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Mathematical Identities and Tracking: An Exploration of Efficacy in Children and Women

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An Exploration of Efficacy in Children and Women

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A culminating thesis submitted to the faculty of Dominican University of California in partial fulfillment for the requirement for the degree of Master of Science in Education

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Abstract

This study seeks to understand the impact of elementary school mathematical identities and mathematics tracking on the identities of women and girls. "Tracking" is an institutionalized education method developed in the 1960s and 1970s in which schools sort their students into smaller class-sized groups based on their observed achievement (Domina et al., 2016). Too often, when students test onto the lower track, they are confronted with a sense of futility and a lack of self-efficacy (Domina, Hanselman, Hwang & McEachin, 2016; Houtte & Stevens, 2015). Further, in STEM disciplines, students who identify as female report lower self-efficacy rates than those who identify as male (Hand et al., 2017). Girls typically form during their elementary school years a dislike and disinterest in mathematics across their academic careers and into adulthood (Tang, 2019; Carter, 2020). This comparative mixed methods study included student surveys with students in kindergarten, and 4th grade, pre-ability-based testing, and interviews with several adults who identify as female, some of whom serve as educators, some who have been tracked, and all of whom have provided mathematics biographies. The central research questions included: (1) How do mathematics placement tests and tracking impact student math identity and self-efficacy? (2) What perceptions do students and professional educators have about ability-based learning groups and tracking? (3) How does mathematics tracking in elementary school impact lifelong mathematical success? The findings show that most children have high self-efficacy in early childhood, and that tracking does matter over time. Lastly, the findings suggest that the self-efficacy of women and girls in mathematics increase through methods of teaching and co-teaching. This study illuminates the mathematical identities of students who identify as women and girls to promote their overall success.

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Chapter 1: Introduction

"I'm not a math person" is a phrase I have often heard children and adults use to identify themselves. This study is interested in what occurs to the math identity before that point. People often discuss their mathematics skill level, confidence, or self-efficacy as a character trait. As an elementary school student placed on the "lower track" from third grade through adulthood, I struggled to bounce back from the internalized identity that I was "not a math person."

When I declared as a pre-business major during my first year in college, I sat down in a lecture hall for the pre-business orientation. The first thing the department head said to the group of incoming freshmen was, "If you don't consider yourself to be a math person, I do not think you are in the right room." I got up, left, and scrambled to find a new major where I felt I would succeed. My lacking self-efficacy in math made me feel inferior to my peers throughout my education and ultimately drove me away from pursuing a career in anything related to STEM.

Although research exists on this topic at the secondary and high school levels, there is a research gap in connecting the analyses of mathematics identities at the elementary level to women in STEM fields. Research has found a correlation between girls' math self-efficacy and interest in pursuing STEM career paths (Tang, 2019). It is crucial now more than ever that we examine the impacts of ability-based grouping at the elementary level to ensure that all students, regardless of gender, have the same opportunities to thrive in STEM fields. Opportunities in science, technology, engineering, and mathematics all come down to a confident foundation of mathematical knowledge. This study aims to pinpoint the moments that define the mathematical identities to strive toward a classroom where all students are math people.

Statement of Purpose

The intent of this study was to examine the mathematical identities and efficacy levels of elementary students and adult women before and after tracking occurs. A tentative definition at this time for tracking is a method of grouping students into “curriculum tracks” or by dividing them into low-, average-, and high-achievers (Oakes, 1987).

The following themes of lacking self-efficacy with lower track placement, gender biases in STEM, and girls forming an opinion about mathematics during their elementary years have shaped the approach to this research. When students are on the lower track, they are confronted with a sense of futility and a lack of self-efficacy (Domina, Hanselman, Hwang, & McEachin, 2016; Houtte & Stevens, 2015). Students and teachers perform gender biased behaviors that impact self-efficacy—the confidence in one’s ability to control one’s behavior, motivation, and performance—of women and girls in STEM (Hand, Rice, & Greenlee, 2017; Hidalgo, 2019). Girls typically form a dislike or disinterest in mathematics during their elementary school years (Tang, 2019; Carter, 2020). The research gap on these topics resides at the elementary level. There is abundant research on the negative lifelong effects of gender biases in tracking and placement starting in secondary, upper, and collegiate levels. However, to get to the root of the problem, examining the beginning of the child’s educational journey may prove foundational to dismantling these disadvantages.

This research will help fill the gap on how to provide a more equitable and inclusive education to girls and women. However, there is still a long road ahead. To continue providing young women with more opportunities for success in STEM fields, we must analyze the life course of their mathematical identities to see where we are going wrong, on both micro-interactional to institutional levels.

Overview of the Research Design

This research used a mixed method approach from a transformative philosophical worldview. The research design was developed to effectively identify the conditions for inclusive and equitable practices to best support people who identify as girls in math and other STEM fields. This study sought to understand the following research questions:

1. How do mathematics placement tests and tracking impact student math identity and self-efficacy?
2. What perceptions do students and professional educators have about ability-based learning groups and tracking?
3. How does mathematics tracking in elementary school impact lifelong mathematical success?

The research site for the kindergarten and 4th grade surveys took place on campus in their homeroom classrooms at Kirkland Elementary School in San Anselmo, a town in Marin County, California. The researcher had previously taught as the 4th grade students' community activism teacher. The 4th grade survey was distributed virtually on Google Forms with short answer and Likert scale multiple-choice questions. Besides seeing the kindergarteners around the school campus, the researcher had no pre-existing relationships with the kindergarten participants. The kindergarten survey was distributed on paper using a multiple-choice Likert scale format, and the questions were presented verbally by the researcher.

The individual interviews with adult women occurred at different locations depending on the convenience and preference of the interviewee. Two interviews took place at the interviewee's place of work (local classrooms) and two interviews took place virtually on Zoom. All interviews were audio recorded and transcribed. The researcher conducted analytic memos for each individual interview. The interviewees were chosen based on personal relationships and broader networks of the researcher. Two of the interview participants previously attended high school with the researcher. One of the interview participants was the former teacher of the researchers' partner. One of the interview participants was previously employed in a school setting with the researcher. All of the interviewed women either grew up in Marin County or are employed as educators in Marin County.

Significance of the Study

There were three primary thematic findings illuminated through the research process: (1) students have a positive math efficacy in early childhood, (2) tracking matters over time, and (3) self-efficacy can be (re)built through teaching. This research sought to fill the research gap of exploring the effects of mathematics placement at the elementary level. Because of the recent local detracking efforts in elementary school mathematics, it was unable to pinpoint current effects on students. However, this study was able to gain new insights on the lasting effects of mathematics tracking as well as illuminate the impacts of tracking throughout the mathematical education of adult women. For example, this research found a theme of positive math efficacy in early childhood. This contributes to the findings of Carter (2020), who found increased amounts of self-agency among primary-aged students when they have equitable access to STEM. The finding of positive math efficacy in early childhood challenges the findings of Tang (2019) and Carter (2020) who found that girls typically form a dislike or disinterest in mathematics during their elementary school years that lasts for years into their educational futures.

The second thematic finding, namely, that tracking matters over time, illustrates the experiences that shaped the mathematical identities of three of the four interviewed women. These women each shared a moment on their mathematical journey when they felt the most self-efficacy. There were also commonalities found between negative identity-shaping experiences shared by the two interviewed women who were on the "lower" mathematics track. The finding of tracking matters over time is connected to the literary finding of social role theory (Eagly, 1987) and gender identity. This study found that if a girl or woman is on the "lower track" they are more likely to assume the social role of "not a math person."

Lastly, this research found a new contribution to the literature on women's success in STEM fields. The final theme of this research discovered that women effectively build efficacy through teaching and co-teaching. In other words, women succeed in mathematics when they are in a learning environment where they are able to collaborate with their peers in the form of presenting their knowledge and thinking to others. Providing all students with the opportunity to shift their social role (Eagly, 1987) from the student to the teacher is an effective way to build mathematical efficacy in the classroom.

Research Implications

This research provides implications for classrooms, schools, and policy. The findings of this study highlight the necessity for teachers to maintain the students' high level of early childhood efficacy throughout their K-12 education. In a school where mathematics tracking is present, there are methods to promote a more equitable mathematics learning environment for women and girls. This research suggests that incorporating the method of grouping students into co-teaching groups will strengthen the overall efficacy of the mathematics students. Making this co-teaching style of learning accessible to students as much as possible will create a space where various learning styles are celebrated and encouraged.

This research has implications for district and state policy. The research found that participants, in general, have positive experiences with mathematics and high self-efficacy prior to the occurrence of tracking. The researcher suggests that districts and state policymakers consider detracking mathematics altogether. Detracking mathematics would provide all students with more opportunities to enroll in more advanced mathematics and science courses, ultimately opening up doors into STEM careers. This shift would benefit the long-term success of all students in the digital age.

Chapter 2: Literature Review

This literature review integrates analysis of social role theory, gender bias versus self-efficacy in mathematics, and the history and impact of academic tracking. The comparative lack of women and girls in mathematics and STEM-related fields is apparent and consistent. This research seeks to uncover the lifelong impacts of early education mathematics placement exams and mathematics tracking methods on females from primary age into adulthood. Although research exists on the negative results of mathematics and STEM gender biases in secondary schools, high schools, and higher education, there is a research gap in studies that acknowledges the dictating role of these determining factors at the elementary level.

