12-1-2022

Beyond the Numbers: A Deeper Dive into the Dearth of Girls and Women in STEM

Jennifer John Buck

BEYOND THE NUMBERS: A DEEPER DIVE INTO THE DEARTH OF GIRLS AND WOMEN IN STEM

By

Jennifer E. John Buck

Bachelor of Arts – Psychology
North Central College
2010

Master of Social Work
Boston University
2013

Master of Arts – Experimental Psychology
University of Nevada, Las Vegas
2019

A dissertation submitted in partial fulfillment
of the requirements for the

Doctor of Philosophy – Psychology

Department of Psychology
College of Liberal Arts
The Graduate College

University of Nevada, Las Vegas
December 2022

UNLV | GRADUATE COLLEGE

Dissertation Approval

The Graduate College
The University of Nevada, Las Vegas

October 14, 2022

This dissertation prepared by

Jennifer E. John Buck

entitled

Beyond The Numbers: A Deeper Dive into the Dearth of Girls and Women in STEM

is approved in partial fulfillment of the requirements for the degree of

Doctor of Philosophy – Psychology
Department of Psychology

Rachael Robnett, Ph.D.
Examination Committee Chair

Jennifer Rennels, Ph.D
Examination Committee Member

Paul Nelson, Ph.D.
Examination Committee Member

Harsha Perera, Ph.D.
Graduate College Faculty Representative

Alyssa Crittenden, Ph.D
Vice Provost for Graduate Education &
Dean of the Graduate College

Abstract

Despite decades of research attempting to better understand the dearth of girls and women in science, technology, engineering, and math (STEM), gender imbalances persist in many STEM fields. This is particularly the case in math-intensive STEM fields. The current program of research used mixed-methods research to better understand these inequities. The first paper identified gender and ethnic variation in how undergraduates reason about STEM inequities. The second paper found that how emerging adults narrate “turning points” in their relationship with math was associated with their current math outcomes and future plans to pursue math. The final paper demonstrated that how participants narrate a “low point” in their math education varies depending on their current level of math self-concept. Implications and future directions for mixed-methods research are discussed.

Acknowledgements

I’d like to thank my committee members, Jennifer Rennels, Paul Nelson, and Harsha Perera, for their time and valued feedback on my dissertation.

Jennifer – thank you for always asking the tough questions on application and implications, pushing me to think critically about my work and the world, and holding me accountable in more ways than one during my time in the program; thank you for being a strong and supportive role model.

Paul – thank you for introducing me to the wonderful world of narrative identity, life stories, and for supporting me through the trials and tribulations of achieving interrater reliability; I am so grateful for your thoughtful contributions to my very first, first-authored manuscript.

Harsha – thank you for creating a safe and supportive environment for me to push beyond the false limits created by my own math anxiety, for offering me opportunities to do research and publish with your lab, and for helping me understand that I can do hard things; you have had an immeasurable impact on my life and my understanding of my own abilities.

I’d also like to thank Mark Ashcraft for introducing me to math anxiety; the thing I always felt but never had words for, and the topic that catalyzed my entire program of research at UNLV.

To Kindy, Allie, KV, Blake, and Jackson - it’s been a wild ride, but thank you for making this graduate school journey fun, and for being there through both the tough times and the good. I’m grateful for all of you, and I’m lucky to call you my friends.

To everyone in the Social Development Lab – past and present – thank you for being the lab with the best vibes. Thank you for always being a supportive home base and for always being present to give thoughtful and helpful feedback.

Rachael – there really aren't enough words. I would never have been able to create this body of work that I am so proud of without your guidance. Thank you for believing in me and for pushing me to be the best scholar I can be. Thank you for teaching me that I can do things on my own, that it's okay to try and fail, and that there is always a bright side to every situation. Thank you for teaching me about setting healthy boundaries, and for allowing me to explore my own research interests. I wouldn't be where I am today, in the career that I have always dreamed of, without the opportunities, lessons, and support that you have provided over the last six years. I am forever grateful.

Dedication

To Alex – my pillar, my rock, my unwavering support, my biggest cheerleader. Thank you for understanding that this was something I needed to do for myself; for never questioning my need to create my own identity and pursue my dreams. Thank you for jumping back into the trenches of a long-distance relationship and digging through the muck with me when things got tough. You have always believed in me, and after all this time - with all your encouragement - I'm finally starting to believe in myself. I may never be able to express how much this means to me, but I will spend the rest of my life trying to show you.

I love you a million city club chocolate cakes.

Table of Contents

Abstract iii

Acknowledgements iv

Dedication vi

Table of Contents vii

List of Tables ix

Chapter 1: Introduction 1

Research Agenda 6

Overview of Manuscripts 7

Chapter 2: "Maybe These Fields Just Don't Interest Them." Gender and Ethnic Differences in Attributions about STEM Inequities 10

Abstract 10

Introduction 11

Current Study 18

Method 19

Results 21

Discussion 26

Limitations and Future Directions 31

Conclusion 33

References 34

Chapter 3: Manuscript 1 Summary & Bridge 49

Chapter 4: Memories of Math: Narrative Predictors of Math Affect, Math Motivation, and Future Math Plans 50

Abstract 50

Introduction 52

Method 60

Results 65

Discussion.. 72

Limitations and Future Directions 78

Conclusion 80

References 81

Appendix 4A: Your Life Story about your Experiences with Math 97

Chapter 5: Manuscript 2 Summary & Bridge 99

Chapter 6: “I have cried in almost all of my math classes.” Relations between math self-concept, gender, and narrative appraisals of past low points in math 100

Abstract.. 100

Introduction.. 102

Method.. 110

Results 115

Discussion... 128

Limitations and Future Directions 134

Conclusion 136

References 138

Appendix 6A: Your Life Story about your Experiences with Math 156

Online Supplemental Material 158

Chapter 7: Manuscript 3 Summary 164

Chapter 8: Discussion & Implications 165

Chapter 9: Conclusion 169

References 170

Curriculum Vitae 179

List of Tables

Table 2.1: Overview of Demographic Frequencies in Sample ... 45

Table 2.2: Overview of Participants' Reasoning About Whether STEM Inequity is a Serious Problem ... 46

Table 2.3: Overview of Chi-Square Results by Ethnicity ... 47

Table 2.4: Overview of Chi-Square Results by Gender ... 48

Table 4.1: Narrative Sequences in Math Turning Point Themes ... 93

Table 4.2: How Participants Expect to Use Math in the Future Parsed by Turning Point Themes ... 94

Table 4.3: Mean Gender Differences in Math Attitudes ... 95

Table 4.4: Mean Turning Point Narrative Differences in Math Attitudes ... 96

Table 6.1: Demographics for High and Low MSC Groups ... 150

Table 6.2a: High Math Self-concept: Low Point Themes ... 151

Table 6.2b: Low Math Self-concept: Low Point Themes ... 153

Table 6.3: Mean Gender Differences in Math Outcome Variables ... 155

Table S1: Parameter Estimates for the AMAS Two-Factor CFA Model ... 161

Table S2: Full Sample Means, Standard Deviations, and Correlations ... 162

Table S3: Mean Gender Differences in Math Outcome Variables ... 163

Chapter 1: Introduction

The alarming rate at which technology is evolving demands a technologically competent workforce. Given the critical nature of technology to the global economy (National Science Foundation, 2020), individuals with education and training in science, technology, engineering, and math (STEM) are particularly sought after. In fact, the skills developed in STEM degree programs are so highly valued that even those with STEM degrees who are not employed in the STEM industry command higher wages than those without STEM degrees (Committee on STEM Education, 2018). As such, STEM degrees currently confer a breadth of opportunity and economic stability to those who hold them.

Despite decades of work aiming to increase women's participation in STEM, women continue to be underrepresented in the STEM workforce when compared to their representation in the broader US population. Women in the U.S. comprise only 34% of the total STEM workforce, despite accounting for over half of the college-educated workforce (NSF, 2022). Although there are a few STEM fields where women have reached or exceeded parity with men, they are particularly underrepresented in math-intensive STEM fields such as computer science, engineering, math (CSE) and physics (NSF, 2019a). For example, women make up only 35% of physical scientists, 26% of computer and mathematical scientists, and 16% of engineers (NSF, 2022).

These statistics are troubling for several reasons. First, there are broader economic consequences when women are not well-represented in STEM, including that STEM careers pay higher wages than do non-STEM careers. Given that (a) women report lower median income when compared to men (U.S. Census Bureau, 2019), STEM education and careers may provide a particularly important opportunity for women to move up on the socioeconomic ladder and into positions that encourage greater societal equity. Second, organizational research has found that diversity in the workplace is crucial for increased commitment, empowerment, and innovation in the workforce (Chrobot-Mason et al., 2013; Ostergaard et al., 2011). As such, recruiting and maintaining a diverse STEM workforce is imperative for both individual success and economic growth. In addition, there are well-documented, systemic barriers that dissuade women from pursuing and persisting in math-intensive STEM fields. These barriers include persistent stereotypes about women's math capabilities, which are known to reduce women's confidence and value in math (Bieg et al., 2015; Cvencek, 2011; Eccles & Wigfield, 2020). Experience with these stereotypes and biases over time can influence how girls and women envision themselves and their futures, and ultimately steer them away from STEM careers (Eccles & Wigfield, 2020; McLean et al., 2020; Zavala & Hand, 2019).

STEM education has been a priority for U.S. education policy and research for several decades (see Committee on Integrated STEM education, 2014 for a review), and although some progress has been made the persistence of gender disparities in math-intensive STEM careers indicates that current research may not be capturing enough nuance regarding the experiences that contribute to women's attrition from STEM. Indeed, a complex array of developmental, educational, and social factors have been found to influence math outcomes and STEM interest. Below, I outline several key factors that have played a central role in my program of research, including math anxiety, gendered ability stereotypes, and theories of achievement motivation. When studied using mixed methodologies that allow for qualitative distinction, these factors may provide unique avenues for interventions to encourage girls' and women's persistence in STEM.

Math anxiety, or a fear of situations involving math, is particularly detrimental to math achievement (Ashcraft, 2002). It has been seen in children as early as first grade and is associated with reduced math confidence, interest, and value (Ahmed et al., 2012; Casanova et al., 2021; Hembree, 1990). In fact, both theory and research have indicated that experiencing math anxiety can steer students away from STEM-related degrees and careers altogether (Ahmed, 2018; Beilock & Maloney, 2015), and research on math anxiety has found that women consistently report higher math anxiety than do men (Ma, 1999). Research suggests math anxiety may be socially transmitted by parents and teachers, as well as through classroom experiences (see Chang & Beilock, 2016; Maloney et al., 2013; Ramirez et al., 2018). For instance, research has found that math-anxious parents can pass math anxiety onto their children (Casad et al., 2015; Maloney et al., 2015). Other research has found that the teaching strategies used by highly math-anxious math teachers are associated with reduced math achievement for their students (Ramirez et al., 2018). This reduction in math achievement may be due – in part – to an increased endorsement of math-gender stereotypes, such as the notion that "not everyone can be good at math" or that "girls are bad at math" (Beilock et al., 2010; Ramirez et al., 2018). In addition, research by Beilock and colleagues (2010) found a reduction in girls' – but not boys' – math achievement in classrooms with women math teachers who were also highly math-anxious. Girls' lower achievement in these classrooms was mediated by an increase in girls' endorsement of math-gender stereotypes. Indeed, research has found that endorsement of math-gender stereotypes is associated with not only an increase in math anxiety, but also reduced math identification and performance (Cvencek, 2011; Casad et al., 2015). There is also some research suggesting that peers may contribute to math anxiety, however, this research has been mixed (Ahmed et al., 2010; Garba et al., 2020).

In addition to influencing math anxiety and achievement, socio-contextual factors can also affect math motivation. The ways in which these factors influence STEM motivation can be partially explained by the Expectancy Value Theory of achievement motivation (EVT; Eccles, 1983; Wigfield & Eccles, 2000). EVT posits that socio-cultural factors (e.g., stereotypes, societal expectations) and one's interpretation of achievement-related experiences over time (e.g., classroom contexts, interactions with parents, teachers, or peers) influence the development of an individual's ability self-concept, expectancies for success, and valuation of a particular domain. *Self-concept* refers to a person's overall perception of their competence in a domain (Bong & Skaalvik, 2003), *self-expectancies* refer to future expectations for success in a domain (Wigfield & Eccles, 2000), and value refers to how much a person values the domain for various reasons. For instance, *attainment value* refers to the personal importance of doing well on a given task, *intrinsic value* refers to the enjoyment one gains from a task, *utility value* refers to the usefulness of a task for the achievement of some future goal, and *cost* refers to how much engaging with a task will limit other aspects of a person's life (Wigfield & Eccles, 2000). These components, as influenced by socio-cultural factors, then have downstream effects on motivation, achievement, and persistence in the domain. For instance, research has found that students with higher math self-concept and values are more likely to pursue STEM-related careers (Eccles & Wang, 2016; Lauermann et al., 2017; Wang & Degol, 2013). However, there are well-documented gender differences in levels of math self-concept, with girls consistently reporting lower math self-concept than boys (Huang, 2013; Skaalvik & Skaalvik, 2004). According to EVT, this gender difference likely occurs because of negative cultural stereotypes about girls' math abilities, paired with the socialization of traditional gender norms that can influence how girls interact with math and perceive their own abilities over time (Eccles, 1994; Eccles & Wigfield, 2020).

Although math anxiety is not specifically included in EVT, empirical work has established a relationship between math anxiety and components of math achievement motivation. For instance, Meece and colleagues (1990) found that higher math anxiety is related to reduced math self-expectancies and values, which in turn are associated with reduced enrollment in future math courses. Relatedly, Ahmed and colleagues (2012) found a reciprocal relationship between math anxiety and math self-concept, with math self-concept exerting a stronger effect on math anxiety over time than the reverse. The demonstrated relationships between math anxiety and components of EVT suggest that math anxiety should be considered as an important component when attempting to understand STEM career pursuits. The emotional aspect of math anxiety may be particularly important, given recent theoretical developments that echo the notion of individual interpretations of achievement-related experiences seen in EVT. More specifically, Ramirez and colleagues (2018) proposed an *interpretation account* of math anxiety, which suggests that math anxiety develops due to individual differences in the emotional appraisal of math experiences and outcomes.

