dull side, they could still explain it really well." What Devin valued most in his teachers was their willingness to work with him when he needed extra help. It was also important they had a "solid understanding" of the math because that enhanced a teacher's ability to help individual students. "A good math teacher is good at figuring out a different way to help somebody else's way of thinking match the problem you are working on."

While no single experience stood out to him, Devin remembered his teachers being very supportive of him. "The entire time they spoke to me or were helping me they made it really stick out in my mind that 'you can do math,' that it is possible, even with this section where you really struggled. It just takes time, practice, and is a whole different thinking mindset. It's just going to [require] applying yourself." Devin has internalized this message. "I think one of the biggest lessons that I learned throughout that education is just that you can do it. It's nothing you need to panic about. If you panic, you stress out about it, it just doesn't work out for you. Your mind's just not in that set where you can learn at your best level. So I think that's the biggest thing is just really putting math in its place. As you go through school . . . it's just this kind of preset idea that math is hard and you're not good at it. So I think that was one of the biggest things—just breaking out of that traditional mindset that holds people back." This understanding

helped Devin's confidence in his ability to learn math. Even though there were times he wondered if he would ever get through a class—trigonometry in particular—he knew that with time he could catch on. He expected this understanding to help him in his more challenging college math classes. "Deep down I'm going to know I have what it takes, but at the same time there are going to be those times where it's 'Oh boy. What did I get myself into? I don't know if I can figure this out in time for my grade.' I always have that attitude that eventually I will catch on, but will it be in time for a good grade? Will I figure it out before the test?"

Devin also developed a strong appreciation for the value of math, algebra in particular. Even math that seemed to only be of academic value is "very practical because it teaches you a new way to think—how to be very organized and systematic about things. So I think even that academic application can be very practical throughout your life. You can always pull a good learning experience in every subject in more than just facts and figures. I think math is one that really stands out how it does that—that systematic thinking. How beneficial that is for everything. . . . Honestly, there's just too many applications for algebra in life not to say, 'yeah, I have to know this. . . . Having a good understanding of math is definitely a requirement to get through anything in today's world."

Appendix G

Participant Narrative—Heather

Participant Narrative—Heather

At the time of her interview, Heather, a 30 year-old freshman, had just completed Intermediate Algebra. She was majoring in visual communications and planned to become a photographer for National Geographic.

At the time she entered seventh grade, Heather already did not like math and "felt very inadequate in math." She had leukemia as a child and missed a lot of math instruction due to her illness. "I missed out on a lot of the beginning steps, and math is such a stepping stone system that I kind of got frustrated really early on." Her mother worked "super, super, duper full time," and Heather never bothered her mother about her challenges in learning math. Through junior and senior high school, Heather mostly got D's and F's. She couldn't remember which classes she took specific years and probably repeated some courses multiple times.

Heather described most of her junior and senior high school teachers as "there because that was their job" not because they cared about it. "Part of it was my fault in that I didn't really push myself, I wasn't super motivated, but at the same time, I didn't feel like my teachers really tried to motivate me either." Her 7th grade prealgebra teacher taught a little bit during class but didn't seem to be very committed to teaching. She did recall that when he taught at the board he would spit on people. Sitting on the front row was not preferred.

Her 8th grade teacher ridiculed students for giving wrong answers. Homework was corrected orally in class with students row-by-row reading aloud their answers. "Everyone got nervous when it came to be their turn because … he loved to make a joke out of you. So I just really didn't love it. . . . When it would be your turn to say your answer and you're kind of shakin' in your boots and you say your answer and you get it wrong. He would put his hands down (slapping hands on the table) and just "ohhhh," and roll his eyes and say [sarcastically] 'Really? How'd you get that one? Where'd you pull that one from?' Stuff like that. I don't really remember other specific things he would say but he was negative. He was a negative teacher. I can't really remember him doing things up on the board. I'm sure he probably did, somewhat, but I don't remember him doing a lot." He was a "really crusty old man." Heather was the sixth child in her family to be in his class. He gave Heather a silly nickname based on her last name. This teacher made her feel like "a complete idiot." He didn't say those words, "but it was just there."

The 9th grade teacher was "a bumbling idiot." He was very disorganized and stumbled over his words a lot. He became the brunt of students' jokes. "He tried to be nice, but you could tell he wasn't particularly interested in the students. I had a good friend in there and we would sit and laugh and kind of draw pictures of him and that kind of stuff that 9th graders do. Ridiculous stuff." He was not well suited to teaching and did not assert authority over the class, so "it was really chaotic." Heather didn't recall

learning anything in that class.

As she did every semester of school, Heather started the semester with high hopes and a commitment to try really hard, but soon she would fall behind. She remembered trying to get help from her tenth grade teacher, but wasn't able to get the help she needed. This teacher felt her lunch and after-school time was her personal time, and she didn't want to spend that time with students. She was willing to help during class, however she only provided an explanation of the steps for the specific problem without any kind of reasoning or foundational explanation. Without a thorough understanding of the math, Heather eventually fell too far behind and gave up.