This research will investigate the unequal and inequitable biases that are at play in tracking and placing students who identify as girls into mathematics courses. Further, the hope is to discover the lasting effects of these methods on adult women's math identities, self-efficacy, and career choices. This topic is important because of the power that educators hold in determining the life course and identity of women.

Social Role Theory and Gender Identity

Attitudes surrounding appropriate responsibilities, rights, and roles of men and women in society are referred to as gender ideology and gender role ideology (Kroska, 2007). Value placed on the distinct roles for women and men are congruent to a traditional gender ideology (Kroska, 2007). To understand the social behavior of gender, this research will be framed in the theoretical findings of the social role theory of gender (Eagly, 1987) which was coined in the 1980s, during the heightened interest in gender stereotype research to determine whether or not the behavior of people who identify as females and males differs (Eagly et al., 2000). Social role theory states that psychologically studied behavioral differences of women and men originate from the placements of men and women into different social roles (Eagly, 1987).

Acclaimed sociologist Talcott Parsons used a status-role complex to understand the structure of a social system. In his theory, Parsons refers to “status” as a structural position within a social system, and “role” as what the actor does in that position, viewed from the contexts of the functional significance to the larger social system (Ritzer & Stepnisky, 2018). West and Zimmerman (1987) added that, “Moreover, many roles are already gender marked, so that special qualifiers–such as ‘female doctor’ or ‘male nurse’–must be added to exceptions to the rule” (p. 129).

Gender Biases and Inequity in Mathematical Education

Hand, Rice, and Greenlee (2017) aimed to uncover why comparatively few people who identify as women and girls pursue STEM disciplines and found that teachers and students alike exhibited biases that attribute scientists with more masculine characteristics and people who work in the humanities with more feminine characteristics. Both teachers and students also reported through survey data that they believe girls simply do not perform as well as boys do in STEM disciplines (Hand et al., 2017).

These biases also correlated to self-efficacy. Specifically, Hand et al. (2017) found that women and girls lack self-efficacy when they report on their beliefs about their potential and successes in STEM disciplines, which also resulted in a lack of equity in math and science courses from teachers providing gender-balanced teaching initiatives in the classroom. Collectively, these findings suggest that there are a variety of deeper-rooted socioemotional and institutionalized inequalities at play to help us understand why it is that girls and women are avoiding STEM (Hand et al., 2017).

The Impact of Early Educational Experiences

Tang (2019) and Carter (2020) note how girls typically form a dislike or disinterest in mathematics during their elementary school years that lasts for years into their educational futures. During these years, family mathematics experiences and meaningful role models are crucial in building a foundation for establishing girls' math self-efficacy (Tang, 2019; Carter, 2020).

Tang (2019) established a correlation between girls' math self-efficacy and interest in pursuing STEM career paths on their professional journeys and pursuing higher levels of advanced mathematics in their educational journey. Tang (2019) argues that identifying these common trends can offer parents, administrators, teachers, and policymakers informed strategies to effectively increase self-efficacy for girls in mathematics. In addition to identifying how impactful early education experiences are on girls' interest in mathematics, Tang (2019) found that family mathematics experiences and meaningful role models are crucial during the childhood years of girls. Tang (2019) further noted that girls began to identify their math self-efficacy only through the pathways of nonstandard opportunities outside of mathematics coursework in the classroom school setting, in real-world and extracurricular settings, and that girls' math efficacy is inherently fragile, regardless of how stable or strong of a math foundation they have.

Carter (2020) documents how STEM really emerged from the era and advent of the Space Race around 1957 (Marick, 2016), and has evolved through the educational policy implementation of the Next Generation Science Standards (NGSS) which were released in 2014. Carter (2020) noted how STEM has not been equitably introduced at the elementary level, and that these schools require specific funding for professionals to be trained as well as funding to provide schools with age-appropriate grade level STEM curricula. If elementary students are capable of learning about relevant life skills and real-world knowledge in a developmentally appropriate manner, these students deserve the opportunity to start developing these 21st Century Skills (21st Century Skills, 2016). Carter (2020) had incorporated STEM into their student teaching curriculum and documented how "STEM education requires deep thought, intensive planning, adaptability, and reflection for successful implementation" (p. 2). Carter (2020) found increased amounts of self-agency among primary-aged students when they have equitable access to STEM disciplines.

The Role of Trust and Modeling

Mbaidjol (2022) researched the influence of experiences and self-concepts of middle school individuals who identify as girls on academic success with mathematics. Mbaidjol (2022) found that girls are more likely to be motivated and engaged in mathematics when they build a mutual and trusting relationship with their educators in the classroom compared to their male peers. This unique social dynamic is a key discrepancy that students who identify as girls face when compared to boys. There are a few conditions required to allow girls to achieve success in the mathematics classroom: (1) Girls feel like they can comprehend what is being taught; (2) Girls feel heard in the classroom - leaving none of their questions unanswered while avoiding embarrassment; (3) Girls want and need to be challenged; (4) Girls need to be taught mathematics by educators who understand that they view mathematical accomplishments and ability through a more negative lens than their male peers (Mbaidjol, 2022). This finding suggests a re-evaluation of how to professionally develop and maintain meaningful student-teacher relationships is necessary to promote the engagement and success of girls in mathematics education.

Bias and Tracking in Education

"Tracking" is an institutionalized education method developed in the 1960s and 1970s in which schools sort their students into smaller class-sized groups based on their observed achievement (Domina, Hanselman, Hwang, & McEachin, 2016). While designed as a way to sort students to match their skills and provide support or enrichment, it has been widely documented that the actual result is that when students are on the lower track, they are confronted with a sense of futility and a lack of self-efficacy (Domina et al., 2016; Houtte & Stevens, 2015). Even more controversially, tracking has resulted in both subversive and overt racism and gender segregation (Barnes & Torres, 2018; Barragan, 2021; Gandara & Orfield, 2010).

Types of Tracking

Tracking splits students who are entering college or the professional world into different "curriculum paths" or "curriculum tracks" by dividing them into low-, average-, and high-achievers (Oakes, 1985). These curriculum tracks provide students with a series of courses based on "ability grouping," which divides student bodies into leveled classes based on student ability (Oakes, 1985). Students may also experience "tracking up" or "tracking down" (Oakes, 1985). There are notable consequences to "within-school tracking" pertaining to sense of identity and social pressures (Houtte & Stevens, 2015).

"Ability-Based" Tracking. Typically, ability grouping places students in either a college-preparatory (high ability group), general (average ability group), or vocational (lower ability group) sequence by ability-grouping in their social studies, English, science, and mathematics classes at the junior and senior high school levels (Oakes, 1985). However, curriculum tracking and ability grouping yield inconsistencies in the amount of levels available to students, the types of subjects being tracked, and the methods of placement, all depending on the school (Oakes, 1985). Although some believe that tracking is conducive to student achievement in a sense that students are learning amongst peers at similar achievement levels, it ends up reinforcing a stereotype amongst educators and administrators that there is such great variation in student capabilities that it is necessary to endure completely separate educational experiences with no overlap (Oakes, 1985). Another consequence of tracking is the emotional damage that students who are deemed less-capable undergo from being compared and placed into competition with their higher-achieving peers (Oakes, 1985). Students grouped into lower-ability tracks face a more negative overall experience in the classroom, lowered self-concepts toward learning, lowered self-esteem, lowered ambition, and overall negative attitudes toward learning (Oakes, 1985). When a student is placed onto a lower track in elementary school, it is extremely likely that that student will remain on that lower track throughout the entirety of their K-12 education and end up on the non-college-preparatory track (Oakes, 1985).

Tracking Up and Detracking. Domina, Hanselman, Hwang, and McEachin (2016) documented the long-term effects of organizational processes, the variety of internal pressures that guided the responses of California middle schools, and how they deemed themselves accountable to the algebra-for-all educational movement that occurred between 2003-2013. Notably, Domina, Hanselman, Hwang, and McEachin (2016) distinguished that the primary responses of California middle schools fell into two categories: tracking up and detracking. The authors (2016) found that some schools responded to algebra-for-all by “tracking up,” or placing students into the “higher ability” math class more or less by default - and some schools responded by detracking their schools or taking away ability-based grouping altogether.

Within School Tracking versus Between School Tracking. Houtte and Stevens (2015) compared the impact of “within-school” tracking “between-school” tracking. As might be assumed, within-school tracking is a system that occurs within one school that offers a variety or combination of academic tracks, and between-school tracking is a system that occurs when the tracking is organized between two schools (Houtte & Stevens, 2015). An example of between-school tracking is the communication that occurs between the mathematics instructors of a graduating 8th grade student with soon to be 9th grade mathematics instructors working at the matriculating high school. Houtte and Stevens (2015) found that within-school tracking has a more significant implant on students' sense of futility than between-school tracking. The research suggests that they are confronted with a sense of futility more often because they are socially and academically compared to their higher-track counterparts on their campus daily. Lower-track students that are products of the within-school tracking system are more likely to "put luck above working hard or above merit" and "lose faith in a meritocratic system" (Houtte & Stevens, 2015, p. 782). Students and teachers perform gender biased behaviors that impact self-efficacy of people who identify as women and girls in STEM (Hand, Rice, & Greenlee, 2017; Hidalgo, 2019).