Taken together, the existing research on EVT, math anxiety, and STEM outcomes identifies several socio-contextual factors that contribute to the gender gap in math-intensive STEM careers. Although this work is critical, it leaves many questions unanswered. Most importantly, it often fails to capture critical nuance regarding specific experiences that contribute to the dearth of women in math-intensive STEM fields, as well as how individuals appraise and process these experiences. Without these details, researchers, educators, and policymakers cannot create or test effective interventions. For example, Maloney and colleagues (2015) found that students who had math-anxious parents that regularly assisted them with math homework saw reduced math performance and increased math anxiety at the end of the school year. Although these findings clearly indicate that math-anxious parents can transmit math anxiety to their children, the study did not obtain evidence for how this transmission occurs. For instance, it is possible that math-anxious parents speak in certain ways about math or approach teaching math in ways that are particularly detrimental for students, both of which might be leveraged for parent-child interventions. However, this opportunity is lost without deliberate observations of parents helping their children with math homework or interviews with parents about how they engage their children in math. As another example, Beilock and colleagues (2010) found that an increase in gendered math-ability beliefs explained the relationship between female teachers' math anxiety and a reduction in their female students' math achievement. However, the authors did not obtain observations or other information to explain how female teachers' own math anxiety might permeate their teaching strategies or choice of words in the classroom to influence gendered math-ability beliefs for their female students. Without this information, targeted interventions for female teachers with high math anxiety are unlikely to produce results. As such, my current program of research uses mixed methods research to obtain critical nuance about the relationships between experiences, emotions, and attributions that contribute to women's attrition from STEM.

Though the current literature on gender and STEM is robust and encouraging, it is primarily quantitative, and despite its strengths, leaves nuance to be desired if testable and costly interventions for improving STEM outcomes are to be developed and evaluated. Mixed methods research provides an avenue for researchers to continue progressing quantitative work while also capitalizing on the detail afforded by qualitative approaches. More specifically, blending quantitative and qualitative research allows investigators to gain a more comprehensive understanding of the phenomena they study. These approaches, which aim to meaningfully integrate both qualitative and quantitative information, may be particularly useful for investigating the intricacies of social and educational issues (see McCrudden et al., 2019).

Research Agenda

My program of research aims to understand the socio-contextual factors that contribute to math anxiety and math achievement motivation with the purpose of better understanding inequities in the math-intensive STEM workforce. More specifically, I aim to integrate theories from educational, developmental, and social psychology to illuminate unique pathways for intervention with relation to (a) bolstering the STEM workforce via increased math literacy and engagement and (b) reducing gender disparities in math-intensive STEM fields. Notably, much of the related research on STEM is focused on quantitative outcomes such as interest, persistence, choice, and achievement. My research employs a mixed-methods framework to not only replicate existing research, but better understand qualitative nuance and the emotional and cognitive processes behind these outcomes. For instance, a quantitative measure of math anxiety can reliably indicate how much math anxiety someone currently has, but it provides little insight into how this person developed math anxiety or their phenomenological experience of math anxiety. As another example, someone's math self-concept might be low, and this may be related to high math anxiety. However, these measures and the relation between them cannot explain how someone reasons about *why* they have low math self-concept and high math anxiety. While both qualitative and quantitative methods have their respective strengths, they also have limitations. The use of a mixed-methods approach allows the strengths of each method to offset the limitations of the other for a more holistic understanding of the data and, ideally, a convergence of results across methods (Creswell, 2014; McCrudden et al., 2019).

Overview of Manuscripts

My first dissertation manuscript (Kent, John, & Robnett, 2020) aimed to better understand how college students reason about STEM inequities. Most college students are in the developmental period of emerging adulthood, during which they are often making important life decisions about their futures and careers (Arnett, 2000). As such, emerging adulthood is an ideal period in which to understand how people think and reason about potential career paths, including their understanding of disparities in certain career fields. As such, we asked college students to provide their thoughts about gender and racial inequity in STEM. Thematic analysis (Braun & Clarke, 2006) of participants' open-ended data provided insight into why some participants perceive STEM inequity to be a problem, whereas others do not. Mixed-methods analyses revealed that women were more likely than men to attribute STEM inequities to stereotyping and low confidence; conversely, men were more likely than women to argue that these inequities are caused by women and People of Color being disinterested in STEM fields. In addition, Latinx participants were significantly more likely than White and Asian participants to mention stereotyping as reasons for the current gender and racial inequity in STEM. These findings indicate that there are significant gender and ethnic differences in how emerging adults think and reason about inequities in STEM and support prior work highlighting harmful ability stereotypes and women's lower confidence in STEM.

The purpose of my second dissertation manuscript (John, Nelson, Klenczar & Robnett, 2020) was to understand how aspects of college students' narrative identities might explain their current math anxiety, math confidence, math value, and future math plans. We were particularly interested in how participants narrated a "turning point" – or pivotal moment – they remember having with math in the past. Participants were asked to complete quantitative measures of math anxiety, math self-expectancy, and math value. They were also asked to answer two open-ended questions: one about a "turning point" they had with math and another explaining their future plans with regard to math. Thematic analysis (Braun & Clarke, 2006) revealed four main themes for the math turning point narratives: (1) consistently positive, (2) consistently negative, (3) redemption (e.g., a bad math experience that ended well), and (4) contamination (e.g., a good math experience that ended poorly). Mixed-methods analyses provided insight into the relationships between turning point themes and math outcomes. For instance, participants who told consistently positive turning point stories reported lower math anxiety and higher math self-expectancy than participants from the other three themes. In addition, participants who wrote consistently negative turning point stories were significantly more likely to say that they plan to avoid math in the future. These findings suggest that individual interpretations of past math experiences may be important for predicting math outcomes and future math plans, underscoring the importance of understanding whether certain types of math experiences or narrative interpretation tendencies may contribute to STEM career choice.

My final dissertation manuscript (John, Vierra, & Robnett, 2022) aimed to isolate college students with particularly high or low math self-concept and explore differences in their narration of a past low point they had with math. We were particularly interested in understanding how student memories of bad math experiences might be related to their current levels of math self-concept, math anxiety, and math value. Participants were asked to complete quantitative measures in addition to answering an open-ended question about a "low point" they remember having with math. Thematic analysis (Braun & Clarke, 2006) revealed both similarities and distinctions in how participants with high versus low math self-concept narrated their past math low points. For instance, participants interpreted similar types of experiences (e.g., receiving a bad grade) as low points, but participants with low math self-concept provided more detail and emotional reflection on these experiences. In addition, women with low math self-concept were more likely than men to mention teachers as a key component of their math low point. These findings indicate a clear relationship between current math self-concept and how past math experiences are appraised. In addition, results pinpoint particular experiences that might contribute to low math self-concept and subsequent STEM attrition for women.

Chapter 2: “Maybe These Fields Just Don’t Interest Them.”

Gender and Ethnic Differences in Attributions about STEM Inequities

Sara R. Kent
University of Nevada, Las Vegas

Jennifer E. John
University of Nevada, Las Vegas

Rachael D. Robnett
University of Nevada, Las Vegas

Abstract

The current study investigates how undergraduates reason about gender and racial inequity in fields related to science, technology, engineering, and math (STEM). Participants were 342 undergraduates from diverse ethnic backgrounds who answered an open-ended question about ethnic and gender disparities in STEM fields. Thematic analysis revealed substantial variation in how participants reasoned about these disparities. Corresponding quantitative analyses indicated that participants from different sociodemographic backgrounds tended to reason about STEM disparities in different ways. For instance, women were more likely than men to mention stereotyping and lack of confidence as reasons for STEM inequity, whereas men were more likely than women to mention that these disparities are caused by a lack of interest in STEM. In addition, Latinx participants were more likely to mention stereotyping than participants from other ethnic backgrounds. Discussion focuses on potential implications for intervention and outreach efforts.

Keywords: STEM, perceptions of inequality, student attitudes, career choice, narrative

Introduction

Despite recent efforts to increase diversity in fields related to science, technology, engineering, and math (STEM), People of Color and women more generally are underrepresented in STEM fields relative to their proportion of the U.S. population (Landivar, 2013; National Science Foundation [NSF], 2018; Schmaling, Blume, Engstrom, Paulos, & De Fina, 2017). When collapsing across ethnic groups, women comprise half of the college-educated U.S. workforce, yet they make up only 29% of the STEM workforce (NSF, 2018). These patterns of underrepresentation are especially acute among Women of Color (American Association of University Women [AAUW], 2010), with Women of Color receiving fewer science and engineering degrees than expected. More specifically, Women of Color comprise 21.9% of the population, but receive only 13.3% of STEM degrees (NSF/NCSES, 2015). According to the U.S. Committee on STEM Education (2018), fostering greater ethnic and gender diversity in STEM is important for both economic and humanitarian reasons. From an economic standpoint, for example, workforce diversity is associated with improved innovation and problem-solving capabilities in a world that is increasingly dependent on science and technology (Ostergaard, Timmermans, & Kristinsson, 2011). From a social justice standpoint, it is important to ensure that people from historically marginalized groups have access to STEM careers, given that these careers tend to be high-paying and prestigious.

Although concern about the lack of diversity in STEM fields is well documented among researchers, educators, and policymakers (e.g., NSF, 2018; U.S. Committee on STEM Education, 2018), it is not clear whether this concern extends to students in higher education. This is surprising given that numerous STEM diversity initiatives and interventions target students at the undergraduate level (see Tsui, 2007). Accordingly, the current research investigates how undergraduates reason about ethnic and gender disparities in STEM fields.

Understanding their reasoning will yield actionable insights that can inform more targeted outreach efforts.

Below, we start by explaining why, from a developmental standpoint, it is worthwhile to examine how undergraduates reason about academic inequities. Then we draw from social role theory (Eagly, 1987) to explain how the social context gives rise to role expectations. These role expectations shape stereotypes about People of Color and women in STEM fields; in turn, these stereotypes may inform how people reason about STEM inequities. Next, we summarize three factors—stereotyping, bias, and confidence—that have been linked to STEM inequities in prior research. We were particularly interested in whether participants would reference these empirically grounded constructs when making attributions about ethnic and gender disparities in STEM. Finally, we draw from system justification theory (Jost, Banaji, & Nosek, 2004) and social dominance theory (Sidanius & Pratto, 1999) to discuss whether and how participants' ethnicity and gender may relate to their reasoning about inequities in STEM.

The Developmental Context

The current study focuses on reasoning about STEM inequity among undergraduates. For many students, the undergraduate years coincide with emerging adulthood; a developmental period that occurs during the third decade of life (Arnett, 2000). There are several reasons to investigate how emerging adults reason about STEM inequity. First, emerging adulthood is a developmental period of profound growth; it is during this period that many young people explore and solidify their worldviews while also making important decisions about their futures (e.g., career choices; Arnett, 2000; Seiffge-Krenke, Luyckx, & Salmela-Aro, 2014). Thus, the way people reason about societal problems (e.g., occupational disparities) during emerging adulthood likely lays the groundwork for whether and how they will address these problems later in life.

Second, many interventions that focus on fostering diversity in STEM fields target students at the undergraduate level (Tsui, 2007). Yet, research focusing on sociopolitical development suggests that reasoning about societal inequities can vary widely within a given sample (e.g., Watts, Griffith, & Abdul-Adil, 1999). People in the early stages of sociopolitical development are unaware that inequities exist; conversely, people in the later stages are aware of inequities and may even engage in collective action to reduce these inequities (Watts & Abdul-Adil, 1997; Watts et al., 1999; Watts, Williams, & Jagers, 2003). By providing insight into how emerging adults reason about STEM inequities, findings from the current study will enable researchers to design more targeted interventions that take into account students' level of sociopolitical development.

Occupational Expectations and the Social Context

People's beliefs about STEM inequity are embedded in a social context that fosters different occupational expectations for members of different groups. Social role theory (SRT; Eagly, 1987) provides insight into why this might be the case. This perspective posits that people have deeply rooted expectations about personality attributes that are suitable, or "appropriate," for each gender. In particular, men are expected to be agentic and dominant, whereas women are expected to be communal and nurturant (Eagly, 1987). Additional research suggests that people expect these traits to vary as a function of ethnicity as well (see Koenig & Eagly, 2014). These gender and ethnic role expectations likely influence how people reason about inequities in specific occupational domains. For instance, individuals in STEM fields tend to be viewed as highly agentic, successful, and competitive (Carli, Alawa, Lee, Zhao, & Kim, 2016), which are traits that align with traditional White, masculine gender roles. This overlap may help to explain why some individuals are relatively unconcerned about STEM inequities. As detailed later, social dominance theory and system justification theory expand on this possibility.

Common Explanations for Ethnic and Gender Disparities in STEM

An abundance of research has identified potential causes of ethnic and gender disparities in STEM fields (for reviews, see Ong, Wright, Espinosa, & Orfield, 2011; Wang & Degol, 2016). In particular, three social-contextual factors have received a significant amount of attention. More specifically, individuals who pursue career fields that conflict with society's expectations tend to experience *stereotyping* (Fisher, Wallace, & Fenton, 2000; Gay, 2004), *bias* (Robnett, 2016; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012), and a resulting erosion of *confidence* (Correll, 2001; Eccles et al., 1989). Accordingly, we were interested in whether participants would mention any of these constructs when reasoning about STEM inequities. We further explain each of the three constructs below.

Stereotypes. STEM has historically been stereotyped as a "male" domain, such that individuals tend to believe that math and science ability come more naturally to men than to women (Carli, Alawa, Lee, Zhao, & Kim, 2016; Kuchynka et al., 2018; Smyth & Nosek, 2015). Indeed, research demonstrates that even young girls and boys have views consistent with traditional gender roles and stereotypes. For instance, girls believe they are worse at math and science than their male counterparts (Freedman-Doan et al., 2000). Similarly, People of Color commonly report battling with stereotypes that question their intelligence, ability, and qualifications in STEM (Fisher et al., 2000; Gay, 2004). Other research shows that ethnic minority youth are aware of negative racial stereotypes surrounding their intellectual ability (Kellow & Jones, 2008), and that children's endorsement of these ability stereotypes seems to increase with age (Rowley, Kurtz-Costes, Mistry, & Feagans, 2007). Moreover, repeated exposure to these negative stereotypes may contribute to heightened awareness of discrimination among People of Color and women more generally (Inman & Baron, 1996; Brown & Bigler, 2004; Brown & Bigler, 2005).

Systemic Bias. Despite the existence of negative stereotypes, some individuals from marginalized groups nonetheless persist in STEM. Unfortunately, research indicates that they may encounter bias as they work toward STEM degrees and careers. For instance, in one study, 52% of adolescent girls reported experiencing academic sexism in science, math, or computer technology (Leaper & Brown, 2008). Similarly, another study demonstrated that the majority of women in STEM majors and graduate programs had experienced at least one instance of academic sexism in the past year (Robnett, 2016). Hiring discrimination in STEM is also common for women (Moss-Racusin et al., 2012) and People of Color (Quillian, Pager, Hexel, & Midtboen, 2017). Women are half as likely as men to be hired for a math-intensive job, which may be in part because employers expect reduced math performance from women (Reuben, Sapienza, & Zingales, 2014). The few women who are hired into STEM still face barriers to success in their careers. For instance, female STEM faculty members are less likely than their male counterparts to believe that their departments view them as productive; they also simultaneously report experiencing the highest amounts of discrimination when compared to men in STEM and women in non-STEM faculty positions (Blackwell, Snyder, & Mavriplis, 2009). These issues may be particularly acute for Women of Color, who cite low belongingness and discrimination as key challenges for their persistence and achievement in STEM fields (for a review, see Ong et al., 2011).