The only time Heather got a grade higher than D or F was in 11th grade. She had a teacher who was new and enthusiastic. The teacher was hired midway through the year to replace the wrestling coach who was fired due to drinking alcohol on the job. The new teacher developed a positive rapport with the students. "She seemed to care [about] what we were doing in life. She liked to joke around with us and I felt that she genuinely cared for the students." Where the other teachers were less enthusiastic about helping students and offered limited explanations—this teacher was not that way. Instead of going to lunch with the other teachers, she would eat lunch in her classroom and be available to help students. "She had a different way of explaining things. She would say . . . this is why we do it. Not just 'here's the steps.' At least for me, it makes more sense for me to remember it if I know why I'm doing it, and I can apply it that way instead of just memorizing the steps of things. And I'm just not a mathematical person to begin with, so I have to know why I'm doing all this stuff that I hate doing." Additionally, the teacher did not allow students to talk negatively about their ability to do math. "If someone were to be frustrated—'Ugh. I'm just so stupid' or 'I'm horrible at this' she would [say] 'No, we don't talk like that!' She was the type who said, 'not everyone's good at math, but everyone's good at something and this might not be your forte but that doesn't mean you can't do it. You just need to put more effort into it than some other people.' " Heather earned a B in this class. She attributed her success to the teacher taking time to provide real help. In return for the teacher's efforts, Heather was more motivated and put forth more effort to learn. "I could tell that she truly cared if I succeeded or didn't succeed, and I knew it, so it was more motivating."

Heather was able to graduate from high school by earning credits doing a computer-based program after school in addition to her regular math classes. She started this during 11th grade.

Heather thought it was 12th grade when she took Geometry. As for her teacher, "I really didn't like her and she really didn't like me. . . . She was too cool to be there. . . . She had this authoritative, I am better than everyone, kind of vibe." With many of her teachers, Heather felt like there came a certain point in time when they "stopped looking at you." This was especially the case with the Geometry teacher. "I remember times

where I remember thinking, 'she just totally skipped right past me, like I'm just not even here.' " When this teacher returned papers to students, she would nicely place the papers on the desks of her good students. For the others, she would throw the paper and "hopefully it would land on your desk, and some kids thought it was funny and they would make a contest of being able to grab it before it hit the ground. But she was not doing it as a game."

In general, Heather "would really try to start out doing what I thought I should and tried to be really motivated, but I would get lost really quickly. I didn't feel that the teachers really cared if I came in for help." I feel like when teachers can be a little bit more open about themselves as a person, it makes you feel like you can identify with them more. For me, that motivates me more and makes me feel more comfortable in asking questions. Heather recalled going in for extra help a few times, but "didn't particularly feel like they really wanted to be there to help me. … I kind of felt they had an attitude like 'what aren't you getting about this? … how can you not see this?' . . . I got very discouraged very quickly. And I just would give up very quickly." Reflecting back, she realized her biggest problem was a weak foundation in prerequisite skills—so she was always behind. At the time, she didn't understand why she was struggling so much. She just thought she was stupid.

Except for eleventh grade, Heather avoided building any kind of relationship with her teachers. "I was not comfortable with math. I was not comfortable with my math teachers. I was not comfortable with any of it. And I would try to just slink in my desk and make sure I had candy in my pocket that could make sitting through it a little sweeter. I just tried to stay as invisible as possible through out my math experience." She did not relate well to their teaching methods. "It was just like 'this is the first thing you do, this is the second thing you do, this is the third. You'll get your answer.' That was it. . . . But if I could understand why it was done this way, why this step was done before this step, then it helps me to remember."

After graduating from high school, Heather had no confidence in her ability to learn math. Additionally, her father was attending college and struggling with math at the same time, so she was certain her problems with math were genetic. Heather never saw the value of math in her personal life, but recognized its value in the world in general. When she finished high school, Heather didn't go to college. One of the reasons was that she was terrified to have to take math classes. When she took the ACT and SAT in high school, she didn't bother trying on the math section. "I was so frustrated with it, and I hated it so much that I would just go a-b-c-d-a-b-c-d all own the math part." So she knew she would have to take math in college. After getting married and having children there were many times she wanted to start college, but fear of math deterred her from pursuing a degree. "One of my struggles with math is that I am not a rule follower, and I like things that fall into the gray area. This is not possible with math—you're either right or you're wrong and that is a struggle for me."

Appendix H

Participant Narrative—Joel

Participant Narrative—Joel

Joel was a 38-year-old junior enrolled in math 990 at the time of his interview. He was a non-commissioned officer in the Air Force National Guard and enrolled in school to facilitate getting advanced to the next rank, which required having a degree. He is finishing two associate degrees—aviation maintenance and paralegal—and starting a bachelor's degree in field service engineer operations through the automotive department.

Joel remembered always not liking math. This was in part due to a significant experience in his math education in the 6th grade. He and another student could not understand what the teacher was explaining, and seemed to be the only students in the class who didn't understand. The teacher told them if they couldn't understand he would put them in the 5th grade math class for the day, which he did in a "really mean and demeaning" way. Joel felt he honestly tried to understand the math, but it didn't make sense. But going to the 5th grade class didn't help. "I felt humiliated. . . . I really did not do any math after that."