Historical Overview of Tracking

Tracking is prevalent in American schooling. Tracking sorts students based on curriculum and perceived academic ability as a form of educational differentiation, and is a controversial method in the field of education (Ansalone, 2009). Ability-based grade level grouping based on age, or "age-grading" has existed in America since 1850 (Loveless, 1998). At the turn-of-the-century, tracking became a standard American practice (Ansalone, 2009). Loveless (1998) argues that grouping students into grade levels based on their age is essentially a form of ability-grouping. In the 19th century, only about 8% of the country's teenagers attended high school, where they could learn algebra and other "higher knowledge" subjects (Loveless, 1998). These high school students were of the highest socioeconomic status, and their middle and lower-class counterparts typically did not have opportunities to attend school beyond the 8th grade. They were, instead, expected to join the labor force in order to provide their families with more income (Loveless, 1998).

Loveless (1998) documents how, when the American economy shifted from an agricultural economy to an industrial economy from the 1790s to the 1830s, the influx of high school students skyrocketed. The combination of Social Darwinism idealists and racial segregationists resulted in a new form of schooling that provided students with individual coursework based on their socioeconomic status and race, “to prepare them for their rightful stations in life” (Loveless, 1998, p. 11). “The earliest forms of tracking developed within the urban centers of the North and many viewed this as an attempt to ‘Americanize’ and segregate the newly arriving immigrants and poor Southern blacks pouring into the cities” (Ansalone, 2009, p. 177). The widespread use of tracking, especially through IQ tests, became a form of discrimination to place teenagers into tracks that the institution pre-determined based on the students’ demographic factors (Loveless, 1998). The success of an individual student then depended on a variety of factors including high school attendance, highest grade level achieved, to more specifically what track the student was placed on (Loveless, 1998). According to Ansalone (2009), using ethnicity, race, and class to select curriculum tracks for children raised concerns as to how equitable the American schooling system was (Bowles & Gintis, 1976). Following the Great Depression and into the 1940s, the “life adjustment” movement and educational reform, which drove curriculums away from strictly academic-based courses and towards more life-skill-based courses.

Another wave of educational reform involving science, technology, engineering, and mathematics hit after the Russian launch of the Sputnik satellite in 1957 (Carter, 2020). This era of educational reform is also known as “The Sputnik Effect” (Loveless, 1998). Programs in math and science that fostered gifted and talented students gained popularity. The general consensus was that the student population needed more challenge and a heavier workload. Social inequality, racial discrimination, and poverty became a priority in American policy initiatives during the time of President Johnson’s “Great Society” political movement of 1964-1965. This shifted the standardized education system towards an effort to tailor to the needs of the individual students through the implementation of “categorical programs,” which consisted of bilingual programs, special education, compensatory education, and gifted education (Loveless, 1998). The “war on poverty” and “Great Society" movements were birthed from morally justified ideals, but the institutionalized reforms of these movements resulted in further social class and racial stratification amongst student bodies. And, by the 1970s, tracking was the norm in the American classroom. Although these efforts in the 1960s and 1970s were aimed at “equalizing” education, the result was quite the opposite (Oakes, 1985). Amidst the birth of tracking in the American classroom, new research was being discovered regarding the relationship between mathematics and cognitive development.

The 1970s brought forth new research on the connection between scientific reasoning and cognitive development, which shifted the way society thought specifically about mathematical education. The association between cognitive development and scientific reasoning was first established in Piaget’s (1970) research, which established that the cognitive development of children progresses through stages. It is necessary to consider this correlation when comparing the mathematics knowledge with the scientific knowledge of any individual. According to Joyce et al. (2017), students can practice formal reasoning skills in core sciences such as physics, chemistry, and biology. Therefore, success in these core sciences may require foundational math learning knowledge to succeed (Joyce et al., 2017). Decades later, the lingering results of inequitable ability-based grouping still exist. Recent efforts in detracking schools have gained more attention. On the state level, the Mathematics Placement Act of 2015, also known as SB-359, requires incoming Californian high school students' mathematics course placement to be based on more than just one placement test (SB-359). Educators are now required to consider previous course grades, individual growth, periodical benchmarks, and conversations with prior year mathematics teachers to place students in a more holistic manner (SB-359).

Moving Beyond Tracking and Toward Equity

Barragan (2021) sought to determine if detracking students desegregates racially based student learning groups and increases student learning. The findings showed that students prefer to learn reading in an integrated classroom rather than an ability-grouped setting, and that they performed better on testing when integrated. While none of the adult participants interviewed in her study admitted supporting racially segregated classrooms, there was widespread support from the adult participants for ability-based grouping that results from tracking. The perception (bias) that ability groups are valuable contrasted sharply with the student performance when the students were integrated (Barragan, 2021). Ultimately, Barragan (2021) argued that ending tracking would improve academic performance in a more equitable and inclusive (less segregated) educational experience.

Barnes and Torres (2018) documented the recent push towards detracking student populations in San Francisco Unified School District (SFUSD) in 2014 when there were not enough students successfully passing Algebra 1. Barnes and Torres (2018) identified that another benefit to detracking is that it provides previously lower tracked students the option to enroll in higher level courses, such as Algebra 2.

Regardless of the hope to allow student growth at their individual level, being on a lower track omits crucial curriculum that in turn prevents upward mobility towards future achievements, social implications, and institutionalized perceptions (Ballard, 2019; Oakes, 2005). In order for these institutionalized perceptions to be dismantled, and a strive toward equity to be made, professional development is required (Ballard, 2019; Oakes, 2005).

Conclusion

This study seeks to understand the impact of elementary school placement exams and mathematics tracking on women and girls in STEM. This research hopes to advance educational equity and social justice in the field of education to provide all genders and identities with equitable mathematics learning opportunities. Tang (2019) established the correlation between girls' math self-efficacy and interest in pursuing STEM career paths on their professional journeys and pursuing higher levels of advanced mathematics in their educational journey. Carter (2020) found increased amounts of self-agency among primary-aged students when they have equitable access to STEM disciplines. There is however a research gap in studies that explore the disadvantages of gender and identity that begin in elementary school with regards to mathematics tracking and placement. There is another research gap in studies that explore mathematical biographies of adult women.

Chapter 3: Methods

This research aims to better understand how mathematics tracking and biases influence the math identities of individuals who identify as women. More specifically, this research focuses on the impact of tracking that begins in elementary school on mathematics identities and self-efficacy. Research shows that when students are on the lower track, they are confronted with a sense of futility and a lack of self-efficacy (Domina et al., 2016; Houtte & Stevens, 2015), and that there is a correlation between girls' math self-efficacy and interest in pursuing STEM career paths professionally as well as pursuing higher levels of advanced mathematics education (Tang, 2019). In addition, there are documented subtle biases that stem from both students and teachers that accredit scientists with more masculine characteristics (Hand et al. 2017). Although there is existing research on the effects of tracking on mathematics identities and self-efficacy at the middle school and high school levels, there is a research gap on analyses at the elementary level. There is also a research gap on the exploration of adult mathematical biographies of women.

Research Questions

This research sought to explore what correlation might exist between elementary school tracking placements, mathematics identity and self-efficacy of individuals who identify as women through adulthood. Specifically, this research sought to understand:

1. How do mathematics placement tests and tracking impact student math identity and self-efficacy?
2. What perceptions do students and professional educators have about ability-based learning groups and tracking?
3. How does mathematics tracking in elementary school impact lifelong mathematical success?

Description and Rationale for Research Approach

A mixed methods approach from a transformative philosophical worldview was used to explore the effects of tracking at the elementary level on the mathematics identities and STEM experiences of adults who identify as women. Mixed methods research is an approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks" (Creswell & Creswell, 2018, p. 4).

The involvement of qualitative research was necessary to understand the experiences and narratives of students and adults in their own words and lets researchers understand and explore the various meanings that groups and individuals assign to a proposed problem (Creswell & Creswell, 2018) by providing rich contexts that could not have been encompassed using only quantitative research. Quantitative research examines relationships between variables to effectively test objective theories: "These variables, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures" (Creswell & Creswell, 2018, p. 4).

The transformative worldview philosophical framework allows the researcher to advocate for and create a more just society for underrepresented populations including in the case of this research, students and past students who identify as female (Mertens, 2010). The transformative worldview provides participants, institutions, and the researcher with an action agenda for reform and prioritizes individuals and groups of society who may be marginalized by focusing on their needs and integrating philosophical assumptions of the issues presented in the research (Creswell & Creswell, 2018). The stated goal of this research is to identify the conditions for equitable and inclusive practices to support people who identify as girls in math and STEM subjects and careers.

Research Design

This research sought to explore the variables of mathematics tracking and gender biases in mathematics on the educational and professional experiences of individuals who identify as women and girls. To gather rich qualitative data, I interviewed adults to provide a mathematics biography and to reflect on their elementary mathematics experiences. I surveyed kindergarten and 4th grade students' mathematics experiences to find the level of impact that elementary mathematics may have already had on their math identities, and before any tracking had occurred.

Research Site and Entry into the Field

Adult interview participants were drawn from the professional and educational sites of the researcher. Two of the four interviewed women had been classmates of the researcher at a local public high school in Marin County, California. The other two women were either past co-workers or current colleagues of the researcher employed at schools in Marin County, California. The survey research was conducted at an elementary school in Marin County, California. The kindergarten and 4th grade classroom research sites were located at Kirkland Elementary School in San Anselmo, California. The researcher had a pre-existing relationship with the student participants as their community activism instructor from the previous semester. Pseudonyms were used for all participants of this research to protect their identities. Marin County has an estimated population of 256,018 residents, and 84.7% of these residents are White (Census.gov, 2022). The median household income in Marin County between 2017-2021 (in 2021 dollars) is $131,008 (Census.gov, 2022). Kirkland Elementary School has a student population of 318 students: 77% White, 10% Hispanic, 8% two or more races, 4% Asian, <1% Black, 1% unspecified (GreatSchools.org).