Confidence. Confidence is broadly defined as one's self-perceived likelihood of success in specific domains (Lent, Brown, & Gore, 1997; Moakler & Kim, 2014). Experiencing negative stereotypes and systemic bias in STEM over time can erode confidence among People of Color as well as girls and women more generally (e.g., see Robnett, 2016). For instance, girls' confidence in their science and math abilities begins to decline as early as middle school (Eccles et al., 1989). In high school, girls regularly underestimate their own math ability, despite performing comparably to their male counterparts (Correll, 2001). This low confidence persists for college women in STEM, as they tend to judge themselves more harshly than do men in STEM (Litzler, Samuelson, & Lorah, 2014; Robnett & Thoman, 2017). Similarly, Students of Color in STEM express lower confidence than do White students. For example, a lack of role models and peers from similar backgrounds is associated with feelings of exclusion in STEM among People of Color, which appears to erode their confidence (Litzler et al., 2014; see also Marra, Rodgers, Shen, & Bogue, 2009).

Sociodemographic Variation in Reasoning about Ethnic and Gender Disparities in STEM

In addition to examining how emerging adults reason about inequity in STEM fields, the current study also examines whether participants' reasoning varies according to their ethnicity or gender. System justification theory (SJT; Jost, Banaji, & Nosek, 2004; Jost & Hunyady, 2005; Jost, Kay, & Thorisdottir, 2009) offers an explanation for why both dominant and subordinate groups tend to justify current social systems. SJT suggests that individuals are motivated to perceive the systems that exert control over their lives as legitimate. As such, dominant groups, such as White men in STEM fields, are motivated to maintain the systems that keep them in power. However, underrepresented groups such as women and People of Color tend to tolerate and even justify the inequality they experience. More specifically, when presented with social inequities – particularly those that seem impossible to change – people are motivated to rationalize them, even if it is to their own disadvantage. Indeed, research has found that people have a tendency to create attributions that "explain away" stereotype-inconsistent information as a way to maintain common stereotypes (e.g., Sekaquaptewa, Espinoza, Thompson, Vargas, & von Hippel, 2003).

In comparison, social dominance theory (SDT) purports that dominant groups are more likely to endorse hierarchies that legitimize the status quo because it is directly to their benefit (Sidanius & Pratto, 1999). Low-status groups are often stereotyped as incompetent or unambitious, whereas high-status groups are stereotyped as intelligent and successful; these stereotypes justify social hierarchies that maintain high-status groups (Cuddy, Fiske, & Glick, 2007). According to SDT, men may feel the need to justify issues like sexism and bias against women in order to maintain STEM as a male-dominated field. For instance, research shows that boys and men are generally less aware and more skeptical of sexism and bias in STEM fields than are girls and women (Becker & Swim, 2011; Robnett & John, 2018). Other research has found that men are more likely than women to justify the existence of sexism and bias against women in an effort to uphold their own status (Morton, Postmes, Haslam, & Hornsey, 2009; Moss-Racusin, Molenda, and Cramer (2015). Thus, whereas SJT suggests that members of all groups will be motivated to rationalize disparities in STEM fields, SDT indicates that this tendency will be particularly common among members of dominant groups.

Reasoning About STEM Inequities

Social role theory, system justification theory, and social dominance theory all offer insight into factors that may shape how undergraduates reason about STEM inequities. However, relatively little research has examined the specific explanations undergraduates provide for patterns of ethnic and gender underrepresentation in STEM. Moreover, it is not clear whether undergraduates from different sociodemographic backgrounds will reason about STEM inequity in different ways. Extant literature on individual variation in thoughts about STEM inequities is primarily focused on gender. For instance, in a study focusing on adolescents, Robnett and John (2018) found that girls were more likely than boys to perceive sexism in STEM as pervasive and serious. This is consistent with the idea that those with high status (e.g., boys) tend to downplay issues of inequity and justify current systems, which is a core premise of SDT. Beyond adolescents, Cundiff and Vescio (2016) examined undergraduates' attributions for gender disparities in STEM. They found that attributions varied as a function of stereotype endorsement, such that students who strongly endorsed gender stereotypes were less likely to attribute gender disparities in STEM to discrimination. These findings are aligned with both SRT and SJT, which suggest that role expectations and stereotypes encourage the justification of the current hierarchies in STEM. This may be particularly the case among members of dominant groups.

Current Study

The current study builds on prior work by investigating how emerging adults reason about ethnic and gender disparities in STEM fields. Specifically, the current study is guided by two overarching research questions. Our first research question (RQ1) is as follows: *How do participants reason about ethnic and gender inequity in STEM fields?* As detailed earlier, prior research consistently links stereotyping, bias, and confidence to STEM inequities. As such, we expected that at least some participants would mention these constructs in their responses. However, we also anticipated that participants would reference additional constructs that have received less empirical attention. Accordingly, our coding approach incorporated both deductive and inductive elements with the goal of capturing the full scope of participant responses.

Our second objective is guided by system justification theory and social dominance theory in an effort to explore sociodemographic variation in how individuals reason about STEM inequity. For instance, research suggests that certain stereotypes are associated with the motivation to justify current systems and social inequities (see Oldmeadow & Fiske, 2007 for a review). As such, explanations for inequities in STEM may vary by perceiver demographic variables – such as gender or ethnicity – that are associated with status and representation in the field. Hence, our second research question (RQ2) is as follows: *To what extent is there ethnic or gender variation in how participants reason about STEM inequity*?

We addressed these research questions via a blend of qualitative and quantitative data (i.e., a mixed-methods approach), which has several advantages over exclusively qualitative or quantitative approaches. For instance, a mixed-methods approach can provide insight into *how* participants reason about a given question, rather than simply measuring whether they agree or disagree (Creswell, 2009). This approach also leverages the strengths of both quantitative and qualitative data, thus enabling the investigation of a more complex range of issues (Johnson & Onwuegbuzie, 2004).

Method

Participants

A total of 342 undergraduates from a large public university in the Southwestern United States participated during the 2017-2018 academic year. Demographic information about the sample is summarized in Table 2.1. The sample had a mean age of 20.4 years (*SD* = 3.67). With respect to gender, the sample included 195 women (57%) and 135 men (39.5%); one participant (<1%) identified as non-binary, and 11 participants (3%) did not disclose their gender. With respect to ethnic background, 112 participants (32.5%) identified as White, 84 (24.6%) identified as Hispanic/Latinx, 65 (19%) identified as Asian/Pacific Islander, 38 (11%) identified as African-American, 29 (8.5%) identified as Other, 2 (<1%) identified as Native American, and 12 participants (3.5%) did not disclose their ethnic background. In terms of major, 125 (37%) participants identified as STEM majors. In this case, STEM majors included biological sciences, chemistry, physics, geoscience, agricultural and environmental science, engineering, computer science, and mathematics. This list is generally consistent with how the National Science Foundation (NSF) defines STEM fields, although social sciences were excluded from STEM in the current study. Correspondingly, 217 (63%) of participants identified as non-STEM majors, which included all other majors not mentioned in the STEM category.

Procedure

The current study originates from a larger project that focuses on constructs such as math anxiety and stereotype threat. After providing informed consent, participants completed an online survey that included a variety of closed- and open-ended questions as well as a demographics questionnaire. Upon completion of the survey, participants were compensated with one research credit for their introductory psychology course.

Measures and Qualitative Coding

To examine how participants reason about STEM inequity, we asked them to respond to the following open-ended question: “White men are overrepresented in science, technology, engineering, and math (STEM) fields. This means that women and People of Color are underrepresented. What do you think about this?” This question was intentionally broad to avoid leading participants toward any particular response.

Participants’ responses were coded using thematic analysis, which is a qualitative technique used to identify patterns, or “themes,” within a given dataset. Our approach to thematic analysis was informed by the steps outlined in Braun and Clarke (2006). Specifically, after thoroughly reading through the full body of data several times, the lead author used a hybrid deductive-inductive approach to develop a coding manual. That is, coding was informed by prior research on stereotyping, bias, and confidence (i.e., a deductive approach), but also allowed for the inclusion of emergent themes (i.e., an inductive approach).

The coding manual was composed of two overarching themes, both of which contained four subcategories (see Table 2.2). The subcategories within each theme were not mutually exclusive. That is, responses with content pertaining to more than one subcategory were grouped into each relevant subcategory. Nearly a quarter (n = 64, 24%) of the responses fell into more than one subcategory within a given theme. Only two responses (<1%) fell under three or more categories. Responses that mentioned a subcategory multiple times were not coded multiple times. For example, if a participant mentioned "lack of interest" four times in their response, the response was only coded once for that subcategory.

Overall, 219 responses (64%) could be classified according to the coding manual. Responses were classified as "not codable" when they were incoherent, failed to address the prompt, or raised idiosyncratic issues that were not mentioned by other participants. For example, one participant wrote, "Women and People of Color already in STEM fields should help fellow youth that are underrepresented across the world." Another participant simply wrote "True." These and similar responses are not further considered in the forthcoming analyses.

Inter-rater reliability was tested by having two trained research assistants and the lead author code 60 participant responses separately. All coders then met to revise and refine the coding manual. Disagreements were resolved through consensus. After revision, responses were again coded by the lead author and research assistants separately before reconvening to calculate inter-rater reliability, which was indexed by Cohen's kappa. Reliability then was computed separately for each theme. The two undergraduate coders had an acceptable level of agreement with one another for both of the themes (*k* range: .85 to .91). Similarly, both of the reliability coders had an acceptable level of agreement with the lead author for both themes (*k* range: .87 to .92).

Results

Findings from the current study are presented in two sections. We begin by describing the qualitative findings that address RQ1, which asked how participants reason about ethnic and gender disparities in STEM fields. As summarized in Table 2.2, the qualitative data are broadly grouped into two themes according to whether participants perceived STEM inequity as a problem. These themes are then further divided into several more specific subcategories.

Second, we present quantitative analysis pertaining to RQ2, which asked whether reasoning about STEM inequity varies as a function of participants' ethnicity or gender.

Qualitative Analysis

Theme 1: STEM inequity is a problem. As summarized in Table 2.2, we derived two overarching themes from the data. Theme 1 was composed of responses that acknowledged inequity in STEM and subsequently listed factors that participants believed to contribute to the inequity. Three-quarters of the sample (*n* = 164, 75%) provided responses that fell under Theme 1. Responses that fell under this theme were coded into at least one of four possible subcategories: *fairness, systemic bias, stereotypes,* and *confidence*.

Fairness. Responses in this category (*n* = 87, 26%) highlighted fairness and representation in STEM fields. Participants who were coded into this category tended to view STEM equality as necessary and considered inequity to be a major problem. For example, Blair[1] noted: "I believe that [STEM inequity] needs to change because White men aren't the smartest and women and People of Color are just as smart and/or smarter."

Systemic Bias. Responses in this category (*n* = 66, 20%) tended to mention that White men receive more resources (e.g., better environments, better schooling, more money) and/or opportunities (e.g., better job offers, scholarships) than do women and People of Color. For example, Taylor remarked: "I believe that the opportunities presented for White men within the STEM fields are much easier to come by and to take advantage of, [whereas] women and People of Color have to work harder for less opportunities."

Stereotypes. Responses in this category (*n* = 34, 10%) made note of positive stereotypes for White men and/or harmful stereotypes for women and People of Color in STEM. For example, Alex wrote: "People don't expect women to have jobs that include

---

[1] All names used in this paper are pseudonyms.

science as much as society does for men. I think women need to be brought up with the thoughts in their head that they can be in STEM fields and be successful."

Confidence. Responses in the final subcategory for Theme 1 (*n* = 16, 5%) mentioned that White men have more confidence when pursuing STEM careers, and/or that women and People of Color have less confidence or feel more pressure to succeed in STEM. For example, Riley noted: "It's extremely unfair because the people who are underrepresented don't feel as though they can succeed in these fields or they have a lot of potential obstacles in their path to get there."

Theme 2: STEM inequity is not a problem. Theme 2 was composed of participants who did not perceive STEM inequity as a problem. One quarter (*n* = 55, 25%) of the sample provided responses that fell under Theme 2. Responses that fell under this theme were also coded into at least one of four possible subcategories: *lack of interest, merit-based, STEM is diverse,* and *not unique to STEM*.

Lack of interest. Responses in this category (*n* = 24, 7%) indicated that women and People of Color simply are not interested in or do not have the motivation to pursue STEM fields. For example, Robin wrote: "I am a little shocked but not so much, girls seem to maybe focus on more girly jobs or [ones that are] less technical."

Merit-based. Responses in this category (*n* = 18, 5%) reflected that STEM positions should not be given to individuals simply because they identify with an underrepresented group. Responses in this category most often indicated that the "best-qualified person" should work in STEM. For example, Avery noted: "I believe that women and People of Color should be represented for their accomplishments and not what they look like. One cannot give praise for work based on looks."

STEM is diverse. Responses in this category (*n* = 10, 3%) most often indicated that, based on their personal experiences, STEM fields are already diverse, with respect to both gender and ethnicity. For example, Charlie remarked: “From prior experiences there are a variety of individuals in the STEM fields. Doctors, for example, are … diverse.”

Not unique to STEM. Responses in the final subcategory for Theme 2 (n = 5, 2%) tended to acknowledge the inequity in STEM, but did not find it particularly concerning because other career fields also have inequity. Although one interpretation of this category could be that the participants are concerned about inequity in all fields—not just in STEM—the tone of these responses conveyed feelings of indifference about correcting these inequities. For example, Elliot noted:

> “If you mean that women and People of Color are not prevalent in the fields of science, technology, engineering, and math, then I see no problem with that. There are more women [than men] in the field of nursing, but should we complain about it? Not really.”

Quantitative Analyses

A series of chi-square analyses provided insight into RQ2, which asked whether participants who differed on the basis of ethnicity and gender reasoned in different ways about STEM inequity. Findings are summarized in Tables 2.3 and 2.4. Prior to conducting the analyses, we omitted the response from the nonbinary participant in order to meet cell size requirements. Along the same vein, we were only able to test for variation across the three largest ethnic groups: White, Asian/Pacific Islander, and Latinx. Finally, we omitted three responses from participants who mentioned subcategories related to both overarching themes.

Ethnic variation. Findings did not reveal significant ethnic variation in the *fairness, systemic bias, confidence, lack of interest*, *merit-based, STEM is diverse,* or *not unique to STEM* subcategories. Findings did, however, illustrate that Latinx participants were significantly more likely than White or Asian/Pacific Islander participants to mention *stereotyping* in their responses, ($\chi 2$ (2, N=179)=7.772, p=.021, V=.208). Most of these responses focused on common stereotypes ascribed to White men, women, and People of Color. For example, Sofia, a Latina woman, wrote, “I agree with the statement made. It all comes down to women and People of Color being underestimated to complete these tasks and being capable of doing something a White man is expected to do." April, another Latina woman, wrote: "…Women have been always seen as the stay at home parent that should choose "easier" fields to major in." Similarly, Nicole, a Latina woman, wrote: "I think it is expected that White men are good at STEM and women and People of Color are not so good at it." Importantly, these sentiments were not limited to women. For example, Sergio, a Latino man, expressed:

> "I think it's [a] stereotype where the White men are seen as the people that would get involve[d] in any math applied field while women and People of Color are seen as getting involved [in things other than] math."