Joel struggled with learning in general. "At home I didn't have a support system or anyone helping me except for my sister." Joel credits his sister for helping him learn any math at all while he was in public school. He started struggling with math in fourth and fifth grade. "She remembers better than I do sitting beside me and trying to put it in layman's terms, put it in a way that I could understand. She was great at that. She had some great insight into how my mind ticked. She got in there and helped me see the way that I needed to see and helped me get through it." His parents were uneducated. His mother was an immigrant, and his father didn't get past the 8th grade or so. Around the time Joel entered junior high, his sister left for college, so he lost his support system. There was no one to motivate him to do anything. Combined with the bad experience in sixth grade, those factors led to him not caring about school. "I honestly stopped paying attention. Because I was working and had a lot going on, my mind wasn't in school at all."

After 6th grade, Joel never participated in a math class. Some teachers in junior high tried to reach him, but "my mind wasn't in school at all." He began working nights and sleeping in class. "A lot of [his teachers in general] wouldn't pay attention to me or [would] tell me I was a waste of time." A guidance counselor told him he should quit school. He dropped out of school in 9th or 10th grade. At age 18 or 19 he earned his GED through a university program. He couldn't remember anything about the math involved with doing that. Not the instruction or the test questions.

Math was a non-entity for Joel when he was a teenager. His attitude was "I'm going to grow up and not use math. The closest I came to using math was doing wheel alignments of the front end of automobiles and trucks. That's the closest thing I've come to math, but for the most part the machine would do the calculations for me, so I still had that old cliché of grow up and not use math." He did not remember any instruction in actually using math or learning what it was used for.

Appendix I

Participant Narrative—Kayla

Participant Narrative—Kayla

At the time of her interview, Kayla was a 21 year-old freshman taking Prealgebra. She planned to major in English and was interested in studying creative writing and art. She made an attempt to complete prealgebra two semesters prior, but was unable to complete the course because she struggled with one particular concept and couldn't get past it.

Kayla lived in England when she began junior high school in seventh grade. She had never been really talented at math, always needing help, so she was in one of the lower classes while in England. Her registration was based on a placement test, rather than on her age or grade level. The class had about 15 people in it. The structure of the class was fairly traditional. The teacher taught the material. The students worked problems in class, asking for help as needed. They completed assigned homework at home. The teacher was strict, but likeable. He explained concepts well. She earned a grade equivalent to a B that year.

In eighth grade, Kayla was in Germany, enrolled in a basic eighth grade math class in an American school on a military base. Due to having a really good teacher, she earned B and C grades, which is good for her. This teacher would put stories into learning math. For example, she taught them to "rise before you run" and taught songs to help learn formulas. Through her facial features and actions in teaching, as well as her love of the subject, she kept students' attention and interest. When students had a question about a concept, she would show different examples until students understood. She did a lot of group activities and made things into games. For a math class, it was kind of fun, more fun than other math classes she'd had. Kayla recalls this teacher encouraging her to work hard in math, complimenting her for trying hard, but the teacher also pointed out to her that she would likely always struggle with math.

In ninth grade, Kayla took prealgebra with another good teacher. He was energetic and showed a lot of examples, like the eighth grade teacher. The class was structured similarly to her seventh grade class. She was also registered in a lab class with four or five other people who were also struggling with math. They were able to help each other as they worked together. They also used a computer-based math program that adapted based on their individual understanding and knowledge of the math to review prerequisite skills and build prealgebra skills. Thanks to having a really good teacher, combined with the computer program, Kayla was able to get B and C grades in prealgebra.

Both her 8th and 9th grade teachers encouraged her to work hard. They never downgraded her in spite of her struggles. They were always happy and smiling, saying things like "you can do this" and "if we work on it a little bit more, I know you can do this." Kayla always felt comfortable with these teachers. If she had a question she was never afraid to ask. She never felt like they were too smart for her, or that they thought

she wasn't smart enough. They knew she struggled with math and always put it in a way that she would understand it. She trusted that they could explain the math well.

Kayla took geometry in 10th grade in the U.S.. She was living with and had the help of her grandparents that year, so she got B's in that class. Also, she related better to geometry because it was more visual. As an art student she connected better to the visual aspect of geometry than to the numerical aspects of algebra. The geometry class followed a different classroom structure. Each day the teacher did a little review of what was taught in the previous class period and connected it to what was going to be taught that day. Instead of group activities students were partnered up with someone for the entire quarter to work together. Kayla didn't rely much on her geometry teacher for help. Because of the help from her grandparents, she rarely needed to ask questions.

Kayla had two different math teachers in 11th grade algebra. The first semester teacher was pretty good. He explained things pretty well, starting at "step one." He included stories in the explanations and used visual cues to help the students remember. Most of his instruction was lecture and individual work, but sometimes he included group work. Typically the class would correct the homework together, then go on to the day's lesson. This teacher integrated tips on how to learn math in his lessons. In spite of having a good teacher, she struggled some with the algebra due to the abstract nature and the need to memorize and apply formulas. She earned a B- in this class.

She had trouble connecting with the second semester 11th grade algebra teacher and didn't learn as much as she would have with a better teacher. She recalled he had a graduate degree in math and had been teaching math for close to 30 years. He also taught calculus, so he tended to expect students to know more than they did. He wasn't so good at explaining concepts from the beginning, "jumping in somewhere like five steps into the process." Because she was often frustrated, she tended to not try as much as she had in other classes. She recalls getting a D from that class. In 12th grade Kayla did not take math because she needed to get other credits towards graduation.