Participants and Sampling Procedure

The researcher connected with professional colleagues and past classmates within their broader educational network to recruit adult women. This was a non-random sampling procedure. The criterion for interviewees was an adult who identified as a woman who either works as a teacher or has experience being tracked in mathematics. These participants were contacted by email and by phone.

The researcher invited one kindergarten and one 4th grade class to participate after presenting the research with a brief introduction on the nature and scope of the project in person. Informed consent forms were signed by parents (all students qualified as minors) who opted to participate in the study.

Methods

Kindergarten student participants participated in a ten-minute survey in class. The survey consisted of questions about their feelings and experiences with mathematics. The kindergarteners were given choice in their response style: showing numbers on their fingers, pointing to a number with their fingers, circling the number in written form, or spoken oral response that was audio recorded by the researcher (see Appendix A for kindergarten survey questions).

The 4th grade student participants participated in a fifteen-minute survey in class (see Appendix B for 4th grade survey questions). The survey consisted of questions about their experiences with mathematics. Most of these participants were familiar with the multiple-choice format from in-school examinations and CAASP testing. The participants were given modeled directions instructing them how to appropriately respond to the survey questions with their answers. Students were reminded not to provide their names or any other identifying information.

Interviews were conducted in one thirty-minute session with one participant at a time (see Appendix C for interview questions). Written analytic notes from the interview sessions did not include any names or other identifying information. All interviews were audio recorded.

Data Analysis

The qualitative data was analyzed using analytic memos, open-coded categorizing strategies, and narrative analysis connecting strategies. Analytic memos were used throughout the research process to facilitate analytic thinking that led to analytic insights (Maxwell, 2013). Analytic memos not only functioned as a tool for data analysis but also aided in reflecting on research goals, methods, theories, relationships with the participants, and personal goals (Maxwell, 2013). Simultaneous procedures allowed the researcher to analyze earlier interviews while a current interview was taking place by writing memos to be included in the final narrative analysis (Creswell & Creswell, 2018).

The first step of the categorizing analysis process was initiated by identifying units and segments of data that the researcher deemed meaningful or important to the contexts of the research (Maxwell, 2013). The data was categorized using the strategy of open coding, "an inductive attempt to capture *new* insights" (Maxwell, 2013). Based on which data seemed most important from the participants' categories and terms when the researcher read the data, the coding category was developed (Maxwell, 2013).

Emergent themes were formed using the concept mapping strategy by grouping the codes into categories. Coding was used to generate a few major themes that were supported by evidence and a variety of quotations to give diverse perspectives of individuals a voice in the findings of this research (Creswell & Creswell, 2018).

Narrative analysis connecting strategies were used to analyze the qualitative data of the interview sessions. A connecting step in analysis is identifying connections into different themes and categories (Maxwell, 2013). Connecting strategies make an attempt to comprehend the data in context by finding connections between the elements of the interview text and analytic memos (Maxwell, 2013). Narrative analysis was the final step of analyzing the qualitative data and was used to bridge the already conducted open coding categorical analysis to the personal experiences of the interviewees.

Validity

My experiences in the California public school system in the same county where this research was conducted drove me to conduct this research. I took my first mathematics placement exam in 3rd grade and was tracked down into the lower track through high school and into my undergraduate studies. This prevented me from having the option to enroll in science and math courses that competitive colleges required as a prerequisite for admission. I was privileged to have the opportunity to attend tutoring sessions outside of school, but I still struggled to keep up with my peers and assumed that I was “just not a math person.” I hope that this research helps dismantle stereotypes that prevent students from achieving success and equity in the classroom. I am inherently biased in this research because of my personal experiences.

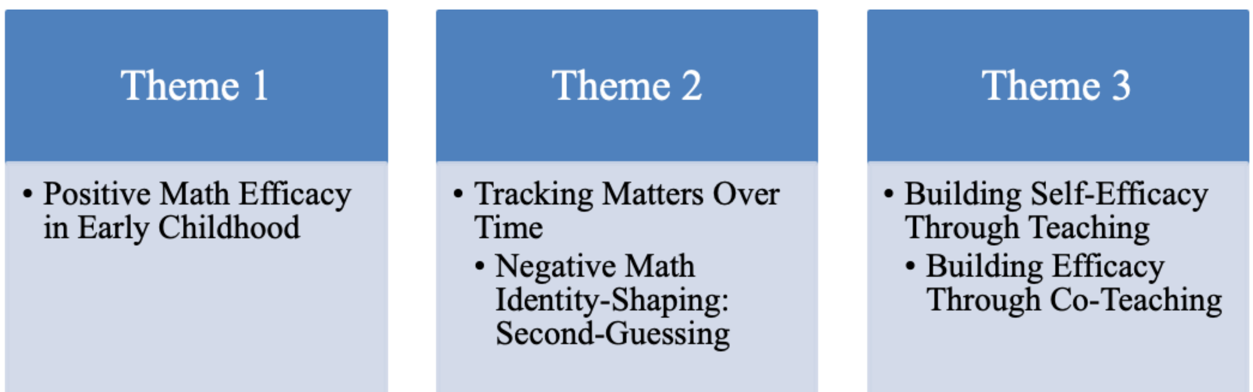
This research employed multiple approaches to establish validity, monitor my bias, and ultimately increase the accuracy of these findings. Evidence was examined from varying data sources to build a cohesive backing to the thematic finding; a validity procedure referred to as triangulation (Creswell & Creswell, 2018). To add to the credibility of the accounts found in this research, this study presents negative and discrepant information to counter the themes found in the data analysis (Creswell & Creswell, 2018). I acknowledge that real life brings a variety of perspectives that are not always linear (Creswell & Creswell, 2018). I attempted to take the reader to the situation that the participants were speaking from by providing rich, thick descriptions of interview data (Creswell & Creswell, 2018). Rich data yields opportunities to develop shared personal experiences and establish higher validity (Creswell & Creswell, 2018). Respondent validation for the surveying of kindergarten and 4th grade students was conducted through verbal confirmation that their responses were aligned with their true feelings during the course of the survey before moving on to the next question. To ensure respondent validation, the researcher walked around to each participant in the classroom and confirmed that their responses were intentional and thoughtful. Undergoing multiple measures to establish validity, monitor my bias, and increase the accuracy of these findings were central to the researcher's goals.

Chapter 4: Findings

The findings in this chapter are based on individual interviews and survey data. The individual interviews were conducted with four adult women, Roxy, Sam, Nina, and Olivia, who are educators or who have experience being tracked in mathematics. Roxy and Nina are college students who have experiences being tracked during their public education in California. Roxy's experience with math tracking in middle school and high school was on the "lower track." Later in this chapter, Roxy shares her negative mathematical biography and her experiences with low mathematical self-efficacy as an adult. Nina's experiences with math tracking in middle and high school were on the "on level" and "high" tracks. Nina shares her positive mathematical biography that includes her success in STEM in her graduate studies and professional endeavors. Sam and Olivia are currently employed as teachers in California. Although Sam and Olivia do not have significant tracking experiences, they both reflected on their mathematical self-efficacy during childhood as high. However, they each had breaks in their self-efficacy during their educational endeavors. As teachers, Sam and Olivia are able to rebuild their math efficacy through teaching. They feel confident with the math material that they are teaching to their students and are actively building math efficacy in their careers. The survey data was conducted in two elementary school classes. The kindergarten class included 18 students, and the 4th grade class included 21 students. The kindergarten classroom participated in a multiple-choice format with auditory and visual reinforcement for understanding. The 4th grade student completed short answers and multiple-choice Likert scale response questions.

Three following three overarching thematic findings emerged from this research: (1) there is a strong and positive sense of math efficacy in early childhood, (2) tracking students matters over time, and (3) women are able to rebuild a sense of self-efficacy when they are able to participate in the (co)teaching of math. The first theme discusses the high level of math self-efficacy found in early childhood. The second theme explores tracking matters over time. This section includes a subcategory about experiences that negatively shaped the interviewed women's math identities. The third and final theme discusses building self-efficacy through teaching. This section includes a subcategory on building efficacy through co-teaching. The figure below demonstrates the three thematic findings and subcategories.

Figure 1
Theme Figure



Positive Math Efficacy in Early Childhood

This section connects to the first thematic finding of positive math efficacy in early childhood. All four of the interviewed women reflected on remembering having a high level of self-efficacy with mathematics as a child. Although Roxy did not enjoy mathematics as a child, she remembers her elementary school years in math class as successful. Sam enjoyed mathematics as a child and had a high mathematics self-efficacy in early childhood. When asked if she enjoyed mathematics as a child, Sam responded, "Yes. I thought I was really good at it too." Nina enjoyed math as a child in elementary and middle school up until her enrollment in high school-level courses, pre-calculus and calculus: "I feel like I enjoyed math up until high school and then didn't really love math anymore. Especially pre-calc and calculus. But I feel like in middle school, I did enjoy math. And before that as well." Olivia enjoyed and felt confident in mathematics until her multiplication table drills. There was a high level of confidence in mathematics during the childhoods of most of the interviewees before the occurrence of any middle school or high school math tracking. These findings are on trend with the survey data of the kindergarten and 4th grade classes.