Gender Variation. Findings did not reveal significant gender variation in the *fairness, systemic bias, merit-based, STEM is diverse,* or *not unique to STEM* subcategories. Findings did, however, illustrate that men were significantly less likely than women to mention *stereotyping*, ($\chi 2$ (1, N=217)=6.385, p=.012, V=.172), and *lack of confidence*, ($\chi 2$ (2, N=217)=5.475, p=.019, V=.159) as issues that impacted women and People of Color in their pursuit of STEM careers. Participants providing these responses mentioned personal struggles as well as long-standing societal trends. For instance, with respect to stereotyping, Jennifer, a White woman, wrote, "Growing up, everyone is told that boys are better at math, and I have just [grown] up accepting this lie I was told." Elena, a Latina woman, elaborated on how society upholds harmful stereotypes:

> "I think this is due to how our society views gender roles and race. Women in STEM fields have been kept back due to gender and they can be just as capable as men in these fields. I think that to get more women into STEM fields we must work on the gender roles of society."

Other women focused more on confidence. For example, Laura, a Latina woman, speculated that "White men would probably have the most confidence while applying for jobs or positions and would not be as scrutinized [as to] whether or not they have the abilities in the first place." Lynne, an Asian American woman, provided a similar response: "I do not think that it has anything to do with who has more brains. I believe it is because White men are more confident and will not be looked at the way a [woman of color] would be."

In contrast, men were significantly more likely than women to reference *lack of interest* as a reason for STEM inequity, ($\chi 2$ (1, N=217) = 7.934, p=.005, V=.191). Participants often framed this lack of interest as an incidental contributor to inequity in STEM. For example, Lucas, a Latino man, wrote, "Maybe a great number of White [men] might like these subjects a lot more. It does not mean White [men] are better than women and other People of Color." Likewise, Dylan, a White man, remarked that "Women choose different career paths from men. It's not because they cannot get hired in those fields. It's because they don't want to be; it's because they want to go into other fields." Logan, a White man, spoke from personal experience:

> "I think that it is true due to the fact that many of the White men I know are pursuing careers in those fields. On the other hand, while I have minority friends who are interested in these fields, I have yet to meet a female on campus that is majoring in technology, engineering, or mathematics."

Discussion

The current study provides novel insight into how emerging adults reason about ethnic and gender inequities in STEM domains. Findings revealed that participants varied widely in how they reasoned about STEM inequities. As discussed below, the themes that emerged in participants' responses can inform the development of targeted interventions aimed at increasing diversity in STEM. Consistent with social dominance theory, findings also showed that men were more likely than women to rationalize STEM disparities by focusing on a lack of interest, whereas women were more likely than men to express concern about STEM inequity. Below, we elaborate on these findings and conclude by describing limitations and future directions for research.

Overview of Key Findings

Our coding categories were sorted into two overarching themes—*STEM inequity is a problem* and *STEM inequity is not a problem—*that each had four subcategories. Within *STEM inequity is a problem,* the four subcategories were *fairness, systemic bias, stereotyping,* and *confidence.* Within *STEM inequity is not a problem*, the four subcategories were *lack of interest, merit-based, not unique to STEM,* and *STEM is diverse*. In line with prior research focusing on common causes of ethnic and gender disparities in STEM, we expected participants to mention stereotyping (Carli et al., 2016; Fisher et al., 2000; Gay, 2004; Kuchynka et al., 2018; Smyth & Nosek, 2015), systemic bias (Leaper & Brown, 2008; Reuben et al, 2014; Robnett, 2016), and confidence (Bandura, 1977; Correll, 2001; Eccles et al., 1989; Robnett & Thoman, 2017).

In contrast, several of the emergent coding categories were unexpected. For instance, we were surprised that some participants mentioned that STEM is already diverse, given that we explicitly highlighted the lack of diversity in STEM within the question prompt. In addition, responses that mentioned inequity as not being unique to STEM were unexpected. Further, given that much of the literature on STEM inequity is focused on sexism (e.g., Leaper & Brown, 2008; Robnett, 2016), we were surprised to find that sexism was not explicitly mentioned in the majority of participant responses. Finally, given the abundance of extant literature on agentic versus communal values and their relation to career choice (e.g., Evans & Diekman, 2009), we were surprised that participants did not mention these types of values in their responses. However, it is possible that individuals who attributed ethnic and gender disparities to a lack of interest were influenced by group-based expectations about agentic and communal traits.

Gender Variation. Findings revealed key gender differences in how undergraduates reason about STEM inequities. Specifically, women were significantly more likely than men to mention stereotyping and low confidence as issues that contribute to the gender and ethnic gap in STEM. These results complement research indicating that negative stereotypes about women's math ability can reduce women's identification with STEM domains and lower their motivation to pursue STEM careers (Cundiff, Vescio, Loken, & Lo, 2013; Starr, 2018). The results of the current study also add to a growing body of evidence that cite confidence as integral to the success of girls and women in STEM (Cech, Rubineau, Silbey, & Seron, 2011; Schmader, Johns, & Barquissau, 2004; Stake & Mares, 2001). More specifically, prior research suggests that girls and women – even those who pursue STEM majors – tend to report lower academic confidence than do men with comparable academic performance (Litzler et al., 2014; Moakler & Kim, 2014; Robnett & Thoman, 2017). In contrast, men were significantly more likely than women to mention a lack of interest from women and People of Color as a contributor to inequity in STEM. This finding also aligns with social dominance theory (Sidanius & Pratto, 1999), such that men may justify the status quo by referencing lack of interest in the field as opposed to social justice issues that would necessitate action for change. In other words, if women and People of Color are simply not interested in STEM, then the current inequities in STEM are not a problem and are not worth addressing.

Our findings also indicate that for some participants, attributions for STEM inequities are shaped by stereotypes and other socio-cultural factors, as purported by social role theory (Eagly, 1987). More specifically, women may feel pressure to show less interest in careers that do not align with what is stereotypically perceived as "female." In addition, men are expected to have "innate talent" in math and science, whereas women are not (Leslie, Cimpian, Meyer, Freeland, 2015; Mascret & Cury, 2015; Rattan, Good, & Dweck, 2012; Starr, 2018). These gendered stereotypes and expectations do not go unnoticed, as women are more likely than men to perceive sexism and discrimination (Brown & Bigler, 2004; Hayes &

Bigler, 2012; Robnett & John, 2018). Indeed, they may help explain why women are more likely to generate stereotype-based explanations for STEM inequities.

Ethnic Variation. Findings from the current study also revealed that Latinx participants were significantly more likely to mention stereotyping than were White or Asian American participants. Although Latinx students and Asian American students are collectively considered "People of Color," Latinx students are negatively stereotyped in STEM domains (Gandara & Contreras, 2010), whereas Asian American students are positively stereotyped (Lee, 1994; Trytten, Lowe, & Walden, 2012). In addition, Latinx groups are underrepresented in STEM relative to their proportional representation in the U.S. population, whereas Asian Americans are overrepresented. Specifically, Asian Americans hold 17.4% of STEM occupations, yet make up only 5.7% of the U.S. population. By comparison, Latinx groups hold 6.1% of all STEM occupations, but make up nearly 18% of the U.S. population (NSF, 2018; US Census Bureau, 2017). These statistics, in addition to the variation in stereotype content regarding Asian and Latinx students, may help to explain why Latinx participants were particularly likely to mention stereotyping. More specifically, individuals from underrepresented ethnic groups who are targeted by stereotypes and experience discrimination tend to be more perceptive of stereotypes and prejudice (Brown & Bigler, 2005). For instance, Black and Latinx groups are more likely than White individuals to report experience with discrimination and are more likely to report bias from others (see Brown, 2006).

Our findings pertaining to ethnic variation are also consistent with prior research showing that Latinx students are more likely than students from other ethnic groups to express concern about stereotyping and leave a STEM major in order to avoid stereotyping (McGee, 2016). Further, prior work indicates that negative stereotypes might be particularly harmful for Latina girls and women. For example, when examining what it meant to be “scientific” in a sample of fourth grade students, Carlone, Haun-Frank, and Webb (2011) found that Latina girls were among the students who least identified as “smart science [people],” despite performing comparably to their White classmates in science. In addition, Brown and Leaper (2010) found that Latina adolescents’ math self-efficacy was more negatively impacted by stereotypes about women’s math and science ability than the math self-efficacy of White adolescent girls. More generally, our findings are consistent with extant research suggesting that discrimination is more apparent when directed at groups who do not benefit from favoritism (Rodin, Price, Bryson, & Sanchez, 1990; Verkuyten, 2002). That is, Latinx students tend to be negatively stereotyped in STEM realms (Gandara et al., 2010), and as such may perceive more discrimination in these fields relative to students from other ethnic groups.

Implications for Intervention. Our findings may be useful to scholars who design interventions that aim to foster greater equity in STEM fields. According to Watts and colleagues’ (2003) theory of sociopolitical development, individuals progress at different rates through various stages of acquiring the knowledge, skills, and emotional intelligence to act against oppressive social systems. Consistent with this premise, participants in the current study varied widely in how they reasoned about STEM inequity. Accordingly, interventions that aim to foster greater STEM equity at the undergraduate level may be more effective if they take into account students’ level of sociopolitical development. For example, some participants in the current study were unconcerned about STEM inequities and seemed unaware of systemic biases that women and People of Color encounter in STEM fields. These students may benefit from interventions designed to simply raise their awareness of inequity, bias, and their societal implications. In contrast, other participants had a fairly sophisticated understanding of STEM inequities and their potential causes. These individuals could be targeted with more advanced interventions that encourage action to reduce inequity (e.g., sensitivity training, structured mentoring programs or support groups).

Limitations and Future Directions

The current study should be interpreted in light of several limitations. First, analyses were limited by sample size. A larger sample would allow for analyses examining how reasoning varies by gender and race simultaneously. This type of intersectional analysis would allow researchers to probe subgroups of particular interest (e.g., Latina women; Crenshaw, 1991; Else-Quest & Hyde, 2016). Future research should also obtain data from individuals who do not identify as gender-binary (e.g., trans men and women, gender fluid individuals). The opinions of a nonbinary or transgender individual could differ significantly from those of a cisgender person, as their experiences with gender roles, expectations, and stereotypes are likely unique. Understanding how non-binary individuals reason about inequities in STEM is a crucial component in understanding broader issues of diversity in the field.

Another limitation of the current study is that we did not examine whether participants' response patterns differed by college major. Whereas the STEM workforce has nearly reached gender parity in some fields (e.g., life sciences), math-intensive STEM fields such as physics and astronomy are only 11% women (NSF, 2018). Similarly, although People of Color are underrepresented as a whole across STEM fields, there is significant ethnic variation in patterns of representation in specific STEM subfields (NSF, 2018). Given that ethnic and gender disparities fluctuate from one STEM field to the next, it is plausible that participants in different majors would have different perspectives on STEM inequity.

Next, data were collected from a single university in the U.S. Thus, findings may not generalize to emerging adults from other parts of the U.S. or other countries. Moreover, the sample was largely composed of undergraduates who were early in their college careers.

Future research should investigate the thoughts and reasoning processes of college students who are further along in their majors, as they will have had more time and experience navigating the college environment.

Another limitation lies in the wording of our open-ended prompt. Although the wording of the prompt was intentionally broad to avoid priming, it is possible that we would have obtained more specific information if we had phrased the question differently. For example, it would have been interesting to ask participants about their thoughts regarding agentic and communal values in relation to STEM career attainment. Relatedly, explicitly asking participants about their personal experiences with stereotyping, bias, and low confidence would have provided meaningful information. Although many participants mentioned topics such as confidence or stereotyping when reasoning about inequity in STEM fields, we cannot make inferences about their personal experiences with these challenges. In other words, findings from the current study do not provide insight into whether participants' responses were grounded in personal experience versus more general observations about the world.

A final limitation to the current study is the cross-sectional nature of the data. A longitudinal study that follows students over the course of their entire college career would provide compelling insight into whether their thoughts about STEM inequity change over time. Further, a longitudinal design would also provide insight into whether certain response patterns (e.g., expressing concern about systematic bias in STEM) are associated with action to change the STEM climate. Such a design would facilitate the development of interventions that focus on (a) increasing confidence for women who want to pursue STEM, (b) reducing instances of stereotyping within higher education, and (c) promoting initiatives that educate college students about the importance of diversity and inclusion in the STEM workforce.

Conclusion

The current study not only examines how undergraduates reason about STEM inequities, it also sheds light on how reasoning differs according to participants' ethnicity and gender. Findings replicate and extend existing research in several ways. For instance, with respect to ethnicity, findings suggest that stereotyping may be a unique concern for people from Latinx backgrounds when compared to people from White and Asian American backgrounds. With respect to gender, women's mentions of stereotyping and low confidence reinforce a large body of research documenting these challenges for women who are currently in STEM fields. From a theoretical standpoint, findings are consistent with social role theory, such that widely-held societal expectations for what people "should" do can reinforce stereotypes and biases that impose both real and perceived limits on certain groups, such as women and People of Color. Findings are also consistent with social dominance theory. Specifically, men were more likely than women to explain that patterns of inequity in STEM are caused by "different" interests that steer members of marginalized groups toward fields other than STEM. Collectively, findings illustrate that individuals from diverse backgrounds have distinct concerns about STEM inequity. Understanding these concerns is a vital component of developing targeted interventions that promote greater diversity in STEM fields.

References

American Association of University Women (2010). *Why so few? Women in science, technology, engineering, and mathematics.* Washington, DC: Author

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, 55(5), 469–480. https://doi.org/10.1037/0003-066X.55.5.469

Becker, J. C., & Swim, J. K. (2011). Seeing the unseen: Attention to daily encounters with sexism as way to reduce sexist beliefs. *Psychology of Women Quarterly*, 35(2), 227–242. https://doi.org/10.1177/0361684310397509

Blackwell, L. V., Snyder, L. A., & Mavriplis, C. (2009). Diverse faculty in STEM fields: Attitudes, performance, and fair treatment. *Journal of Diversity in Higher Education*, 2(4), 195–205. https://doi.org/10.1037/a0016974

Brown, C. S., & Bigler, R. S. (2005). Children's perceptions of discrimination: A developmental model. *Child Development*, *76*(3), 533–553. https://doi.org/10.1111/j.1467-8624.2005.00862.x

Brown, C. S. (2006). Bias at school: Perceptions of racial/ethnic discrimination among Latino and European American children. *Cognitive Development*, *21*(4), 401–419. https://doi.org/10.1016/j.cogdev.2006.06.006

Brown, C. S., & Leaper, C. (2010). Latina and European American girls' experiences with academic sexism and their self-concepts in mathematics and science during adolescence. *Sex Roles*, *63*(11–12), 860–870. https://doi.org/10.1007/s11199-010-9856-5

Carli, L. L., Alawa, L., Lee, Y., Zhao, B., Kim, E. (2016). Stereotypes about gender and science: Women ≠ scientists. *Psychology of Women Quarterly*, 40, 244–260. doi:10.1177/0361684315622645

Carlone, H. B., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge- and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. *Journal of Research in Science Teaching*, 48(5), 459–485. https://doi.org/10.1002/tea.20413

Cech, E., Rubineau, B., Silbey, S. & Seron, C. (2011) Professional role confidence and gendered persistence in engineering. *American Sociological Review*, 76,5, 641–66.