Kayla had confidence in her ability to learn math, but knew that it comes only after a lot of hard work. She typically had to work harder at it than most people. She always believed that if she could work hard enough and get a good teacher, then she could understand it. She often needed concepts explained in multiple ways and preferred the use of visual tools. It also helped when a teacher made it into a story that is related to her personal life or used techniques to help with memorizing and using formulas. She felt that if she repetitively worked each problem from the beginning ("step one") often enough, it would become automatic. Kayla liked math when she understood it. It's not really a subject she would personally choose to study. She preferred English. She was motivated to learn math to finish her required math classes and stop taking math. When she had a good teacher, she had a positive attitude toward learning math, saying, "Yeah, I can do this." When she understood the math, she felt motivated to work hard. If she tried

hard to understand an idea and could not, she chalked it up to the fact that, "Math is just one thing, I probably won't understand unless something miraculous happens."

While she recognized that math has value in the world and that it enhances her life—"you wouldn't have your laptop if there wasn't math . . . we are an advancing world in technology and science"—she saw math more as a milestone to be achieved so she can go on with life. She did not expect to ever actually apply math in her life, particularly the things she learned in algebra. "There wasn't anything drastic in my high school or life that makes me say 'yeah, math is awesome.' I mean, I'm sure it's awesome, just not awesome for me." She expected to have to work hard in college and felt she would be successful if she had a good teacher to explain the math to her. Her general feeling was "Math and I have never gotten along. I have never truly understood math concepts unless I had an extremely good professor that explained the concepts well. If I could understand the concepts, then I love learning about it and doing it. If I don't then I tend to procrastinate and get frustrated."

Appendix J

Participant Narrative—Lauren

Participant Narrative—Lauren

Lauren was a 23 year-old junior in Intermediate Algebra who planned to major in Business Management with a finance emphasis. Intermediate Algebra was her first college math class, but she was making her second attempt to pass it. She took it a few years ago at a community college and was unable to complete it due to some health challenges.

In seventh grade Lauren was in a Prealgebra class. Her strongest memory of the class was that she hated it. She had just moved to a new community and while she had done well in math, compared to the 16 other students in her class, she didn't do well in Prealgebra. This challenge was made worse because classmates graded quizzes and tests. She would frequently hear comments such as: "You got all of them wrong, it's amazing!" or "Lauren stunk at this quiz again." She didn't have a very good teacher. She pretty much ignored the students; just telling them to "go work on your homework." The manner in which she answered students' questions sent messages like, "Quick. Let's get this over with. Sit back down. I don't care if you get this." While the teacher never verbally critiqued her, Lauren felt put down by having her peers correct her quizzes and tests. "I felt stupid. It reminded me [that] the kid behind you knows what grade you got. The kid two people in front of you knows what grade you got. Eventually, the whole row knows what grades you get, so that perception carries outside of the classroom. The other kids are like 'she's bad at math.' " In spite of the difficulty, she earned low B's in this class.

Her eighth grade experience was even worse because the teacher didn't want to be there. He was a high school shop teacher who was sent to the junior high to cover a math class. When the teacher presented the class lecture, he would not stop to check for student understanding, and Lauren didn't understand what was going on. She would get one-on-one help from the teacher, but she simply could not understand his explanations. Nor could she understand the information from the textbook. Sometimes students would correct each other's work in this class, but "it really didn't matter because most of the kids in that class really stunk at math, too. So I made a few friends in that class because we'd say, 'Oh, it's ok. I missed that question, too.' " Lauren had this class after lunch and because she hated to go to class, she often had a stomachache from the anxiety of having to go. She often considered skipping class, but didn't have any place to go, other than hiding in the bathroom, and she didn't want to do that. The physical reaction to the anxiety worsened. Soon around the time of the first test, she began to have "night terrors." She would wake up in the middle of the night and have physical spasms similar to a seizure. She would have bad nightmares dealing with numbers and not being able to balance equations. This would happen every time she had a math test during the entire year, or when she was greatly struggling to understand specific concepts. They occurred

more than ten times during the year. Again, Lauren earned low B grades. She did work over and over again until she got the points she needed.

Ninth grade was much better. She had the best math teacher she ever had because she explained each concept "three different ways." She was a first year teacher. The class was about 20 students who all struggled with learning math. The teacher did many things to help the students learn, including group activities, making worksheets, and demonstrating math principles using "toys and stuff"—small items such as marbles and handy objects such as pencils or pieces of paper. This teacher provided encouragement telling Lauren things such as "You can do this. You're not dumb. You're not stupid. You're a smart girl." She would say these things to the class as a whole, as well as directly to Lauren. She also showed interest in the students' lives outside of math class. Lauren passed with an A, her first.

Lauren took geometry in 10th grade. She loved geometry and got A's and A-'s without really having to study. She helped other students in the class and earned extra points on tests and assignments because she always got the bonus questions right. The teacher showed a lot of real life connections using concrete objects to demonstrate the geometry concepts, and she explained how geometry is used in real life. One class period they went outside and worked an exercise with a tree and the shadow. Lauren's family was also building a new house that year, and Lauren saw a lot of geometry applications in the construction of the house.