The survey findings suggest that before tracking, most children are confident in mathematics. The elementary school site where the survey research was conducted does not participate in ability-based grouping or tracking in mathematics. The findings from the survey data also connect to the first thematic finding of positive math efficacy in early childhood. The survey data collected from kindergarten and 4th grade students found that the mathematical enjoyment of both grade levels was relatively high. However, there is a slight decrease in mathematical enjoyment between the grades of kindergarten and 4th grade, although no mathematical tracking has occurred. Figures 2 and 3 display these enjoyment levels.

Figure 2
Kindergarten Class Level of Math Enjoyment

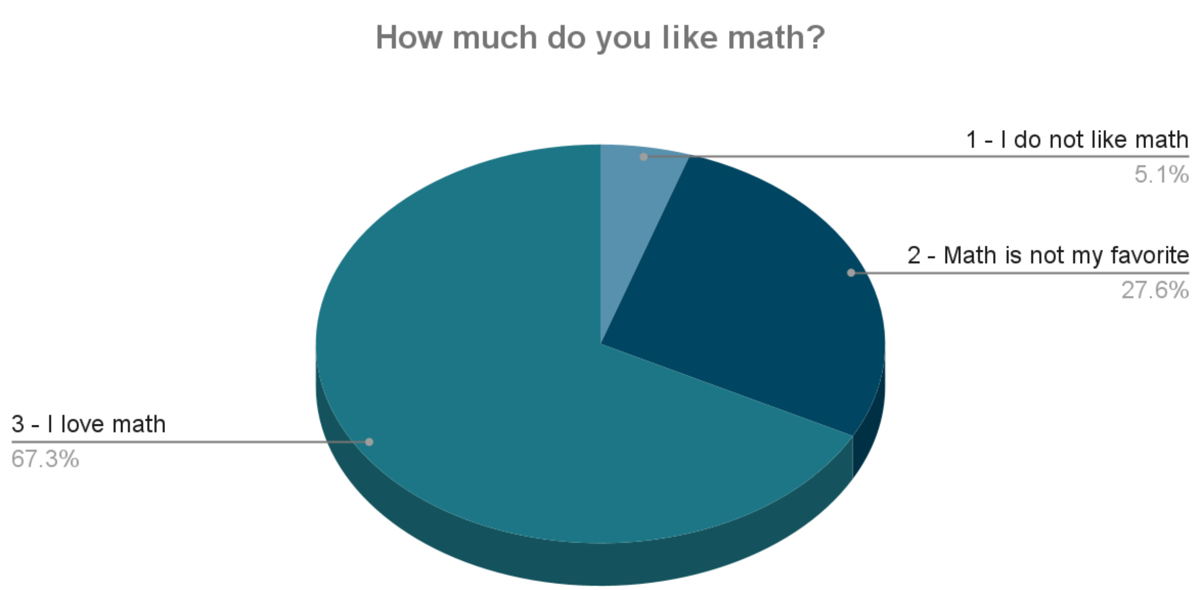
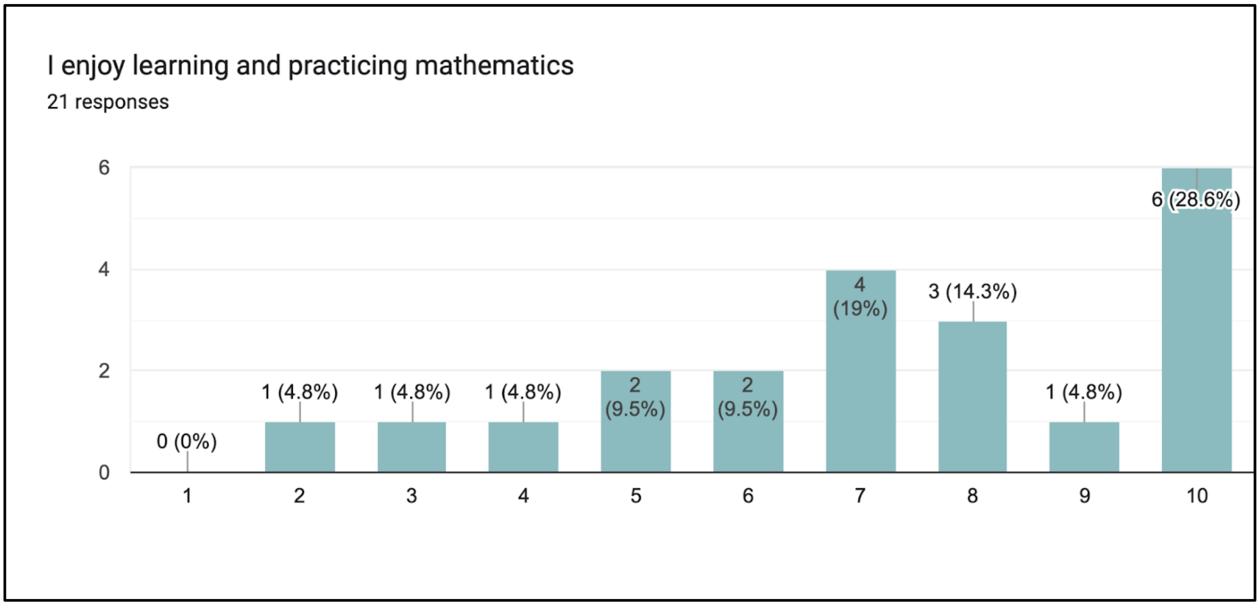


Figure 3
4th Grade Class Level of Math Enjoyment

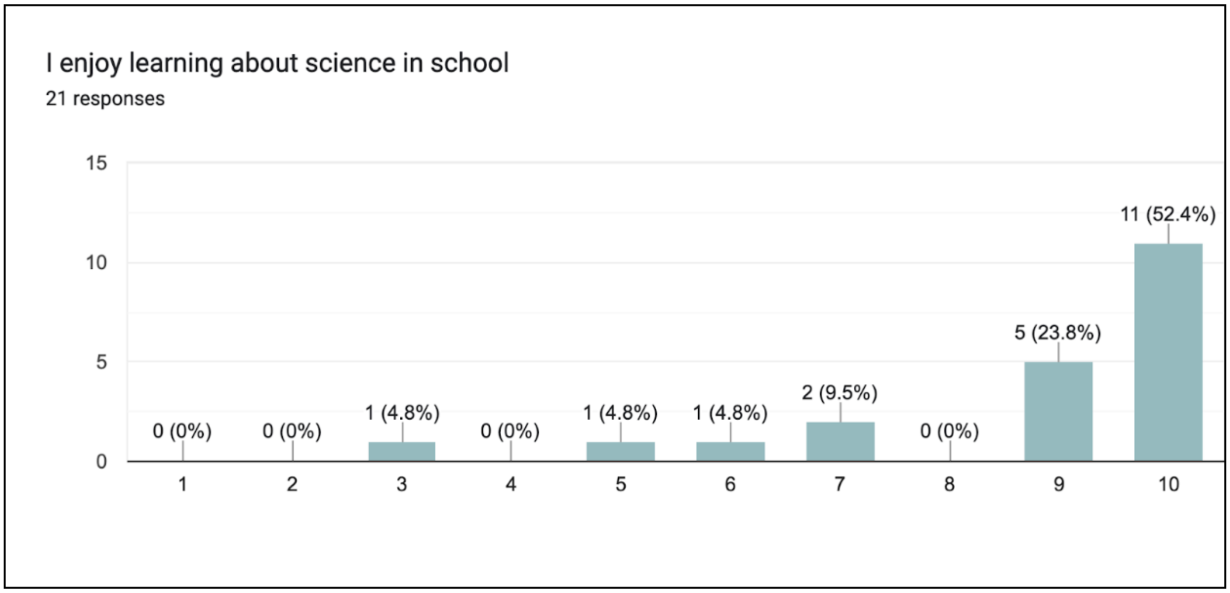


Note: The x-axis represents the Likert response scale of 1-10 (1 represents complete disagreement with the statement and 10 represents complete agreement with the statement). The y-axis represents the number of students.

Figure 2 and Figure 3 depict the enjoyment levels of kindergarten students and 4th grade students, respectively. Figure 2 shows that 67.3% of the kindergarten respondents love math, 27.6% of the kindergarten respondents say that math is not their favorite, and 5.1% of the kindergarten respondents do not like math. With 5.1% of the class not liking math, the mathematical efficacy of kindergarten students is generally high during the first year of their public education, prior to any tracking or ability-based grouping. Figure 3 shows a Likert response scale of 1-10, where 1 represents complete disagreement with the statement, and 10 represents complete agreement with the statement "I enjoy learning and practicing mathematics." For ease of analysis, categories 1-3 will correlate to "I don't really like math," categories 4-6 correlate to "math isn't my favorite subject," and categories 7-10 correlate to "I generally like math." Figure 3 shows that 9.6% of 4th grade respondents don't really like math. Math isn't the favorite subject of 23.8% of 4th grade respondents. 66.7% of 4th grade respondents generally like math. Figure 3 shows that no students in the class (0%) responded with the lowest score of 1. The mathematical efficacy of the 4th grade respondents is generally high, prior to any tracking or ability-based grouping. Although these surveys were distributed in different formats to be developmentally appropriate, the comparison between Figure 2 and Figure 3 show that there is a slight decline in mathematical efficacy between kindergarten and 4th grade.