Committee on STEM Education, National Science & Technology Council. (2018). *Charting a course for success: America's strategy for STEM education*. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

Correll, S. J. (2001). Gender and the career choice process: The role of biased self-assessments. *American Journal of Sociology*, 106(6), 1691–1730. https://doi.org/10.1086/321299

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*(6), 1241. https://doi.org/10.2307/1229039

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2008-13604-000&site=ehost-live

Cuddy, A. J. C., Fiske, S. T., & Glick, P. (2007). The BIAS map: Behaviors from intergroup affect and stereotypes. *Journal of Personality and Social Psychology*, 92(4), 631–648. https://doi.org/10.1037/0022-3514.92.4.631

Cundiff J. L., Vescio T. K., Loken E., Lo L. (2013). Do gender–science stereotypes predict science identification and science career aspirations among undergraduate science majors? *Social Psychology of Education*, 16, 541–554. doi:10.1007/s11218-013-9232-8

Cundiff, J. L., & Vescio, T. K. (2016). Gender stereotypes influence how people explain gender disparities in the workplace. *Sex Roles: A Journal of Research*, 75(3–4), 126–138. https://doi.org/10.1007/s11199-016-0593-2

Eagly, A. H. (1987). *Sex differences in social behavior: A social-role interpretation.* Hillsdale, NJ: Lawrence Erlbaum Associates, Inc. Retrieved from http://ezproxy.library.unlv.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=1987-97607-000&site=ehost-live

Eccles, J. S., Wigfield, A., Flanagan, C. A., Miller, C., Reuman, D. A., & Yee, D. (1989). Self-concepts, domain values, and self-esteem: Relations and changes at early adolescence. *Journal of Personality*, 57(2), 283–310. https://doi.org/10.1111/j.1467-6494.1989.tb00484.x

Else-Quest, N. M., & Hyde, J. S. (2016). Intersectionality in quantitative psychological research: I. Theoretical and epistemological issues. *Psychology of Women Quarterly*, *40*(2), 155–170. https://doi.org/10.1177/0361684316629797

Evans, C. D., & Diekman, A. B. (2009). On Motivated Role Selection: Gender Beliefs, Distant Goals, and Career Interest. *Psychology of Women Quarterly*, *33*(2), 235–249. https://doi.org/10.1111/j.1471-6402.2009.01493.x

Fisher, C. B., Wallace, S. A., & Fenton, R. E. (2000). Discrimination distress during adolescence. *Journal of Youth and Adolescence,* 29(6), 679–695. https://doi.org/10.1023/A:1026455906512

Freedman-Doan, C., Wigfield, A., Eccles, J. S., Blumenfeld, P., Arbreton, A., & Harold, R. D. (2000). What am I best at? Grade and gender differences in children's beliefs about ability improvement. *Journal of Applied Developmental Psychology*, 21(4), 379–402. https://doi.org/10.1016/S0193-3973(00)00046-0

Gandara, P. C., & Contreras, F. (2010). *The Latino education crisis the consequences of failed social policies*. Cambridge, MA: Harvard University Press.

Gay, G. (2004). Navigating marginality en route to the professoriate: Graduate students of color learning and living in academia. *International Journal of Qualitative Studies in Education*, 17(2), 265–288.

Hayes, A. R., & Bigler, R. S. (2012). Gender-related values, perceptions of discrimination, and mentoring in STEM graduate training. *Science and Technology, 5*(3), 254-280.

Inman, M. L., & Baron, R. S. (1996). Influence of prototypes on perceptions of prejudice. *Journal of Personality and Social Psychology*, 70(4), 727–739. https://doi.org/10.1037/0022-3514.70.4.727

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, 33(7), 14–26. https://doi.org/10.3102/0013189X033007014

Jost, J. T., Banaji, M. R., & Nosek, B. A. (2004). A decade of system justification theory: Accumulated evidence of conscious and unconscious bolstering of the status quo. *Political Psychology*, 25(6), 881–919. https://doi.org/10.1111/j.1467-9221.2004.00402.x

Jost, J. T., & Hunyady, O. (2005). Antecedents and consequences of system-justifying ideologies. *Current Directions in Psychological Science,* 14(5), 260–265. https://doi.org/10.1111/j.0963-7214.2005.00377.x

Jost, J. T., Kay, A. C., & Thorisdottir, H. (2009). *Social and psychological bases of ideology and system justification*. (J. T. Jost, A. C. Kay, & H. Thorisdottir, Eds.). New York, NY: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195320916.001.0001

Kellow, J. T., & Jones, B. D. (2008). The effects of stereotypes on the achievement gap: Reexamining the academic performance of African American high school students. *Journal of Black Psychology*, *34*(1), 94–120. https://doi.org/10.1177/0095798407310537

Koenig, A. M., & Eagly, A. H. (2014). Evidence for the social role theory of stereotype content: Observations of groups' roles shape stereotypes. *Journal of Personality and Social Psychology*, 107(3), 371–392. https://doi.org/10.1037/a0037215

Kuchynka, S. L., Salomon, K., Bosson, J. K., El-Hout, M., Kiebel, E., Cooperman, C., Toomey, R. (2018). Hostile and benevolent sexism and college women's STEM outcomes. *Psychology of Women Quarterly, 42*, 72–87. doi:10.1177/0361684317741889

Landivar, L. C. (2013). Disparities in STEM employment by sex, race, and Hispanic origin. Report, U.S. Department of Commerce/U.S. Census Bureau. Retrieved from: http://www.census.gov/prod/2013pubs/acs-24.pdf.

Leaper, C., & Brown, C. S. (2008). Perceived experiences with sexism among adolescent girls. *Child Development*, 79(3), 685–704. https://doi.org/10.1111/j.1467-8624.2008.01151.x

Lee, S. J. (1994). Behind the model-minority stereotype: Voices of high- and low-achieving Asian American students. *Anthropology & Education Quarterly*, 25(4), 413–429. https://doi.org/10.1525/aeq.1994.25.4.04x0530j

Lent, R. W., Brown, S. D., & Gore, P. A. Jr. (1997). Discriminant and predictive validity of academic self-concept, academic self-efficacy, and mathematics-specific self-efficacy. *Journal of Counseling Psychology*, *44*(3), 307–315. https://doi.org/10.1037/0022-0167.44.3.307

Leslie, S.J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science,* 347: 262–5.

Litzler, E., Samuelson, C. C., & Lorah, J. A. (2014). Breaking it down: Engineering student STEM confidence at the intersection of race/ethnicity and gender. *Research in Higher Education*, 55(8), 810–832. https://doi.org/10.1007/s11162-014-9333-z

Marra, R., Rodgers, K., Shen, D., & Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self-efficacy. *Journal of Engineering Education*. 98. 10.1002/j.2168-9830.2009.tb01003.x.

Mascret, N., & Cury, F. (2015). 'I'm not scientifically gifted, I'm a girl': Implicit measures of gender-science stereotypes—Preliminary evidence. *Educational Studies*, 41(4), 462–465. https://doi.org/10.1080/03055698.2015.1043979

McGee, E. O. (2016). Devalued African-American and Latino racial identities: A by-product of STEM college culture? *American Educational Research Journal*, 53(6), 1626–1662. Retrieved from http://ezproxy.library.unlv.edu/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2017-00458-005&site=ehost-live

Moakler, M. W., & Kim, M. M. (2014). College major choice in STEM: Revisiting confidence and demographic factors. *The Career Development Quarterly*, *62*(2), 128–142. https://doi.org/10.1002/j.2161-0045.2014.00075.x

Morton, T. A., Postmes, T., Haslam, S. A., & Hornsey, M. J. (2009). Theorizing gender in the face of social change: Is there anything essential about essentialism? *Journal of Personality and Social Psychology*, 96(3), 653–664. https://doi.org/10.1037/a0012966

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. P*NAS Proceedings of the National Academy of Sciences of the United States of America*, 109(41), 16474–16479. https://doi.org/10.1073/pnas.1211286109

Moss-Racusin, C. A., Molenda, A. K., & Cramer, C. R. (2015). Can evidence impact attitudes? Public reactions to evidence of gender bias in STEM fields. *Psychology of Women Quarterly*, 39(2), 194–209. https://doi.org/10.1177/0361684314565777

National Science Foundation, National Center for Science and Engineering Statistics [NSF/NCSES]. (2015). Women, minorities, and persons with disabilities in science and engineering: 2015 (Special Report NSF 15–311). Arlington, VA: National Science Foundation. Retrieved from https://www.nsf.gov/statistics/

National Science Foundation (2018). Science and engineering indicators. Retrieved from: https://nsf.gov/statistics/2018/nsb20181/assets/nsb20181.pdf

Oldmeadow, J., & Fiske, S. T. (2007). System-justifying ideologies moderate status = competence stereotypes: Roles for belief in a just world and social dominance orientation. *European Journal of Social Psychology*, 37(6), 1135–1148. https://doi.org/10.1002/ejsp.428

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review*, 81(2), 172-209. doi: 10.17763/haer.81.2.t022245n7x4752v2

Ostergaard, C.R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research Policy, 40,* 500-509.

Quillian, L., Pager, D., Hexel, O., & Midtbøen, A. H. (2017). Meta-analysis of field experiments shows no change in racial discrimination in hiring over time. *Proceedings of the National Academy of Sciences, 114*(41), 10870–10875. https://doi.org/10.1073/pnas.1706255114

Rattan, A., Good, C., & Dweck, C. S. (2012). "It's ok — Not everyone can be good at math": Instructors with an entity theory comfort (and demotivate) students. *Journal of Experimental Social Psychology,* 48(3), 731–737. https://doi.org/10.1016/j.jesp.2011.12.012

Reuben, E., Sapienza, P., & Zingales, L. (2014). How stereotypes impair women's careers in science. *Proceedings of the National Academy of Sciences, 111*(12), 4403–4408. https://doi.org/10.1073/pnas.1314788111

Robnett, R. D. (2016). Gender bias in STEM fields: Variation in prevalence and links to STEM self-concept. *Psychology of Women Quarterly, 40,* 65-79. https://doi.org/10.1177/0361684315596162

Robnett, R. D., & John, J. E. (2018). It's wrong to exclude girls from something they love. Adolescents' attitudes about sexism in science, technology, engineering, and math. *Child Development*. Published online ahead of print. https://doi.org/10.1111/cdev.13185

Robnett, R. D., & Thoman, S. E. (2017). STEM success expectancies and achievement among women in STEM majors. *Journal of Applied Developmental Psychology, 52*, 91-100. https://doi.org/10.1016/j.appdev.2017.07.003

Rodin, M. J., Price, J. M., Bryson, J. B., & Sanchez, F. J. (1990). Asymmetry in prejudice attribution. *Journal of Experimental Social Psychology*, 26(6), 481–504. https://doi.org/10.1016/0022-1031(90)90052-N

Rowley, S. J., Kurtz-Costes, B., Mistry, R., & Feagans, L. (2007). Social status as a predictor of race and gender stereotypes in late childhood and early adolescence. *Social Development*, *16*(1), 150–168. https://doi.org/10.1111/j.1467-9507.2007.00376.x

Schmader, T., Johns, M., & Barquissau, M. (2004). The costs of accepting gender differences: The role of stereotype endorsement in women's experience in the math domain. *Sex Roles: A Journal of Research*, 50(11–12), 835–850. https://doi.org/10.1023/B:SERS.0000029101.74557.a0

Schmaling, K. B., Blume, A. W., Engstrom, M. R., Paulos, R., & De Fina, S. (2017). The leaky educational pipeline for racial/ethnic minorities. In A. M. Czopp & A. W. Blume (Eds.), *Social issues in living color: Challenges and solutions from the perspective of ethnic minority psychology: Societal and global issues., Vol. 2.* (pp. 103–122). Santa Barbara, CA: Praeger/ABC-CLIO.

Seiffge-Krenke, I., Luyckx, K., & Salmela-Aro, K. (2014). Work and love during emerging adulthood: Introduction to the special issue. *Emerging Adulthood*, 2(1), 3–5. https://doi.org/10.1177/2167696813516091

Sekaquaptewa, D., Espinoza, P., Thompson, M., Vargas, P., & von Hippel, W. (2003). Stereotypic explanatory bias: Implicit stereotyping as a predictor of discrimination. *Journal of Experimental Social Psychology*, 39(1), 75–82. https://doi.org/10.1016/S0022-1031(02)00512-7

Sidanius, J., & Pratto, F. (1999). *Social dominance: An intergroup theory of social hierarchy and oppression*. New York, NY: Cambridge University Press. https://doi.org/10.1017/CBO9781139175043

Smyth, F. L., Nosek, B. A. (2015). On the gender–science stereotypes held by scientists: Explicit accord with gender-ratios, implicit accord with scientific identity. *Frontiers in Psychology*, 6, 1–19. doi:10.3389/fpsyg.2015.00415

Spears Brown, C., & Bigler, R. S. (2004). Children's perceptions of gender discrimination. *Developmental Psychology*, 40(5), 714–726. https://doi.org/10.1037/0012-1649.40.5.714

Stake, J. E., & Mares, K. R. (2001). Science enrichment programs for gifted high school girls and boys: Predictors of program impact on science confidence and motivation. *Journal of Research in Science Teaching*, 38(10), 1065–1088. https://doi.org/10.1002/tea.10001

Starr, C. R. (2018). 'I'm not a science nerd!': STEM stereotypes, identity, and motivation among undergraduate women. *Psychology of Women Quarterly*, 42(4), 489–503. https://doi.org/10.1177/0361684318793848

Trytten, D. A., Lowe, A. W., & Walden, S. E. (2012). "Asians are good at math. What an awful stereotype": The model minority stereotype's impact on Asian American engineering students. *The Journal of Engineering Education*, 101, 439–468. 10.1002/j.2168-9830.2012.tb00057.x

Tsui, L. (2007). Effective strategies to increase diversity in STEM fields: A review of the research literature. *The Journal of Negro Education, 76*, 555-581.