Eleventh grade was algebra again, and she hated it. She didn't understand what was going on. In algebra there were some concepts that she loved and understood, and others she couldn't understand and hated, which were often foundational ideas. She really enjoyed solving systems of three equations in three variables. But simplifying square roots was confusing. Typically she found it easier to do math that she could equate to money because that made more sense to her. One challenge in eleventh grade was that Lauren missed class often due to athletics. She would try to get help with what she missed, but the teacher wasn't very accommodating. A friend in class shared the notes with her. Lauren's efforts to be responsible for her learning didn't seem to help her efforts with her teacher. "If you missed class, then you missed class, and she wouldn't help you as much." Lauren didn't recall having any meaningful conversations with this teacher, even though she often tried to get extra help. During Lauren's tenth grade year this same teacher was her math lab tutor. She didn't really talk to the students. She sat at her desk and students needing help had to walk to her desk. As a tutor, she did frequently tell the students to "be quiet." This was also typical of the eleventh grade algebra class. After presenting the material for the day, the teacher sat at her desk and students came to her to ask questions.

Lauren fulfilled her high school math credit requirements in eleventh grade, so she did not take math in the twelfth grade. If it weren't for math, she would have had a

4.0 GPA in high school.

Lauren's relationship with her teachers was based on how she perceived them as a math teacher. "If they were a good teacher then I absolutely loved them. If they were a bad teacher and I didn't understand what they were saying I absolutely did not like them." In her view, a good teacher was one who would explain math in different ways until she was able to understand. A bad teacher was one who would "just say this is the way to do it and this is the only way to do it." When she was in seventh grade, she thought most people thought, learned and understood the same way, so when she didn't understand the single explanation that was repeated over and over, "it just made me feel really dumb, and it made me feel mad because I didn't get what they were saying." The repetitive approach to teaching made her feel "really dumb," therefore she didn't like those teachers because "I didn't like feeling dumb." Her relationship with math was also dependent on whether or not she understood. If she didn't understand a concept she didn't like it, but if she understood a concept she liked it. She didn't see the point of algebra, and "if I don't see a point to the math, I don't necessarily like it. " She loved financial math. She grew up enjoying money-related games like Monopoly and at a young age beat her father, a finance teacher, at that game. She thought she would be good at math, but when she got to algebra, "Oh, I'm not good at it." Lauren recognized the value of math in the world, but if it had no value in her own life, she didn't like it. Good grades were really important to her, so she was motivated to learn the math to get a good grade. math was simply a requirement to be met.

Appendix K

Participant Narrative—Sadie

Participant Narrative—Sadie

At the time of her interview, Sadie was 36 years old and enrolled in Beginning Algebra. She was a sophomore, majoring in social work and planning to be a caseworker. In her essay, Sadie wrote: "My relationship with math can be summed up in one word. Hate! I hate math! The minute somebody starts talking numbers my mind goes blank. It's like an invisible wall comes up in my mind with only the purpose of not letting any numbers pass. It's almost like they are speaking a totally different language and I can only make out a few random words and ideas."

Sadie remembers always being in the lower math classes for slower or troubled students. In 7th grade she was in "the lowest math." Her teacher was "a big guy and would yell at us a lot or yell at—because kids were getting into trouble. And he had a fake eye so you never knew who he was yelling at." There didn't seem to be any emphasis on helping the students to actually learn math. "It was kind of—get us in and get us out. There wasn't a lot of one-on-one." Eighth and ninth grades were similar, taught by the same teacher. "Same kind of class. Same kids. The same." In these classes, which last about forty-five minutes, most of the time was spent with the teacher lecturing. Homework was to be completed at home. "I remember hating to do the homework. Sadie "never passed a math class." She never felt like she was learning something and moving forward. The teacher of these classes was also the librarian. Class was held in the library. "They just seemed like they didn't really care. They were frustrated. There were a lot of kids that were in trouble. They just wanted to get you in and out. Get it over with, is what it felt like."

In high school Sadie had mostly male teachers, "and they were a little gruff." Usually, coaches taught the lower math classes. The shop teacher taught one of her math classes. "He was mean. I think he would get frustrated very easy, you know. With math I would kind of space off, and then when I come back I'm lost. And I'm too afraid to ask a question, especially when the teachers were agitated that you'd wandered off." This particular teacher had a sense of humor and joked around with the students, but he was also very tough. He had a sign on the classroom door that said something to the effect of: "I am the lawnmower and you are the grass. If you mess with me I'll cut you down to size." He had a spray bottle of water that he would spray on students if they fell asleep. Sadie was "a shy kid, so I didn't really interact other than what was necessary. I sat in the back and was quiet." She was quite sensitive to the classroom environment and unwilling to ask questions. "I never asked questions. I was too scared to ask questions. I didn't want to be dumb and I didn't want to let them know I wasn't paying attention." Overall, Sadie was intimidated by this tough teacher and intimidated by male teachers in general.

Sadie was required to attend summer school to make up failed math classes. She

doesn't remember much about that experience, but she was able to do what was necessary to get credit. "It might have been just more one-on-one and they wanted to get you out. [Just] put in your time. There wasn't anything particularly hard. I don't retain information very well, so maybe it was more condensed and easier to remember."