Additional insights from the fourth grade survey yielded meaningful results. These additional insights can be connected to educational equity because the topic of gender was not a substantial factor in the findings of the 4th grade students. In fact, these additional findings suggest that the gender binaries are not yet at play during elementary school and before the occurrence of any tracking. The overall enjoyment of mathematics in 4th grade was very high. Only one out of the twenty-one students in the class responded that they like math less than other subjects, when asked the questions: “What subjects do you like less? What don’t you like about them? How might you change them to make them more fun or interesting?” This student responded by saying, "Well I don’t like math because it’s just adding or subtracting numbers. The thing that might make it more fun would be to let us do a math game on the computer.” This student identifies as a male. This finding is consistent with the adult interviews that mathematics efficacy in early childhood is high, regardless of gender. There is a general enjoyment and confidence among students that identify as girls and students that identify as boys in this 4th grade class. The aspirations of 4th grade students who identify as girls showed that the majority, 7 out of 11, see themselves working in a STEM-related field. Figure 4 depicts the level of enjoyment that 4th graders have when they are learning about science in school. The overall enjoyment of learning about science in school for 4th graders was very high. Figure 4 below shows a Likert response scale of 1-10, where 1 represents complete disagreement with the statement, and 10 represents complete agreement with the statement "I enjoy learning about science in school." Categories 1-3 correlate to "I don't really enjoy learning about science in school," categories 4-6 correlate to "learning about science in school is not my favorite," and categories 7-10 correlate to "I enjoy learning about science in school." 84.7% of 4th grade respondents enjoy learning about science in school.

Figure 4
4th Grade Class Level of Enjoyment Learning Science in School



Note: The x-axis represents the Likert response scale of 1-10 (1 represents complete disagreement with the statement and 10 represents complete agreement with the statement). The y-axis represents the number of students.

Tracking Matters Over Time

This section connects to the second thematic finding of tracking matters over time. The interview participants did note that over the course of their lives tracking did matter. Roxy is an adult who identifies as a woman and a full-time undergraduate student. At her university, she is pursuing a degree in community studies, with an emphasis on social justice in the liberal arts college. When asked about her childhood experiences with mathematics, she explained that it has never been her strong suit, although she did enjoy it in elementary school. Between elementary school and high school, the only time she remembered feeling successful with math was in elementary school. She recalled feeling punished for struggling with math and reprimanded by being placed into the "lower track" math classes. This made her feel like she was not as smart as other people at her school. The experience of being tracked down was when Roxy felt the least self-efficacy, which has been central to her mathematical identity since being tracked down and still is central to her mathematical identity as an adult. Although Roxy did not enjoy mathematics classes, she did enjoy the aspects of applied and tactile learning in her science classes. After having a hard time succeeding in her "lower track" math classes throughout middle school and high school, Roxy enrolled in a community college and took a statistics course and had her first positive experience with mathematics since elementary school. Roxy feels the most self-efficacy when she is practicing statistics, which is central to her mathematical identity.

Nina is an adult who identifies as a woman and studies as a full-time graduate student. At her university, she is pursuing her master's degree in genetic counseling. She also has a part-time position working as a genetic counseling assistant. Nina experienced the "on-level track" in middle school and the "higher track" in high school. Nina was able to enroll in more challenging science courses in high school because of her success in mathematical prerequisites. As an adult, she prefers science over math and feels that science is one of her strengths. Nina feels the most self-efficacy when she is practicing science, and this has become central to her mathematical identity. She feels that she has been generally successful in math and science and has cultivated her interest in science into a career in a scientific field. Although mathematics is not her favorite subject, Nina found academic and professional success with science.

Roxy and Nina reflected on their life stories with mathematics, describing it as a biography, and both highlighted a STEM field in which they felt successful. These women can remember a moment on their mathematical journey when they felt the most self-efficacy. These moments of efficacy can be viewed through the lens of whether Roxy and Sam were being tracked, and if so, what track they were on.

Negative Math Identity-Shaping: Second-guessing

This sub-theme of second-guessing as a form of negative math identity-shaping connects to the second overarching thematic finding of tracking matters over time. When Roxy and Sam reflected on their mathematical journeys, they both described a tendency to second-guess their mathematical abilities into their adulthood, regardless of the moments of self-efficacy described in the previous section. Roxy said she felt she was being punished or reprimanded by her teachers for being in the lower math class. She recalled feeling the need to check her work multiple times by either the instructor or the workbook before moving on to a new problem. After being on the “lower track” throughout her general education in math, Roxy has entered adulthood with a tendency to second-guess herself. Roxy feels “almost traumatized from her past experiences.” As an adult, Roxy explained the connection between her experiences with math and her current confidence level with math: “I don’t feel like it’s correct. So confidence is not so much there. And then also going into solving an equation or something, I also have low confidence."

The impacts of psychological factors of tracking down influence students' self-efficacy beyond their kindergarten-12th grade mathematical education. Even though Roxy found success in her community college statistics course, she still struggles with feeling confident in the subject. She describes her lack of ability to feel confident in her problem-solving skills: "I don't believe that my answer was correct unless it's verified by my teacher or the workbook or something."

When the researcher asked Sam to tell her mathematical biography, she shared that when she was a child, she thought of herself as cool and confident with mathematics, remembering that she thought that she was really good at it. Without any breaks in efficacy between elementary school and high school, Sam faced her first major roadblock with self-efficacy in college algebra. Sam shared she felt her teachers missed identifying her as a "struggling student," and didn't provide her with proper extra help or resources to get through this roadblock: "There was no one teacher who was like, 'Hey, you're not getting this. Let's figure it out.' They just kind of let me go knowing that my knowledge wasn't there." Sam explained that the variables in algebra hindered her self-efficacy in math and remembers thinking: "There's an alphabet in it? That does not belong there." She ended up having to retake the course more than once. This negative experience shifted her mathematical experience from positive to negative. As an adult, she avoids mathematical situations whenever possible. She described her low level of self-efficacy with math as an adult in real-life instances, such as calculating the tip on a bill:

> I will always go back and check it and check it again. And then get out my phone calculator and check it again. And then ask someone else to check it. So I have a huge lack of confidence in my capabilities.

This low efficacy has translated into second-guessing correctness in day-to-day scenarios where foundational math is required. Roxy and Sam both struggle with a lowered math efficacy level into adulthood. They both second-guess whether their answer is correct or incorrect, sometimes more than once. This lack of confidence has shaped their mathematical identities in a negative form.

Building Self-Efficacy Through Teaching

This section connects to the third thematic finding of building self-efficacy through teaching. Sam and Olivia are both educators who teach math to children. Sam is a preschool teacher and Olivia is a 4th grade teacher. They both note how their teaching roles helped them shift their mathematical identities of themselves and reach higher levels of mathematical self-efficacy. As a child, Sam wanted to be a teacher and a mother when she grew up. She is now both of those things. Although Sam has low math self-efficacy as an adult and avoids doing mathematical things when possible, being a teacher has helped her gain confidence and efficacy with mathematical concepts. Being able to explain numbers and math in her place of work (a preschool classroom) to her students makes her feel good: "But when I'm teaching it to little kids, then I feel confident. And that's from a college class I got when I was like, oh, now I get all of this and then it all started to make sense." After failing the same math class twice in a row, Sam enrolled in a teaching elementary math course: "But then I took elementary math class, where they teach you to teach the math, and that's when, like, I knew how to do long multiplication and long division." Sam explained how this teaching course positively influenced her self-efficacy: “I didn’t understand the why of it until that class in college. I was like, oh my god. And I was like, oh, now I totally get why I’m doing this.” In this teaching math course, Sam was taught how to teach concepts such as long multiplication, long division, and other foundational mathematics skills. It wasn’t until enrolling and succeeding in that teaching elementary math course and teaching professionally as an adult that Sam’s self-efficacy in mathematics began to build.

Olivia was placed on the “on-level” track in mathematics courses throughout her childhood. In other words, Olivia was on-track for her grade level or age group and was placed into the average ability-grouping during her tracking experience. During her freshman year in college, she enrolled in a calculus course, even though mathematics was not required. She did not succeed in that course. It was not until she began her education career teaching elementary mathematics in a 4th grade classroom that she took her mathematical potential to a new level entirely. Since her first-year teaching, Olivia has taught various elementary and middle school mathematics classes at a private K-12 school. Now, she is back to teaching in a 4th grade classroom. She also has a side job tutoring middle school algebra students after school. When asked how Olivia feels after solving a math problem, she responded, “I feel good. I love doing math problems!” Her confidence in mathematics has developed into two successful careers that inspire children in her school community. Olivia may not have discovered the full potential of her mathematical efficacy had she not decided to teach the subject herself.

Building Efficacy Through Co-Teaching

This section about building efficacy through co-teaching connects to the third thematic finding of building self-efficacy through teaching. When the researcher asked the interviewees to describe their most effective, ideal learning environment, all four of the interviewed women said that they learn best in small groups. Small groups are a form of co-teaching, where individuals share and learn concepts together as a group of learners rather than being traditionally taught in an instructor-to-student whole group manner. The interviewees' ideal learning environments included small groups, hands-on approaches, visual representations, and attention to learning style.

When Roxy was asked about her ideal learning environment, she explained that she needs more engagement to be successful. She noted that the engaging environment of her science classes in high school were conducive to her learning because she was able to engage in tactile learning often. Roxy believes that grouping students by learning style would be a more effective grouping strategy than grouping by ability-level. Roxy prefers learning in small groups with no more than five people.