Verkuyten, M. (2002). Perceptions of ethnic discrimination by minority and majority early adolescents in the Netherlands. *International Journal of Psychology*, 37(6), 321–332. https://doi.org/10.1080/00207590244000142

Wang, M. T., & Degol, J. L. (2016). Gender Gap in Science, Technology, Engineering, and Mathematics (STEM): Current Knowledge, Implications for Practice, Policy, and Future Directions. *Educational Psychology Review*, *29*(1), 119-140. doi:10.1007/s10648-015-9355-x

Watts, R. J., & Abdul-Adil, J. K. (1997). Promoting critical consciousness in young, African-American men. *Journal of Prevention & Intervention in the Community*, 16(1–2), 63–86. https://doi.org/10.1300/J005v16n01_04

Watts, R. J., Griffith, D. M., & Abdul-Adil, J. (1999). Sociopolitical development as an antidote for oppression—theory and action. *American Journal of Community Psychology*, 27(2), 255–271. https://doi.org/10.1023/A:1022839818873

Watts, R. J., Williams, N. C., & Jagers, R. J. (2003). Sociopolitical development. *American Journal of Community Psychology*, 31(1–2), 185–194. https://doi.org/10.1023/A:1023091024140

Table 2.1: Overview of Demographic Frequencies in Sample

Demographic	*n*	Percentage (%)
Gender		
Male	135	39.5%
Female	195	57%
Nonbinary	1	<1%
Undisclosed	11	3%
Ethnicity		
White	112 (63% Female)	32.5%
Hispanic/Latinx	84 (63% Female)	24.6%
Asian/Pacific Islander	65 (43% Female)	19%
African-American	38 (61% Female)	11%
Other	29 (66% Female)	8.5%
Native American	2 (100% Female)	<1%
Undisclosed	12 (8% Female)	3.5%
Age		
18-25	310	91%
25+	21	6%
Undisclosed	11	3%
Major		
STEM Major	125	37%
Non-STEM Major	217	63%
Year in School		
First Year	137	40%
Second Year	84	25%
Third Year	71	21%
Fourth Year	34	10%
Other	4	<1%
Bachelor's Degree	2	<1%
Undisclosed	10	3%

Table 2.2: Overview of Participants' Reasoning About Whether STEM Inequity is a Serious Problem

Themes and Coding Categories	Sample Responses	Percentage of Responses %
STEM Inequity Is a Problem		**75%**
Fairness	"I think that everyone deserves a chance to be a part of a field of their interest. I don't think that anyone deserves to be or should be underrepresented in anything."	40%
Systemic Bias	"I think it is because of the funds and money white families have. It lets the men have a good education."	30%
Stereotyping	"I think the stereotype that men are better in these fields makes women less likely to go into these fields because they believe that stereotype. I think women are just as capable as men to be represented in these fields, but it is common for people to conform to stereotypes."	16%
Confidence	"I do not think that it has anything to do with who has more brains. I believe it is because white men are more confident and will not be looked at the way colored women would be."	7%
STEM Inequity Is Not a Problem		**25%**
Lack of Interest	"Well, being there are more white males in general that makes sense, but also you need more people that are on the underrepresented side to be interested in those subjects."	11%
Merit-Based	"I think as long as those who are fit for the job receive the job, there should not be any problems with that."	8%
STEM is Diverse	"I find this very odd because I have noticed an increasing number of diversities in those areas."	5%
Not Unique to STEM	"This reflects broader institutional racism and sexism, which is not particular to STEM fields."	2%

Table 2.3: Overview of Chi-Square Results by Ethnicity

	Total *N* = 179		White		Asian		Latinx		
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*χ2*
Theme 1									
Fairness	72	40	35	20	18	10	19	10	2.28
Systemic Bias	49	27	25	14	10	5	14	8	.642
Stereotyping	32	18	11	6	4	2	17	10	7.77*
Confidence	14	8	6	3	3	2	5	3	.92
Theme 2									
Lack of Interest	19	11	9	5	2	1	8	5	1.77
Merit-Based	13	7	8	4	3	2	3	1	1.97
STEM is Diverse	9	5	3	2	5	3	1	<1	6.93
Not Unique to STEM	4	2	2	1	0	0	2	1	1.27

Note: *p < .05, ** p < .01.

Table 2.4: Overview of Chi-Square Results by Gender

	Total *N* = 217		Males		Females		
	n	%	n	%	n	%	χ2
Theme 1							
Fairness	86	40	33	15	53	25	.175
Systemic Bias	65	30	26	12	39	18	.000
Stereotyping	34	16	7	3	27	13	6.39*
Confidence	16	7	2	1	14	6	5.48*
Theme 2							
Lack of Interest	24	11	16	7	8	4	7.93**
Merit-Based	18	8	7	3	11	5	.012
STEM is Diverse	10	5	5	2.5	5	2.5	.428
Not Unique to STEM	5	2	4	2	1	<1	3.39

Note: *p < .05, ** p < .01.

Chapter 3: Manuscript 1 Summary & Bridge

Kent et al. (2020) employed a mixed methods approach to better understand how college students think and reason about STEM inequities. Findings highlight not only substantial variation in how undergraduate students qualitatively reason about these inequities, but also that there are differences in this reasoning based on both race and gender. For instance, women were more likely than men to note stereotyping and low confidence as reasons for gender and ethnic STEM disparities. Men, on the other hand, were significantly more likely than women to note lack of interest as a reason for STEM inequities. Importantly, the findings from this study not only confirm prior work on possible explanations for STEM inequities (e.g., Cundiff et al., 2013; Robnett & Thoman, 2017), they also build upon this work by affording a more detailed understanding of individual reasoning around the issue. However, a limitation of this research was that it explored reasoning about STEM inequities broadly, and it was not clear whether participants' responses were guided by their own personal experiences with STEM. As such, John et al. (2020) sought to investigate how personal experiences with math might influence math outcomes and plans for the future. More specifically, the authors explored how narrative recollection and interpretation of a past math experience might be related to current math outcomes and future plans to pursue math.

Chapter 4: Memories of Math: Narrative Predictors of Math Affect, Math Motivation, and Future Math Plans

Jennifer E. John
University of Nevada, Las Vegas

Paul A. Nelson
University of Nevada, Las Vegas

Brittany Klenczar
University of Nevada, Las Vegas

Rachael D. Robnett
University of Nevada, Las Vegas

Abstract

This mixed-methods study focuses on narratives that undergraduates tell about pivotal moments (i.e., turning points) in their prior history with math. A key objective was to examine whether these turning points would be associated with participants' current math attitudes and future plans with math. Undergraduate participants (N = 210) completed quantitative measures assessing math anxiety, math self-expectancy, and math value, and also wrote narratives about a turning point with math and their future math plans. Thematic analysis revealed four themes in the math turning point narratives: (1) redemption, (2) contamination, (3) consistently positive, and (4) consistently negative. Quantitative analyses indicated that participants who wrote consistently positive narratives reported significantly higher math self-expectancy and math value relative to participants who wrote other types of narratives. Further, participants who wrote consistently negative turning point narratives were more likely to indicate that they would avoid math in the future. These results suggest that an individual's memory of their early math experiences can color their math attitudes and plans for pursuing math in the future, even years after the experience has occurred. Implications for math education are discussed.

Keywords: Expectancy-Value Theory, Math Anxiety, Math, STEM Education, Student Narrative

Introduction

In a world that is increasingly driven by scientific and technological innovation, literacy in the domains of science, technology, engineering, and math (STEM) is quickly becoming a basic job requirement and a necessity for daily life functioning (U.S. Committee on STEM Education, 2018). Math education is an important component of STEM literacy. For example, math performance and course-taking during high school are closely associated with matriculation into STEM college majors (Crisp, Nora, & Taggart, 2009; Douglas & Attewell, 2017). Accordingly, it is concerning that U.S. students tend to lag behind their counterparts in other countries in terms of math performance (U.S. Committee on STEM Education, 2018). Moreover, for many students, math interest wanes over the course of their education (e.g., Watt, 2004). Correcting these issues requires a deeper understanding of formative educational experiences that shape students' orientation toward math.

The current study takes an innovative approach to understanding the forces that lead students toward and away from math. Specifically, we asked undergraduates to describe their "math life story" with the goal of identifying critical incidents—or turning points—that had a pivotal influence on their orientation toward math. Then we examined whether different themes in participants' narratives were associated with variation in their math affect and math motivation as well as their future math plans. Our approach was motivated by theory and research indicating that appraisals of past academic experiences play a critical role in shaping academic and career decision-making. Below, we elaborate on this body of work. We also discuss life story narratives and summarize prior work indicating that turning points in these narratives are often associated with meaningful life outcomes.

Math Affect and Motivation

The current study focuses on affective and motivational constructs that are central to math achievement and engagement: math anxiety, math self-expectancy, and math value. An abundance of research links these constructs to math performance, math engagement, and career decision-making (for reviews, see Beilock & Maloney, 2015; Wang & Degol, 2013). Importantly, math anxiety, math-self-expectancy, and math value are distinct from math competence. For instance, a student who is competent in math may nonetheless show low math motivation or have a negative affective reaction to math (Ashcraft & Kirk, 2001; Eccles, 2009; Faust, Ashcraft & Fleck, 1996; Wang, Degol, & Ye, 2015).

Although math anxiety, math self-expectancy, and math value are rarely studied together, Meece, Wigfield, and Eccles (1990) found that higher math anxiety was directly related to reduced math self-expectancy and value, which in turn predicted lower math achievement and a lower likelihood of enrolling in future math courses. This implies that affective and motivational factors work together to shape students' pursuit of math. Below, we provide additional background about these constructs and discuss their theorized origins.

Math anxiety. *Math anxiety* is a fear or tension that occurs with the prospect of doing math (Ashcraft & Moore, 2009; Richardson & Suinn, 1972). This reaction can range from mild to severe and can occur in formal math settings (e.g., math classrooms), more casual settings (e.g., balancing a checkbook), or both. Math anxiety is associated with reduced math achievement scores and a variety of negative outcomes, including an aversion to math (Ashcraft, 2002). Math anxiety is also related to more negative personal views of math. For instance, Hembree (1990) found that higher math anxiety was related to less enjoyment of math, lower math confidence, less motivation in math, and overall more negative attitudes towards math. Math anxiety is also related to a lesser intent to pursue math classes and math-intensive college majors or careers (Ma, 1999). The tendency for math (vs. other academic subjects) to elicit anxiety likely originates in part from math achievement functioning as a vital gatekeeper for STEM college majors and higher education more generally (Douglas & Attewell, 2017; Crisp et al., 2009).

Math self-expectancy and value. The current study also focuses on math self-expectancy and math value, which are core components of expectancy value theory of achievement motivation (Wigfield & Eccles, 2000). *Math self-expectancy* reflects the degree to which a person anticipates being successful in math-related endeavors, whereas *math value* reflects the degree to which a person perceives math-related pursuits as important, interesting, or useful for their future plans. Expectancy value theory posits that individual pursuit of, persistence in, and performance on a given activity, math in this case, is explained by the person's self-expectancies and values surrounding the activity (Eccles, 1983). Indeed, research consistently shows that students with higher math self-expectancy and math value are more likely than other students to pursue math in the future (e.g., Musu-Gillette et al., 2015; Lauermann, Tsai, & Eccles, 2017).

Origins of math affect and motivation. Research focusing on math anxiety was initially guided by Richardson and Suinn's (1972) early work on the validation of a measure for math-specific anxiety, whereas research focusing on math expectancies and values has historically been guided by the expectancy-value model of achievement motivation (Eccles, 1983; Wigfield & Eccles, 2000; Eccles & Wang, 2016). Although these two theoretical traditions have important differences, they parallel one another in key ways. Of particular relevance, both propose that prior experiences surrounding math inform people's current math affect and math motivation. For instance, Ramirez, Shaw, and Maloney (2018) suggest that math anxiety and its consequences stem from an individual's interpretation of their math experiences over time. Derived from emotion appraisal theories (see Reisenzein, 2006), this interpretation account proposes a cycle that perpetuates the development and maintenance of math anxiety. For example, a present or looming math task that seems too difficult to successfully complete will elicit anxiety for an individual. This anxiety then leads to reduced performance on the task, which in turn confirms the individual's initial anxieties and leads to their future avoidance of math. Indeed, several studies show that student perceptions of their own math abilities are better predictors of future math anxiety and math confidence than is their actual math performance (Ahmed, Minnaert, Kuyper, & van der Werf, 2012; Meece et al., 1990). This pathway is also portrayed clearly in the expectancy-value model (see Wigfield & Eccles, 2000), which proposes that interpretations of prior math experiences have downstream implications for math self-expectancy and math value. More specifically, expectancies and values are influenced by a variety of social-cognitive factors, which include interpretations of prior experiences of success or failure and perceptions of past reinforcement or negative feedback (Wigfield & Eccles, 2000). As such, the impact of early math experiences is thought to be transmitted through youths' appraisals of these experiences. To our knowledge, however, these pathways have received relatively little attention in research that seeks to unearth the origins of math affect and motivation. Indeed, in a recent review, Muenks, Wigfield, and Eccles (2018) argued that these pathways merit greater attention in future research.

Life Story Narratives: Looking to the Past to Understand the Present and Future

In the current study, we leverage life story narratives to better understand the origins of math affect, math motivation, and future math plans. Narratives are the retelling of salient past experiences in a manner that conveys meaning to the author and listener (Brunner, 1990). These narratives enable individuals to extract meaning from past experiences in ways that shape their identity as well as their current and future pursuits (McAdams & McLean, 2013; McLean, 2005). This is because the process of constructing and sharing life story narratives enables individuals to consolidate the past, understand the present, and integrate an understanding of the self into a meaningful anticipation of the future (McAdams, 2001). Put differently, creating a life story is a form of self-reflection, which is a vital component of personal growth (Bandura, 1986). As such, life story narratives about math provide a unique vantage point from which researchers can explore links between people's appraisals of prior math experiences (i.e., self-reflection), their current orientation toward math, and their future math plans. Although pathways linking these constructs are depicted in theoretical models of academic decision-making (e.g., Wigfield & Eccles, 2000), they have received surprisingly little attention in empirical research (see Muenks et al., 2018).

Life story narratives specific to math have been the focus of several qualitative studies in the field of education (for a review, see Towers, Hall, Rapke, Martin, & Andrews, 2017). For example, Di Martino and Zan (2011) used math life stories to illuminate vivid connections between primary, middle, and high-school students' emotional disposition toward math, their vision of mathematics as instrumental or relational, and their perceived math competence. Several studies have also descriptively identified the important role of teachers and family in contributing to a positive or negative math life story (Ellsworth & Buss, 2000; LoPresto & Drake, 2005). Another common theme in the narrative math education literature pertains to students' subjective experiences of feeling isolated or not belonging in math classes (e.g., Solomon, 2007). Collectively, these studies illustrate that life story narratives can be used to provide meaningful insight into math-related outcomes.