The philosophy of her eleventh grade math teacher (who was also a coach) was if the student tried, the student got credit. The teacher worked with the students "a little bit more" and she appreciated that environment. "A lot of times I'll do it but just miss it by a hair, just a little thing I missed." This teacher tried to make math fun. "He wasn't so serious about it. More laid back. It wasn't such a big deal if you made a mistake." He "was always very positive about math and about teaching. I don't remember anything specific [he said] to me, but I remember it being positive." Sadie was more willing to try to succeed in this class, although she always had a hard time passing the tests. Sadie felt comfortable enough with this teacher to ask him questions, although she would only ask questions one-on-one, never in front of the class. Sadie passed her eleventh grade math class. "I don't think I really learned a whole lot."

Sadie could not remember anything specific about 12th grade math. She was quite certain she had another male teacher, possibly a coach, and she didn't get much out of the class. Sadie continued to be assigned to classes specifically for those students who were slower in math through all of high school.

When Sadie finished high school she wanted to stay as far away from math as possible. In spite of her dislike of math at that time, she recognized the value of math, "that you use it all the time." She had a job as a teller, and "I was scared to death that I'd have to do the math because I couldn't. I think I got yelled at a couple times because I couldn't, the thing was down, and I miscounted or I did it wrong. I hated working as a teller. It scared me—because I couldn't do the math." Additionally, Sadie didn't think she could learn math. "Doing math, I feel like a block goes up, like a wall. I can't get past the wall to get to the numbers. Sometimes I feel like I'm banging my head against the wall trying to get to it."

Appendix L

Sample Color Coding of Narrative

The only time H got a grade higher than D or F was in 11th grade. She had a teacher who was new and enthusiastic, Ms. S. The teacher was hired midway through the year to replace the wrestling coach who was fired due to drinking alcohol on the job. The new teacher developed a positive rapport with the students. "She seemed to care [about] what we were doing in life. She liked to joke around with us and I felt that she genuinely cared for the students." Where the other teachers were less enthusiastic about helping students and offered limited explanations – Mrs. S was not that way. Instead of going to lunch with the other teachers, she would eat lunch in her classroom and be available to help students. "She had a different way of explaining things. She would say … this is why we do it. Not just 'here's the steps.' At least for me, it makes more sense for me to remember it if I know why I'm doing it, and I can apply it that way instead of just memorizing the steps of things. And I'm just not a mathematical person to begin with, so I have to know why I'm doing all this stuff that I hate doing. " Additionally, Mrs. S didn't allow students to talk negatively about their ability to do math. "If someone were to be frustrated – "Ugh. I'm just so stupid" or "I'm horrible at this" she would [say] "No, we don't talk like that!" She was the type who said, "not everyone's good at math, but everyone's good at something and this might not be your forte but that doesn't mean you can't do it. You just need to put more effort into it than some other people." H earned a B in this class. She attributed her success to the teacher taking time to provide real help. In return for the teacher's efforts, H was more motivated and put forth more effort to learn. "I could tell that she truly cared if I succeeded or didn't succeed, and I knew it, so it was more motivating."

H was able to graduate from high school by earning credits doing a computer-based program after school in addition to her regular math classes. She started this during 11th grade. The teacher was Mrs. A.

H thought it was 12th grade when she took Geometry. As for her teacher, "I really didn't like her and she really didn't like me… She was too cool to be there… She had this authoritative, I am better than everyone, kind of vibe." With many of her teachers, H felt like there came a certain point in time when they "stopped looking at you." This was especially the case with Ms. H. "I remember times where I remember thinking, 'she just totally skipped right past me, like I'm just not even here.'" When this teacher returned papers to students, she would nicely place the papers on the desks of her good students. For the others, she would throw the paper and "hopefully it would land on your desk and some kids thought it was funny and they would make a contest of being able to grab it before it hit the ground. But she was not doing it as a game."

CURRICULUM VITAE

KATHRYN ELLEN VAN WAGONER

ACADEMIC PREPARATION

Ph.D. Curriculum & Instruction, Math Education and Leadership
Dec 2015
Utah State University, Logan, Utah
GPA 3.92
Dissertation: "College Student Perceptions of Secondary Teacher Influence on the Development of Mathematical Identity" Adviser: Dr. A. Brown.

Master of Public Administration
June 2003
Brigham Young University, Provo, Utah
GPA 4.0

Bachelor of Arts, Math Education
April 1988
Brigham Young University, Provo, Utah

PROFESSIONAL EXPERIENCE

Director, Developmental Mathematics, February 2012 - present
College of Science, Weber State University, Ogden, Utah

- Provide leadership and direction for the development of developmental mathematics curriculum and course delivery
- Supervise 13 full-time instructors, and 24 adjunct instructors
- Provide professional development for faculty
- Oversee courses, instructors, and the progress of students in Pre-Algebra, First Course in Algebra, Pathway to Contemporary Mathematics, and Intermediate Algebra
- Create new Pathway to Contemporary Mathematics course
- Manage multiple budgets totally approximately 1 million dollars
- Conduct outcomes assessment, apply for certification through National Association for Developmental Education, and conduct program review for the Utah State Board of Regents
- Teach developmental math courses
- Supervise non-faculty staff, including administrative assistant, department advisor, and software manager, and IT service representative