Sam learns best when she is engaging in student-taught approaches. For example, a classroom dynamic where she is working at a table, and then the table goes around and explains how they got an answer. Sam believes that explaining how a problem is solved helps deepen knowledge. When Sam was asked about her ideal learning environment, she preferred a visual, hands-on environment with manipulatives and opportunities to express herself available. This caters to her visual learning style best. Sam prefers small groups comprised of varied levels of understanding and knowledge.

Nina pursued her undergraduate studies at a very large university. She did not enroll in a mathematics course in college and could not imagine taking a college math course in a big lecture hall with hundreds of people. She believes real-world applications and examples of when concepts would be used keep students interested in math and science. She explained that a learning environment with a lower emphasis on GPA in STEM classes would provide students with more opportunities to succeed in STEM. Nina's ideal learning environment depends on the course; however, smaller groups are always her preference.

Olivia's favorite subject to teach is algebra. She feels that students have the most success when they are in her one-on-one tutoring sessions. She believes that there is a developmental readiness for algebra and that some students simply need a little bit of extra coaching to succeed in the subject. Her tutoring sessions allow algebra students to participate in a small group environment. Olivia's ideal learning environment is in a small group.

Conclusion

Through interviews and surveys, this research uncovered new findings regarding the mathematical identities of elementary students and adult women. This research sought to explore the following research questions:

1. How do mathematics placement tests and tracking impact student math identity and self-efficacy?
2. What perceptions do students and professional educators have about ability-based learning groups and tracking?
3. How does mathematics tracking in elementary school impact lifelong mathematical success?

The first finding identified a general trend of positive math efficacy in early childhood. The second finding explored the matters of tracking over time amongst three of the four interviewees. The perceptions of the interviewed adult women determined that ability-based learning groups and tracking can negatively impact the adult mathematical identity when the student is tracked down. This negative identity can be seen in the form of second-guessing in real-world mathematical situations, such as tipping. The final finding of this study found that self-efficacy in mathematics can be built through teaching and co-teaching. In the following chapter, the implications that the findings have on literature, practice, and policies will be discussed. Through practice, these findings suggest that implementing co-teaching into classroom curriculums as much as possible will give all students more opportunities to build their mathematical self-efficacy. The main policy implication that is suggested from this research that detracking mathematics altogether would benefit the long-term self-efficacy of students. This policy shift would provide all students with more equitable opportunities in STEM.

Chapter 5: Discussion

This research found three primary thematic findings: (1) that there is a positive math efficacy in early childhood, (2) that tracking matters over time - including negative identity-shaping such as second-guessing, and (3) that (re)building self-efficacy is possible and effective through teaching and co-teaching. All four of the interviewed women reflected on a generally high level of self-efficacy with mathematics as young children. This theme was on trend with the survey data, which found that, before tracking, kindergartener respondents and 4th grade respondents had generally high levels of enjoyment and self-efficacy with math. The mathematical biographies of research participants have also revealed how positive and negative experiences with mathematics and tracking proved central to their math identities as adults. Finally, methods of teaching and co-teaching were identified as having successfully contributed to a sense of self-efficacy in math even when it had been lost since early childhood, and pre-tracking.

This chapter will discuss implications for the literature, implications for practice and policy, limitations of the study, and future research. First, a discussion on implications for the literature. This section compares the findings from this study to the existing literature discussed in Chapter 2: Literature Review. Second, the researcher identifies the study’s implications for practice and policy. This section applies the findings to the contexts of classrooms, schools, districts, and policies. Lastly, the researcher provides an acknowledgement to the limitations of the study and suggestions for future research. The findings from the literature review focused on: (1) social role theory and gender identity, (2) gender biases and inequity in mathematical education, and (3) bias and tracking in education. The finding of positive math efficacy in early childhood is connected to the literary finding of bias and tracking in education (Barnes & Torres, 2018; Barragan, 2021; Gandara & Orfield, 2010). This research found that kindergarteners and 4th graders, regardless of gender, inherently enjoy mathematics. The mathematical education of the surveyed elementary students was not gender-biased before the occurrence of tracking.

The finding of building efficacy through teaching and co-teaching can be looked at through the lens of the literary finding about gender ideology and gender role ideology (Kroska, 2007). Once the women's perceived social roles shifted from the student to the teacher, the women became confident in their mathematical skills, and self-efficacy was built. The finding of tracking matters over time is connected to the literary findings of social role theory (Eagly, 1987) and gender role ideology (Kroska, 2007). When a person who identifies as a girl or woman is on the “lower track” they are more likely to assume the role of “not a math person.” When a girl or woman is on the “higher track” they are more likely to assume the role of “math person” and potentially engage in STEM disciplines professionally (Eagly, 1987; Kroska, 2007).

Implications for the Literature

The finding of positive math efficacy in early childhood differs slightly from the findings from the literature. Tang (2019) and Carter (2020) found that girls typically form a dislike or disinterest in mathematics during their elementary school years that is long-lasting. This study found that gender is not a factor in the overall high enjoyment level of students in mathematics during their elementary school years. This study found that girls and women typically form a dislike or disinterest in mathematics in their secondary, high school, or college years, and especially after tracking. The explorative approach to gathering data about experiences with tracking and identity through the telling of math biographies provided rich data about what situations and environments are most conducive to building and breaking efficacy. The finding of (re)building self-efficacy through teaching and co-teaching is a new perspective regarding a potential method for women and girls to build efficacy academically and professionally.

Implications for Practice and Policy

This study presents implications for educational equity and social justice. Detracking mathematics would provide all students with equal access to opportunities in STEM. Disadvantaged and marginalized groups would no longer be disproportionately tracked down. There are implications for classroom practices based upon the findings in this study. Generally, these findings deem it crucial for teachers, regardless of the level of mathematics being taught, to try their best to keep the students' high level of childhood efficacy existent beyond elementary school ages. This implication connects to the first major finding: positive math efficacy in early childhood. It was further found that it is possible to build self-efficacy through teaching and co-teaching. In practice, it is possible to implement co-teaching methods often so that all students have ample opportunities to build their efficacy through shifting their perceived social role from student to teacher. This is an important step toward providing all students a more equitable education. In the case of this study, more specifically the marginalized group of students who identify as women and girls. When students become the teachers of any given topic, they are more likely to build efficacy and ultimately become experts. Co-teaching groupings will create a space where students are learning from each other and building efficacy through peer understanding.

Based upon the findings of this research, there are implications that can inform the practice of schools and school districts. This section connects to the second major finding: tracking matters over time, including negative identity-shaping such as second-guessing. The research found that participants generally had positive experiences with and views on mathematics before the occurrence of any ability-based tracking. Because of this, the researcher suggests that detracking schools and districts would be in the best interest of the students. Although tracking in mathematics provides learners the environment to be in a class with peers at their level, including providing more challenging subjects to more advanced thinkers, the negative consequences of not being placed into the most advanced track seem to outweigh the positive. Lower mathematics placement can prevent students from having the proper prerequisites to enroll in more advanced science courses and prevent students from being eligible to apply and be accepted to four-year universities. A student who struggles with a given mathematics course may succeed in a different STEM course that they are unable to take. It is for these reasons that the researcher suggests schools and districts consider detracking altogether.

These findings provide suggestions for implications to educational policy. This section connects to all three major findings. Efforts in educational policy to detrack schools at the district and state levels would be the most effective way to promote the educational equity of all students in mathematics and STEM. Students who identify as women and girls are underrepresented in STEM fields. To combat these numbers, detracking mathematics courses would provide a more equitable and level playing field for all students to achieve the proper educational foundation to succeed in STEM academically and professionally. It is in the best interest of the future of our society to give all students the opportunity to succeed in the digital world.

Limitations of the Study and Future Research

This research provides educators, policymakers, and students with updated perspectives on mathematical identities, gender, and tracking. However, there were limitations to this study that can help guide future researchers toward more in-depth analyses of these topics. Limitations of the study include limited geography, sampling procedures, and positionality of the researcher.

Future research can include a wider variety of participant geographical locations, more random sampling procedures, and less close relationships between the researcher and participants to decrease biases and increase reliability.

Limitations of the Study

This study was conducted over the course of two semesters. The data collection segment occurred over the course of three months. A limitation of this study was the limited demographics included in the study. The participants of this study were all enrolled in or teaching at schools in the San Francisco Bay Area. In particular, this study was limited to the grade levels of kindergarten and 4th grade. The majority of the participants were White, which is another limitation. The participants were recruited through the broader education network of the researcher. The positionality of the researcher could have steered the responses in a specific direction.

Future Research

Although these findings are noteworthy, there is plenty of opportunity to conduct more in-depth research on the topics of mathematics tracking, identity, and gender. In the future, research can be extended to include the experiences of students from all K-12 grade levels, over a longer course of time, in a larger geographic area, and with a more random sample. It would be helpful to the field of education to include all grade levels to be able to more concisely pinpoint the effects of tracking while students are going through the process. It would be interesting and substantial to conduct this research over a longer period of time to have the option of a random sampling technique with a larger sample size. In particular, the diversity of the interviewees was limiting. Greater diversity in interviewees would be helpful to the field of education. This would provide the field with more reliable findings and more guidance toward an equitable education.