In their review of math narrative research, Towers et al. (2017) observed that most prior work focuses on preservice teachers and subsequently called for research that focuses on students from other academic backgrounds. Accordingly, the current study focused on math life story narratives among undergraduates from a variety of academic majors. Participants were in the developmental period of emerging adulthood, which occurs during the third decade of life (Arnett, 2000). Due to a convergence of cognitive and social-contextual factors, emerging adulthood is an ideal time to solicit narratives about specific academic subjects such as math. From a cognitive standpoint, telling thematically coherent narratives requires high-level cognitive abilities (e.g., abstract thinking; meta-cognition) that are often not fully developed until emerging adulthood (Habermas & Bluck, 2000; McLean, 2008). From a social-contextual standpoint, emerging adulthood is a time of intensive identity exploration, particularly with respect to academic and career pathways (Arnett, 2000; Habermas & Bluck, 2000; McAdams, 2001; Schwartz, Zamboanga, Luyckx, Meca, & Ritchie, 2013). For these reasons, life story narratives about math are likely to be particularly illuminating when told during emerging adulthood.

Turning points in life story narratives. Research examining life story narratives often focuses on a person's entire life story, which includes low points and high points, challenges, values, and future goals (McAdams, 2008). However, *turning points* (i.e., significant moments of transition) in life stories may be particularly relevant to the identity formation processes that characterize emerging adulthood (Bruner, 1994; McLean & Pratt, 2006). Turning points in a life story are characterized by clear shifts in a person's emotional tone. McAdams and Bowman (2001) described these emotional shifts as narrative sequences of redemption or contamination. *Redemption* occurs when a person narrates a turning point in a way that begins negatively, but ends on a positive note. Redemptive stories typically involve experiences of personal sacrifice, illness, relational growth, achievement, and wisdom. For example, a student who works hard to overcome math anxiety and eventually earns an A on a math exam is exhibiting a redemptive story. In contrast, *contamination* occurs when a good experience is later undermined in some way to become negative. Contamination stories typically involve experiences of failure, betrayal, and accidents. For example, a student whose enthusiasm for math deteriorates after a negative experience with a math teacher is exhibiting a contamination story. Prior research has linked redemptive stories to positive outcomes such as heightened wellbeing and self-esteem (Bauer, McAdams, & Pals, 2008; Dunlop & Tracy, 2013; McAdams, Reynolds, Lewis, Patten, & Bowman, 2001).

In contrast, contamination stories tend to be associated with psychological challenges such as depression and distress (Adler & Poulin, 2009; McAdams et al., 2001).

Correlates of life story narratives. A key objective of the current research was to examine whether participants who narrated different math turning points differed from one another in other regards as well. First, we tested for variation on the basis of ethnicity and gender. People of Color and women more generally are underrepresented in math-intensive fields (AAUW, 2008; NSF, 2016), and many who do pursue math report that they encounter stereotypes about their math ability (e.g., AAUW, 2008; Robnett, 2016; Williams, Phillips, & Hall, 2014). Given these negative experiences, we anticipated that People of Color and women may be more likely than White participants and men to narrate turning points with a negative valence (e.g., contamination sequences). Second, we tested for associations between turning point narratives and participants' current math affect and motivation (i.e., mean values of math anxiety, math self-expectancy, and math value) and their future plans in math. As noted earlier, math affect and motivation are shaped by appraisals of past math experiences (e.g., Wigfield & Eccles, 2000). Hence, we anticipated that people who narrated turning points with a positive valence (e.g., redemption sequences) would tend to report more positive math affect and greater motivation, whereas people who narrated turning point narratives with a more negative valence (e.g., contamination sequences) would tend to report more negative math affect and less motivation. By the same token, we also expected that turning points with a consistently positive valence would be associated with greater enthusiasm for pursuing math in the future, whereas we anticipated the reverse pattern for turning points with a consistently negative valence.

A Mixed-Methods Approach

Prior work focusing on math narratives often relies on purely qualitative methods (see Towers et al., 2017). The current study builds on this work through a mixed-methods design.

This approach confers several advantages over purely qualitative or purely quantitative research (see McCrudden, Marchand, & Schutz, 2019). By leveraging a mixture of both qualitative and quantitative methods, researchers can enhance the strengths and minimize the weaknesses of these methods within a single study. This can contribute to a more thorough understanding of the data and, correspondingly, heightened confidence in the findings (McCrudden et al., 2019). The specific mixed-methods approach taken in the current study aligns with Creswell's (2014) sequential mixed-methods design. That is, we first used qualitative data to identify themes in participants' math turning points. We then turned to quantitative data to examine whether these themes were associated with meaningful, theoretically grounded correlates.

Current Study

The current study is focused on turning points that participants narrate when reflecting on their prior history with math. The overarching objective is to provide deeper insight into how appraisals of prior experiences in math relate to current math affect, current math motivation, and future math plans. Prior research indicates that turning points can often be characterized in terms of redemption or contamination sequences (see McAdams & Bowman, 2001), but little work has examined whether these sequences emerge in academic life stories. Accordingly, Research Question 1 is as follows: *How do participants narrate key turning points in their math life stories?* Our coding process had two components. Specifically, we began by examining the circumstances surrounding participants' turning points in math (i.e., turning point content areas). The purpose of this preliminary step was to contextualize the narrative sequences that participants produced, which were the primary focus of the current study. Although we anticipated that redemption and contamination sequences would characterize at least some narratives, we also coded for emergent themes with the goal of capturing the full scope of narrative sequences.

The current study also examines whether participants who narrated their turning points in different ways (e.g., redemption vs. contamination sequences) differed from one another in other regards as well. First, the research detailed above suggests that People of Color and women more generally experience unique challenges in math-intensive domains (e.g., Williams et al., 2014), which may play a role in the narrative sequences that characterize their turning points. Therefore, Research Question 2 is as follows: *Do narrative sequences such as redemption and contamination vary in prevalence depending on participants' ethnicity or gender?* Second, prior work indicates that current math affect, math motivation, and future math plans are shaped by prior math-related experiences and appraisals of these experiences (e.g., Ramirez et al., 2018; Wigfield & Eccles, 2000). Hence, analyses also addressed the following questions: *Are narrative sequences associated with math anxiety, math self-expectancy, or math value?* (Research Question 3) and *Are narrative sequences associated with participants' plans for pursuing math in the future?* (Research Question 4).

Method

Participants

Participants were recruited from a large, public, R1 university in the Southwestern U.S. The median family income for students at this university is similar to that of students from other selective public colleges in the region and the U.S. (The New York Times, 2017). A total of 373[2] undergraduates participated in an online survey for course credit during the spring semester of 2018. All participants were enrolled in introductory psychology, a popular general education course taken by students broadly, regardless of major. Nearly all participants (91%) were between the ages of 18 and 24. Forty-four percent of the sample

[2] All narrative analyses focus on a subset of 210 participants who provided substantive responses to the narrative questions.

indicated that they were first-generation college students. The sample included 245 women (66%), 124 men (33%), two transgender men (.5%), and two participants (.5%) who elected not to disclose their gender. With respect to ethnic background, 136 participants (36%) identified as White, 99 participants (27%) identified as Hispanic/Latinx, 79 participants (21%) identified as Asian/Pacific Islander, 38 participants (11%) identified as African American/Black, 12 participants (2%) identified as multi-racial, four participants (1%) identified as Native American/American Indian, three participants (1%) identified as "other," two participants (0.5%) identified as Middle Eastern, and one participant (0.5%) elected not to disclose their ethnic background. Multi-racial participants who identified with ethnic groups that are both underrepresented and overrepresented in STEM (e.g., African American/Black and White) were grouped into the underrepresented category.

Procedure

Participants were recruited for an online survey through the university's introductory psychology subject pool. All participants provided consent before beginning the survey. The survey included a short demographic questionnaire; scales assessing both academic (e.g., math anxiety) and non-academic (e.g., resilience) constructs; and open-ended questions pertaining to participants' math-related experiences. Below, we elaborate on the measures used in the current study. We begin by describing our method of eliciting turning points narratives as well as the corresponding qualitative coding process. Then we detail the constructs that we expected to correlate with the turning points themes (i.e., math anxiety, math expectancy, math value, and future math plans).

Math Turning Points

To assess turning points in participants' math life stories, we developed a math-specific version of McAdams' (2008) Life Story Interview. The full instructions for this portion of the survey are presented in Appendix 4A. The instructions began by encouraging participants to think about their relationship with math over the course of their lives as if it were a novel that contained several key chapters or scenes. Then participants were prompted to consider key turning points in their relationship with math:

> In looking back over your life and relationship to math, it may be possible to identify certain key moments that stand out as turning points—episodes that marked an important change in your relationship to math. Please identify a particular episode in your life story that you now see as a turning point in your relationship to math.

To code the data, we followed the steps for thematic analysis outlined by Braun and Clarke (2006). The first and second authors began by reading the full corpus of data and developing a coding manual through a blend of deductive (i.e., theory-driven) and inductive (i.e., data-driven) methods. The deductive coding was guided by McAdams' (1998, 1999) narrative conceptualization of redemption and contamination sequences in which emotional states shift from negative to positive (redemption) or from positive to negative (contamination). In addition to coding these *valence sequences*, we also inductively coded the *content* of participants' turning point stories with the goal of providing deeper insight into the context surrounding participants' turning points. After the coding manual had been revised several times, the second author and a trained research assistant used the manual to separately code 20 percent of the responses. Interrater reliability, which was indexed by Cohen's kappa (K) and Percentage of Agreement (PA), was high for both narrative sequence (K = .84, PA = 88%) and narrative content (K = .85, PA = 91%). After achieving interrater reliability, the two coders separately coded all of the remaining data. An additional test of interrater reliability on 10 percent of the remaining data indicated that agreement remained high throughout the coding process for narrative sequences (K = .82, PA = 87%) and narrative content (K = .87, PA = 91%). Coders resolved the few disagreements through consensus.

With respect to the narrative content of participants' turning points, the coding process yielded four mutually exclusive themes: (1) *Academic Performance,* wherein participants referred with pride or despair to very good or very poor outcomes on a math test or in a math course; (2) *Relevance*, wherein participants either emphasized or questioned the importance of math to their everyday life, career, or understanding of the world; (3) *Receiving help*, wherein participants gave accounts of teachers, tutors, friends, or parents who either helped or hindered their ability to excel in math; and (4) *Study Habits*, wherein participants attributed their relationship with math to good or poor study habits and their own motivation levels.

Our primary focus, however, was the narrative sequences that participants produced. As summarized in Table 4.1, the coding process yielded four mutually exclusive themes: (1) *Redemption*, in which the participant's relationship with math changed from negative to positive following a pivotal experience; (2) *Contamination*, in which the participant's relationship with math changed from positive to negative following a pivotal experience; (3) *Consistently Positive*, in which the participant reported a consistently positive relationship with math; and (4) *Consistently Negative*, in which the participant reported a consistently negative relationship with math.

Turning Points Correlates

Math anxiety. Math anxiety was assessed using the abbreviated math anxiety scale (Hopko et al., 2003). This nine-item measure asked participants to indicate how much anxiety various math scenarios would cause them. Scenarios include "Thinking about an upcoming math test the day before" and "Starting a new chapter in a math book." Items are rated on a scale from 1 (*low anxiety*) to 5 (*high anxiety*), with higher scores indicating higher math anxiety. The measure had excellent internal reliability ($\alpha = .91$).

Math self-expectancy. Math self-expectancy was assessed using the corresponding scale from the math specific expectancy-value measure (Watt et al., 2012). This nine-item measure asks participants to rate their agreement with items on a scale from 1 (*disagree* *strongly*) to 6 (*strongly agree*). Sample items include "I am better at math than I am at other academic subjects" and "I think I will do well in my math courses this semester." Higher scores indicate higher math self-expectancy. This scale had excellent internal reliability ($\alpha =$ .92).

Math value. Math value was assessed using the corresponding scale from the math specific expectancy-value measure (Watt et al., 2012). This six-item measure asks participants to rate their agreement with items on a scale from 1 (*disagree strongly*) to 6 (*strongly agree*). Sample items include "I find it interesting to work on math projects and assignments" and "What I learn in math is useful for my daily life outside of school." Higher scores indicate higher math value. This scale had good internal reliability ($\alpha = .82$).

Future math plans. Participants' plans for using math in the future were assessed in an open-ended format. As with the turning points data, we elicited responses through a math-specific version of McAdams' (2008) Life Story Interview (see Appendix 4A). After reflecting on their prior history with math, participants responded to the following prompt:

> Your relationship to math includes key chapters and scenes from your past, as you have described them, and it also includes how you see or imagine your future. Please describe what you see to be the next chapter in your life with respect to math. For example, in what ways, if at all, do you expect to study or use math in your future life? What emotions or thoughts do you expect to experience and associate with math in the future? Do you expect your relationship to math will change, or stay the same?

To code future math plans, we used an inductive approach that relied on the responses of the participants to generate themes (see Braun & Clarke, 2006). After developing the coding manual, the lead author and a trained research assistant double-coded 20 percent of the responses. They achieved high inter-rater reliability (K = .81, PA = 88%) and proceeded to separately code the remaining data. An additional test of interrater reliability on 10 percent of the remaining data indicated that agreement remained high throughout the coding process (K = .79, PA = 86%). Coders resolved the few disagreements through consensus.

As summarized in Table 4.2, the coding process yielded three mutually exclusive themes in participants' future math plans: (1) *Willingly Pursue Math*, in which participants reported in an emotionally positive or neutral manner a specific way they would use math in the future (e.g., using math in their career); (2) *Reluctantly Pursue Math*, in which participants reported in an overtly negative manner a specific need to continue taking math classes or use math in their careers despite their strong dislike of math; and (3) *Avoid Math*, in which participants described both not planning to use math in the future and a desire to not use math.

Results

Findings are presented in three sections. We begin by describing how participants narrated their math turning points (Research Question 1), with a particular focus on the narrative sequences (e.g., redemption; contamination) that participants produced. Then we present preliminary analyses that tested for ethnic and gender differences in math affect (i.e., math anxiety), math motivation (i.e., math self-expectancy and math value), and future math plans. Last, we present quantitative analyses that assessed whether the turning point narrative sequences varied on the basis of ethnicity and gender (Research Question 2), math affect and motivation (Research Question 3), and future math plans (Research Question 4). Cohen's (1988) heuristics are used when discussing small (.10 to .30), medium (.30 to .50), and large (.50+) effect sizes for Cramer's V. With respect to partial eta squared, Cohen's effect size ranges correspond to values of .01 to .06 (small), .06 to .14 (medium), and .14+ (large; Lenhard & Lenhard, 2016).

Math Turning Points

The first aim of the current study was to examine the degree to which turning points in participants' math life stories were characterized by redemption or contamination sequences (Research Question 1). Most participants provided rich math turning point narratives (56%, n = 210; 65% female). Of these participants, over half (n = 112) told redemptive turning point stories, making it the most common narrative form. The other three turning point sequences of contamination, consistently positive, and consistently negative were equally distributed at approximately 15% each. Table 4.1 presents descriptive statistics and examples of the four turning point sequences.

Most participants (73%) situated their math turning points within the following content experiences: Help (38%); Performance (27%); Study Habits (23%); and Relevance (12%). Participants whose turning points were not coded for content did not elaborate enough to code or provided vague and mixed responses. Of note, these content domains were not significantly associated with the different narrative sequences, X^2 (9, N = 154) = 6.941, p = .643, V = .123). Below, we draw from these content domains to contextualize the narrative sequences that participants provided when describing their turning points in math.