Manager, Math Tutorial Services, 2000 – February 2012
Tutoring & Academic Skills Services, University College, Utah Valley University, Orem, Utah

- Create and manage programs designed to assist students' successful completion of required math courses
- Supervise approximately 40 tutors and lab assistants in the Math Lab, which serves over 3000 students per semester
- Train employees in tutoring pedagogy/andragogy through three levels of CRLA certification
- Teach Developmental and College Algebra
- Co-create and co-teach Math Success course
- Supervise coordinators of special math programs, such as SLA and Math Pass
- Participate as a member of the TASS Team in department and campus-wide events
- Forecast and manage budgets
- Promote the lab and all special programs sponsored by the lab.
- Assess performance of individual employees and the function of the lab as a whole

Adjunct Instructor, September 1988 to April 1992 and October 1998 to 2011
Department of Mathematics, Utah Valley University
Courses: Intermediate Algebra, College Algebra
Department of English, Utah Valley University, September 1988 to April 1992
Courses: Freshman Writing
(Taught an average of 14 credit hours per semester through Aug 1999)

Secondary Education
Utah County Academy of the Sciences, UCAS District, Orem, UT, 2005

- Taught Intermediate Algebra Independence High School, Provo School District, Provo, UT, 1996-1998
- Taught at-risk students at the alternative high school
- Selected curriculum for basic mathematics that would encourage students to seek higher levels of achievement in mathematics

PUBLICATIONS

Andrade, M. (Writer) & Van Wagoner, K. (Producer and Writer). 2011. *Learning is developmental.* (Video production).

Fearnley, D. & Van Wagoner, K. (2011). The mathematical art exhibit 'Infinite Beauty' at Utah Valley University, 3–30 March 2009. *Journal of Mathematics and the Arts,* 5(1), 29-41.

Van Wagoner, K. (2012). Effectively onboarding new staff. In K. Agee & R. Hodges (Eds.), *Handbook for training peer tutors and mentors* (pp. 99-102). Mason, OH: Cengage.

CONFERENCE PRESENTATIONS

National Presentations

Van Wagoner, K. (2013, November). *Advocating for Developmental Math: Can You tell Your Story?* Concurrent Session, 39th Annual Conference of the American Mathematical Association for Two-Year Colleges (AMATYC), Anaheim, CA.

Van Wagoner, K. (2013, February). *To Redesign or Not to Redesign: That is Not the Question.* Pre-conference Institute, 37th Annual Conference for the National Association for Developmental Education (NADE), Denver, CO.

Hamilton, C., & Van Wagoner, K. (2010, November). *Building Bridges, Not Walls: A Campus-wide Approach to Math Success.* Concurrent Session. 36th Annual Conference of the American Mathematical Association for Two-Year Colleges, Boston, MA.

Hamilton, C., & Van Wagoner, K. (2010, February). *Uncorking the Bottleneck: A Campus-wide Approach to First-Year Success in Math.* Concurrent Session, 29th Annual Conference on the First Year Experience, Denver, CO.

Van Wagoner, K. (2009, September). *Successful Practical Ideas for Math Learning Centers.* Pre-Conference Institute, 24th Annual Conference of the National College Learning Center Association (NCLCA), Denver, CO.

Demke, J., Fox, C., Nunez, A., Van Wagoner, K., & Zempter, J. (2009, April). *Hit and Run Tutoring: Leaving No Casualties Behind.* Concurrent Session, 17th Annual Conference of the National Tutoring Association (NTA), Salt Lake City, UT.

Andrade, M., Copas, L., Simmerman, W., & Van Wagoner, K. (2009, February). *Assessing Tutoring Support Centers: Key Principles and Positive Outcome.* Concurrent Session, 33rd Annual Conference of National Association for Developmental Education (NADE), Greensboro, NC.

Howard, L., White, K., & Van Wagoner, K. (2009, February). *Motivating Math Students to Choose Success.* Concurrent Session, 33rd Annual Conference of the National Association for Developmental Education (NADE), Greensboro, NC.

Taylor, K., & Van Wagoner, K. (2008, February). *Revolutionary Change: Solving the Math Problem as an Institution.* Concurrent Session, 32nd Annual Conference of the National Association for Developmental Education (NADE), Boston, MA.

Van Wagoner, K. (2000, November). *Increasing Student Success in Developmental Mathematics Using Individualized Study Plans.* Concurrent Session, 13th International Conference on Technology in Collegiate Mathematics (ICTCM), Atlanta, GA.

State and Regional Presentations

Van Wagoner, K. (2012, November). *Advocating for Developmental Education: Can You Tell the Story?* Workshop Session, 18th Annual Conference for the Southwest Association for Developmental Education (SWADE), Salt Lake City, UT

Taylor, K., & Van Wagoner, K. (2007, November). *UVSC's Math Task Force: An Institutional Solutions Manual.* Concurrent Session, 13th Annual Conference of the Southwest Association for Developmental Education (SWADE), Salt Lake City, UT.

Sullivan, C., & Van Wagoner, K. (2004, November). *Structured Learning Assistance---A New Idea for Math Success.* Concurrent Session, 10th Annual Conference of the Southwest Association for Developmental Education (SWADE), Las Vegas, NV.