Conclusion

This study found that the mathematical experiences of elementary school students and adult women are dependent on their identities and experiences with tracking. There are a variety of factors that discourage women from entering STEM careers, but the findings of this study provide a starting point of analysis. This study found that young children have high levels of mathematical efficacy, that tracking matters over time (including negative identity-shaping), and that efficacy can be built through teaching and co-teaching. The loss of childhood efficacy in math can be combated by implementing co-teaching techniques in the classroom and detracking mathematics through policy changes. Negative identity-shaping experiences are preventable and need to be addressed through practice. The impacts of tracking on the adult identity are apparent. It is time to detrack mathematics and make our schools the place to equitably prepare for the real world.

References

Ansalone, G. (2009). Tracking, Schooling and the Equality of Educational Opportunity. *Race, Gender & Class*, *16*(3/4), 174–184. http://www.jstor.org/stable/41674683

Barnes, L. H., & Torres, A. (2018). Work to end tracking and offer four years of meaningful math instruction. *National Council of Teachers of Mathematics,* 1-2.

Ballard, J. (2018). Anti-racist leadership in a high-performing high school: A design-based study of detracking mathematics. *San Francisco State University*, 1-159. http://hdl.handle.net/10211.3/213499

Barragan, D. (2021). Linguistic Inclusion and Language Acquisition: An Analysis of a Spanish Reading Group. *Master of Science in Education | Master's Theses*. 37. https://doi.org/10.33015/dominican.edu/2021.EDU.04

Bowles, S., & Gintis, H. (1976). *Schooling in capitalist america*.

Carter, K. C. (2020). STEM education in the classroom. *Master of Science in Education, Master's Theses* (21). https://doi.org/10.33015/dominican.edu/2020.EDU.11

Ceci, S. J., Ginther, D. K., Kahn, S., & Williams, W. M. (2014). Women in academic science: A changing landscape. *Psychological Science in the Public Interest*, *15*(3), 75–141. https://doi.org/10.1177/1529100614541236

Domina, T., Hanselman, P., Hwang, N.Y., & McEachin, A. (2016). Detracking and tracking up. *American Educational Research Journal*, *53*(4), 1229–1266. https://doi.org/10.3102/0002831216650405

D'Souza Dorner, C. & Hutton, I. (2002). Mathematics placement tests and gender bias. *College and University, 77*(3), 1-27.

Eagly, A. H. (1987). *Sex differences in social behavior: A social-role interpretation.* Lawrence Erlbaum Associates, Inc.

Eagly, A. H., Wood, W., & Diekman, A. B. (2000). Social role theory of sex differences and similarities: A current appraisal. In T. Eckes & H. M. Trautner (Eds.), *The developmental social psychology of gender* (pp. 123–174). Lawrence Erlbaum Associates Publishers.

Gándara, P., & Orfield, G. (2010). *A return to the "Mexican Room" The segregation of Arizona's English learners*. UCLA.

GreatSchools.org. (n.d.). https://www.greatschools.org/california/san-anselmo/

Hand, S., Rice, L., & Greenlee, E.T. (2017). Exploring teachers' and students' gender role bias and students' confidence in STEM fields. *Social Psychology of Education, 20*, 929-945.

Hidalgo, T., (2019). Evaluating the relationships between science class success and math placement in high school. *Digital Commons @ ACU, Electronic Theses and Dissertations*, iii-37.

Houtte, M. V., & Stevens, P. A. J. (2015). Tracking and sense of futility: The impact of between-school tracking versus within-school tracking in secondary education in Flanders (Belgium). *British Educational Research Journal, 41*(5), 782–800. https://doi.org/10.1002/BERJ.3172

Joyce, C., Hine, G., & Anderson, R. (2017). The association between secondary mathematics and first year university performance in health sciences. *Issues in Educational Research, 27*(4), 770–783. Retrieved from http://www.iier.org.au/iier.html

Kroska, A. (2007, February 15). *Gender ideology and gender role ideology*. Wiley Online Library. Retrieved April 11, 2023, from https://doi.org/10.1002/9781405165518.wbeosg019

Loveless, T. (1998). Making sense of the tracking and ability grouping debate. *Fordham report*, *8*(2), 4-30.

Marick Group. (2016). A Look At The History Of STEM (And Why We Love It). *Marick Group*.

Mbaidjol, M. (2022). Realizing the Academic Experience of Students Who Identify as Girls in 5th to 8th Grade Math. *Master of Science in Education, Master's Theses* (22).

Oakes, J. (1985). Keeping Track: How Schools Structure Inequality.

Oakes, J. (2005). *Keeping track: how schools structure inequality.*Yale University Press. School Acountability Report Card. (n.d.). https://sarconline.org/public/findASarc

Piaget, J. (1970). *Science of education and the psychology of the child.* New York, NY: Orion Press.

Ritzer, G., & Stepnisky, J. (2018). *Classical sociological theory* (7th ed.). SAGE.

SB-359. Bill Text - SB-359 California Mathematics Placement Act of 2015. (n.d.). Retrieved April 9, 2023, from https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB359

Tang, T. (2019). Fragile strength: Math self-efficacy of high achieving girls. *Master of Science in Education | Master Theses.* 1. https://doi.org/10.33015/dominican.edu/2019.EDU.09

U.S. Census Bureau quickfacts: Marin County, California. United States Census Bureau. (n.d.). https://www.census.gov/quickfacts/marincountycalifornia

Stanley, T. (2016). Importance of 21st century skills. *Creating Life-Long Learners: Using Project-Based Management to Teach 21st Century Skills*, 15–28. https://doi.org/10.4135/9781506313979.n3

Wade, L., & Ferree, M. M. (2019). *Gender ideas, interactions, institutions* (2nd ed.). W.W. Norton & Company, Inc.

West, C., & Zimmerman, D. H. (1987). Doing Gender. *Gender and Society*, *1*(2), 125–151. http://www.jstor.org/stable/1899

Appendix A: Kindergarten Survey Questions

Directions: **Circle** your answer OR **write** your answer in the box.

1. **How much do you like math?**

   1 - I do not like math ☹

   2 - Math is not my favorite 😐

   3 - I love math ☺

2. **Do you enjoy learning about numbers?**

   1 - No ☹

   2 - Sometimes 😐

   3 - Yes ☺

3. **Learning about numbers can be tough. Do you like being challenged when you learn about numbers?**

   1 - No ☹

   2 - Sometimes 😐

   3 - Yes ☺

4. **Do you feel happy when you are learning math?**

   1 - No ☹

   2 - Sometimes 😐

   3 - Yes ☺

Appendix B: 4th Grade Survey Questions

1a. What are your favorite academic subjects at school?
1b. What do you like about these subjects?
2a. What subjects do you like less?
2b. What don't you like about them?
2c. How might you change them to make them more fun or interesting?

The following questions will ask you to scale your answers.
10 means the statement is really true, and 1 means the statement is not true at all.

3. I enjoy learning and practicing mathematics
4. I enjoy mathematics class in school
5. I enjoy practicing mathematics at home and doing things with numbers outside of school
6. I feel confident in mathematics
7. I feel confident with taking tests in any subject
8. I like feeling challenged
9. I like feeling challenged by mathematics
10. I enjoy learning about science in school
11. I enjoy doing science or reading about science outside of school (this might include museums, nature, animals, astronomy, building, the environment, etc)
12. I enjoy learning about technology
13. I enjoy using technology
14. I enjoy learning about or doing engineering
15. I'm excited about learning more challenging math in my future
16. I'm interested in learning more about STEM (science, technology, engineering, mathematics) topics, besides mathematics
17. I'm likely to engage in STEM (science, technology, engineering, mathematics) outside of school (school clubs, extra-curriculars, jobs, internships, hobbies, etc.)

Appendix C: Interview Questions

1. Are you a teacher?
2. Do you have children?
3. How would you describe your "work" in the world?
4. How do you feel about math and science broadly speaking?
5. Did you enjoy mathematics as a child?
6. If you had your own biography with math and science what would that be, briefly speaking?
7. As a child, what did you want to be when you grew up?
8. How do you feel when you solve a mathematics problem?
9. How would you describe your confidence level with mathematics?
10. Have you ever distributed or taken part in a mathematics placement exam?
11. Do you know how you were replaced?
    a. Were you placed into a "lower" or "higher" class based on your math abilities?
12. What are your thoughts about mathematics placement tests?
13. Have you had an experience of being tracked as a student; or being aware of students being tracked in math at one of your school sites?
14. Do you or did you have interest in pursuing a career in STEM (science, technology, engineering, or mathematics)?
15. What do you like about mathematics?
16. What do you dislike about mathematics?
17. Do you think there is gender bias in learning? With math and STEM? If so, why do you think this exists?
18. What is your ideal learning environment?
19. If you have been aware of tracking at one or more of your school sites, how would you describe your observations? What takeaways do you have that you might share? What changes or recommendations might you offer?
20. What do you think is important for students to develop and engage with mathematics or STEM subjects in school? And toward becoming professionals in these fields?
21. What do you think could be changed to improve these conditions?

Appendix D: IRB Approval Letter

DOMINICAN UNIVERSITY of CALIFORNIA

Feb 13, 2023

Emma Hagan
50 Acacia Ave.
San Rafael, CA 94901

Dear Emma,

On behalf of the Dominican University of California Institutional Review Board for the Protection of Human Participants, I am pleased to approve your proposal entitled *Mathematical Identities and Tracking: An Exploration of Efficacy in Children and Women* (IRBPHP Initial IRB Application #[11084]) .

In your final report or paper please indicate that your project was approved by the IRBPHP and indicate the identification number.

I wish you well in your very interesting research effort.

Sincerely,
Michaela George, Ph.D.
Chair, IRBPHP

Cc: Matthew E Davis