Bell, L., Holdaway, R., & Van Wagoner, K. (2004, November). *Decades of Bells, Whistles and Better Students: Tutoring at an Evolving Institution.* Concurrent Session, 10th Annual Conference of the Southwest Association for Developmental Education (SWADE), Las Vegas, NV.

Institutional Presentations

Van Wagoner, K. (2006, May). *Burned Out or Fired Up: Fighting Job Burnout with Enthusiasm.* Breakout Session, Utah Valley State College Summer University Staff Development Conference, Orem, UT.

RESEARCH

Van Wagoner, K. *College student perceptions of secondary teacher influence on the development of mathematical identity.* Dissertation in progress.

Van Wagoner, K. *Attitudes of advanced middle grades mathematics students*. Unpublished pilot study.

Multiple internal studies including:

- Placement Issues in Developmental Education and Financial Aid Students, Utah Valley University
- Structured Learning Assistance Pilot Program Study, Utah Valley University, 2004

GRANTS

Funded

Co-Principal Investigator. ($8661). *Cognitive and Learning Sciences in Higher Education: Research, Instruction, and Dissemincation.* 2013 Weber State University Hemingway Award. Project Goal: to apply research on cognitive learning during the transition from arithmetic to algebra in professional development of developmental

mathematics teachers. (with Eric Amsel, Weber State University)

Principal Investigator ($2500). *Structured Learning Assistance.* (2003-2004). Exceptional Merit Utah Valley State College Foundation Grant. Project Goal: to pilot a Structured Learning Assistance Program. (with Carole Sullivan, Utah Valley State College)

Not Funded

Co-Principal Investigator. *Creating an Online Tutoring Program to Support Distance Education Students.* (2001). Fund for the Improvement of Post-Secondary Education (FIPSE). Project Goal: Improve access to math tutoring support and increase math achievement for distance education students. (with Loretta Palmer, Utah Valley State College)

Co-Implementor. *Utah Valley University Learn and Serve Math K-16 Initiative.* (2010). Learn and Serve America. Project Goal: Use service-learning for university students to implement math enrichment programs in public schools in the local community. (with Alexis Palmer, Jane Loftus, and Benjamin Moulton, Utah Valley University)

PROFESSIONAL MEMBERSHIPS

College Reading and Learning Association
National Tutoring Association
National Association of Developmental Education
National College Learning Center Association
American Mathematical Association for Two-Year Colleges
Utah Mathematical Association for Two-Year Colleges
Southwest Association of Developmental Education

LEADERSHIP AND SERVICE

National

Chair, Political Liaison Committee (2009-2012), National Association of Developmental Education (NADE)

Co-Chair, Political Liaison Committee (2011 – 2012) Council of Learning Assistance and Developmental Education Associations (CLADEA)

Co-registrar (2011), 37th Annual Conference of the National Association of Developmental Education (NADE)

Conference Team Volunteer (2010, November), 43rd Annual Conference of the College Reading and Learning Association (CRLA)

Registrar (2004-2005), 29th Annual Conference of the National Association of Developmental Education (NADE), Albuquerque, NM

State

Co-founder and Co-chair (2012 - present). Utah Women and STEM Education Network.
Committee Member. Math Majors Committee, USHE.

Institutional – Utah Valley University

Chair, Structured Enrollment Committee, 2011-2012
Member, Math Initiative Committee 2011 – 2012
Member, First Year Experience Committee, 2009 – 2011
Chair, Math Awareness Week Planning Committee, 2005 - 2011
Member, Student Success and Retention Committee, 2008-2010
Chair, Instructors Committee, Boy Scout Merit Badge Pow Wow 2004-09
Member, UVUphoria Planning Committee, 2007-2008
Chair, Image and Perception Sub-committee, Math Task Force, 2005-07
Co-Chair, Math Success Committee, 2005
Member, Professional Engagement Pillar of Distinction Exploration Team, Fall 2004
Member, School of General Academics Strategic Research Committee, Fall 2004
Member, Office Professionals Conference Planning Committee, 2001- 2004
Member, Planning, Budgeting and Accountability Task Force, Fall 2003
Numerous search committees including Director of Institutional Research, Associate Dean of University College, and Writing Center Coordinator

Institutional – Weber State University

Chair, Developmental Mathematics Advisory Committee, 2012-14
Member, Assessment and Placement Policy Petition Committee, 2012-14
Member, Assessment and Placement Committee, 2012-14
Member, Math Substitution Petition Committee, 2014
Member, Underrepresented Student Support Committee, 2014

CERTIFICATIONS and AWARDS

- Developmental Educator of the Year, Southwest Association for Developmental Education, 2012
- Distinguished Certification for Utah Valley University Math Lab, National Association for Developmental Education (NADE), 2009.
- Master Tutor, College Reading and Learning Association, 2003.

COMMUNITY SERVICE

PTA Volunteer, Sunset View and Amelia Earhart Elementary Schools
Boy Scouts of America: Roundtable Commissioner, Webelos Leader, Cub Scout Committee Chair, Troop Committee, District Trainer, Wood Badge Staff, Assistant District Commissioner, BYU/UVU Merit Badge Pow Wow Committee, Council Centennial Committee