Change through redemption or contamination. Participants who told redemptive or contaminated narratives often experienced similar math events quite differently. For example, Jenny and Andrea both referenced turning points related to poor math performance. Jenny's redemptive narrative explains, "A turning point was after I got the C in honors Algebra in high school, and then dropped down to regular Algebra. After getting that C, it motivated me to never do that bad ever again. From then on, I have gotten an A in every math class. [I got an] A in 2nd semester Trigonometry, Algebra II, Statistics, and Math 124." Jenny's account suggests that poor performance motivated her to study more, resulting in future success. In contrast, Andrea's contamination narrative describes poor performance that motivated her to abandon prior plans: "Because I didn't score as high on my math portion of the ACT, which I thought was a reflection of my overall knowledge, I did not major in computer science like I originally wanted to since it is very math intensive. I think that this event hurt my confidence in math and shaped my future." Like Jenny and Andrea, participants typically framed unexpected math failures as either (a) an indication that they needed to work harder at math (Jenny) or (b) an indication that they were categorically bad at math (Andrea). These two different appraisals seemed to divert participants along two very different paths.

Courtney and Chelsea showed a similar contrast when describing the role of teachers. For example, Courtney described a redemptive experience that was sparked by a good tutor: “A key turning point in my relationship to math was when I got a tutor. This was important because it helped my math skills dramatically. My tutor was very knowledgeable and explained everything to me step by step. My grade in my math class got a lot better after getting a tutor. I remember feeling more confident in my math skills and it started to come to me easier. I think this says that when I know I'm struggling with something I'm not afraid to get help.” In contrast, Chelsea’s contamination story attributed her disengagement from math to a poor teacher. Specifically, she explained, “A math turning point in my life was when I didn't like math for the first time. It was AP Statistics and the reason I did not like it was because of the teacher. The teacher did not teach. It gave me no motivation to do anything in that class.”

Consistent feelings about math. Some participants provided turning point stories that emphasized consistency in their relationship with math. That is, they noted that their relationship with math had been either consistently negative or consistently positive. The turning point nature of the story often indicated a confirmation or amplification of their already positive or negative association with math. These participants often conveyed that their relationship with math was fixed or unchangeable. For example, in a consistently negative narrative, Marvin noted, “I still hate math and will always hate math. It has never been easy for me and I don't think anything can change that.” Fixed sentiments also came through in participants who told consistently positive narratives. For example, Cassie explained, “From a young age I have always had math come easy to me. It was language and reading that I found hard.”

With respect to the four content areas (i.e., performance, relevance, help, and study habits), participants with consistently negative turning points often referred to math’s lack of relevance to them. For example, Chris reports, “After seeing my family in the industry I was going into, they never used a single thing from [math], and I felt like I was wasting my time from it all because you will never use 2x + 3x = 8, for example, in a hotel.” Jason responded similarly, noting that math was only relevant because it was necessary for graduation: “Each and every year was a turning point for me with math. Each year math seemed to become more stressful and unnecessary for daily life. The more I thought about math negatively the less I tried to do well in the courses. The only thing that kept me motivated to do well in math was the fact that it was a requirement to graduate.”

Other participants with consistently negative sequences focused on teachers. For example, Madelyn’s turning point suggests she developed a poor relationship with math at a young age due to incompetent instruction: “A turning point would be in Elementary School. We didn't learn a lot of math because our teacher wasn't there and someone else taught us. That person wasn't a good teacher. I think this is why I'm not that good at math and I don't like it.” This account meaningfully concludes that Madelyn has been set on a path of failure and emotional distress with math. Another participant, Samantha, provided an even stronger account linking teachers to negative math experiences: “The turning point in math for me personally was the day that I entered my sophomore year of high school. The [teacher] simply said that they really didn't care whether or not we did well in the class because it wasn't on them if we didn't understand the concepts that they were trying to teach. I think that this encapsulates my perspective of math professors.” Samantha continued to elaborate on how this experience confirmed her belief that math teachers think there is only one right way to do things, it is up to students to learn it, and the ability to learn it means they are either smart or stupid.

In contrast, many participants with consistently positive sequences described turning points pertaining to their own performance in math. For instance, Jamie reported, “My math turning points were every single time I scored a 90% or higher in my pre calc tests. I felt like if I could score that high there really was nothing that could stop me from achieving my goals of passing future math classes.” Other responses invoked social comparisons related to performance and ability. For example, Danny reflected on how he came in ahead of other students: “I would have to say it was in the third grade when we used to do timed math tests every day. We would have timed tests of math problems ranging from all difficulties. If you got under a certain time they would put a ribbon on the wall with your name on it. I was the first one in my class to get all the ribbons and it really gave me the confidence to excel in math.” Participants who invoked social comparison often described the realization that they did not need as much assistance with math as other students and, in some cases, that they were capable of assisting other students who struggled with math. This sentiment is clearly exemplified in a response from Rebecca, who explains, “The math turning point for me was when I realized I understood it more than most of the kids in my classes. Even in elementary school, I’d catch along with the lesson fairly quickly and my classmates still wouldn’t understand how to do the work. This went on all the way through high school and even college, to the point where my classmates were asking me for help on the assignments.”

Quantitative Analyses

Preliminary analyses. Preliminary analyses tested for ethnic and gender differences in math anxiety, math self-expectancy, math value, and future math plans. A four-group MANOVA using the four largest ethnic groups from our sample (White, Hispanic/Latinx, Asian/Pacific Islander, and African American/Black) revealed no significant ethnic differences in the linear combination of these variables, λ = .95, *F*(12, 913.076) = 1.445, *p* = .14. However, a second MANOVA revealed significant gender differences in the linear combination of math anxiety, math self-expectancy, and math value, Hotelling's T^2 = 24.82, *F*(3, 363) = 8.179, *p* < .001. As illustrated in Table 4.3, follow-up univariate ANOVAs replicated patterns obtained in prior research: Relative to men, women reported significantly higher math anxiety (Adj. η_p^2 = .042; see Mordkoff, 2019 for discussion of adjusted eta-squared) and significantly lower math self-expectancy (Adj. η_p^2 = .012). These gender differences constitute small effect sizes. There was not a significant gender difference in math value. As well, chi-square analyses indicated no significant differences in future math plans by gender, X^2 (2, *N* = 204) = 1.173, *p* = .556, *V* = .076, or ethnicity, X^2 (6, *N* = 197) = 3.208, *p* = .782, *V* = .090.

Narrative correlates. Our second research question aimed to determine whether significant gender or ethnic differences existed within the four turning point narrative sequences (i.e., redemption, contamination, always positive, always negative). Chi-squares revealed no significant differences by ethnicity, X^2 (9, *N* = 200) = 8.469, *p* = .488, *V* = .119, or gender, X^2(3, *N* = 209) = 4.592, *p* = .204, *V* = .148. That is, participants tended to narrate their turning points in similar ways regardless of their ethnic background or gender identity.

Our third research question asked whether the four turning point narrative sequences were associated with variation in math affect and motivation. A four-group MANOVA revealed a significant multivariate difference on the linear combination of math anxiety, math self-expectancy, and math value by the four turning points themes, λ = .682, *F*(9, 496.633) = 9.395, *p* < .001. As detailed in Table 4.4, follow-up univariate ANOVAs revealed significant differences in math anxiety (Adj. η_p^2 = .120), math self-expectancy (Adj. η_p^2 = .252), and math value (Adj. η_p^2 = .145) as a function of the four math turning point themes. These differences constitute moderate to large effect sizes.

Post-hoc tests were conducted through Bonferroni corrected pairwise comparisons (.05/12 = .004). With respect to *math anxiety*, participants who wrote consistently positive math turning point narratives reported significantly lower math anxiety than participants who wrote redemptive ($p < .001$), contaminated ($p = .001$), or consistently negative narratives ($p < .001$). With respect to *math self-expectancy*, participants who wrote consistently positive math turning point narratives reported significantly higher math self-expectancy than participants who wrote redemptive ($p < .001$), contaminated ($p < .001$), or consistently negative narratives ($p < .001$). Participants who wrote consistently negative math turning point narratives also reported significantly lower math self-expectancy than participants who wrote redemptive narratives ($p = .002$). With respect to *math value*, participants who wrote consistently positive turning point narratives reported significantly higher math value than participants who wrote contaminated ($p < .001$) or consistently negative narratives ($p < .001$); participants who wrote redemptive math turning point narratives also reported significantly higher math value than participants who wrote consistently negative narratives ($p < .001$).

Our fourth research question aimed to determine whether turning point narratives were associated with significant variation in future math plans. A single chi-square analysis was used to reduce the likelihood of Type 1 error. It included all four turning points themes as well as the three future math plans themes. Standardized residuals were used to inform our interpretation of which cells were driving the effect. Results revealed that participants who wrote consistently negative turning point narratives were significantly more likely than other participants to report that they planned to avoid math in the future, X^2 (6, N = 133) = 40.039, $p < .001$, $V = .388$. More specifically, nearly half (46%) of the participants who wrote consistently negative narratives planned to avoid math in the future; this sentiment was much less common for people who wrote redemptive (12%), contaminated (6%), or consistently positive (0%) narratives. Further, the moderate effect size indicates that narrative sequences explain nearly 40% of the variance in individuals' plan to avoid math in the future. No other cells were significantly different from expected counts.

Discussion

The current study provides novel insight into how emerging adults narrate and appraise pivotal moments in their math life stories. Only a few prior studies have used narrative approaches to investigate individuals' math-related experiences (see Towers et al., 2017; Zavala & Hand, 2019). The current study joins this body of research in demonstrating that narrative data—and perhaps turning point narratives in particular—can be a helpful tool for researchers who seek to understand factors that shape students' orientation towards math. Specifically, the turning points that participants narrated provided rich illustrations of how emerging adults extract meaning from key moments in their prior history with math. Further, quantitative analyses demonstrated that the manner in which participants narrated their turning points was associated with their current math affect, motivation, and future math plans. Below, we discuss the key features and correlates of math turning points narratives. We conclude by describing limitations and directions for future research.

Turning Points in Math: Key Features

Participants often described turning points that centered on the following content areas: academic performance, relevance, receiving help, and study habits. Although these content areas were not the primary focus of the current study, it merits noting that they complement prior work in several regards. For instance, expectancy-value theory proposes that the extent to which students perceive math as worthwhile and important (i.e., math value) helps to explain whether they pursue math in the future (e.g., Eccles, 1994; Simpkins, Davis-Kean, & Eccles, 2006). Consistent with this premise, participants in the current study frequently noted that their relationship with math fundamentally changed when they had experiences that either bolstered or eroded the degree to which they perceived math as relevant to their lives. Other participants described turning points in ways that align with research indicating that parents and teachers can inadvertently foster math anxiety while helping students with math (e.g., Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Specifically, these participants explained that receiving help was a process fraught with tension that ultimately pushed them away from math.

From a theoretical standpoint, the potency of these past math experiences lies not in the experiences themselves, but rather in the appraisal process that follows (see Ramirez, Shaw, & Maloney, 2018; Wigfield & Eccles, 2000). When a student constructs a story of their experience with math, the appraisal process involves choosing what parts of the experience to include and what to leave out, how to attribute cause and effect to the various aspects of the story, and how to meaningfully use that experience to guide present and future behavior. Moreover, this narrative construction of salient turning points in math endures by informing aspects of the student's identity such as what they are—and are not—capable of doing (e.g., McLean & Pratt, 2006).

The current study provides insight into this appraisal process by investigating the narrative sequences that overlay math turning points. Consistent with prior work (e.g., McAdams, 2001), sequences of redemption and contamination frequently characterized participants' turning points. In fact, over half of the narratives (53%) were redemptive in nature, making this the most common narrative form. The prominence of redemption narratives is consistent with prior research in non-academic domains that routinely finds redemption to be the most common narrative sequence in U.S. participants (for review, see McAdams, 2006). This is likely due to a master narrative in the U.S. that places strong value on redemption (Syed, Pasupathi, & McLean, 2019). Unexpectedly, nearly one-third of the sample (31%) described turning points that served to consolidate attitudes toward math that were already positive or negative. The stability implied in these “consistently positive” and “consistently negative” narratives reflects commonplace ideologies about math ability being a fixed attribute that requires an inherent aptitude (e.g., Chestnut, Lei, Leslie, & Cimpian, 2018). Indeed, even though the turning points prompt encouraged participants to reflect on formative prior experiences, some participants nonetheless projected into the future and emphatically stated that their relationship with math was unlikely to change (e.g., “I will always hate math.”).

Interestingly, some participants narrated turning points that were similar in content, but appraised these events in fundamentally different ways. For example, Jenny and Andrea both described turning points related to suboptimal math performance. Jenny interpreted her poor performance as a cue to work harder and subsequently earned As in all of her future math classes (a redemptive sequence), whereas Andrea interpreted her poor performance as evidence that she needed to abandon her plan to major in computer science (a contamination sequence). This illustrative example suggests that future research should attempt to identify individual difference variables that inform the appraisal process. One plausible candidate is locus of control. People with an internal locus of control tend to attribute negative experiences to their own behavior, whereas people with an external locus of control tend to attribute negative experiences to divine, social, or natural forces (Findley & Cooper, 1983). Locus of control may be both a cause and a consequence of people’s narrative sequences. For example, Martínez-Hernández and Ricarte (2019) found that adults with alcoholism who narrated their addiction experiences from an internal, agentic actor perspective were more likely to grow from their past struggle in comparison to participants who took an external, passive spectator position. Further research is needed to understand the relationship between locus of control, which is often framed as a relatively stable personality disposition, and the narrative processes of redemption and contamination, which are often framed as being more situationally dynamic (McCoy & Dunlap, 2017).

Turning Points in Math: Correlates

The small body of research examining math narratives is largely composed of studies that take a purely qualitative approach (see Towers et al., 2017). The current study builds on this work through the addition of quantitative analyses that assessed whether participants who narrated their turning points in different ways tended to differ from one another in other regards as well. First, we anticipated that there would be ethnic or gender differences in participants' narratives, given that People of Color and women more generally tend to encounter negative stereotypes and bias related to their math ability (e.g., AAUW, 2008; Robnett, 2016; Williams et al., 2014). Counter to expectations, however, findings indicated that narratives did not significantly differ on the basis of ethnicity or gender. This is somewhat surprising in light of research indicating that math affect and motivation tend to vary as a function of both ethnicity and gender (see Goetz et al., 2013; Hembree, 1990; Riegle-Crumb et al., 2011; Wang & Degol, 2013). Indeed, preliminary analyses in the current study replicated some of this work in that women, relative to men, reported higher math anxiety and lower math self-expectancy. However, effect sizes were small. Taken together with prior research, findings from the current study suggest that although there tend to be mean ethnic and gender differences in math affect and motivation, appraisals of pivotal math experiences do not explain these differences. Other theoretically grounded antecedents of math affect and motivation likely play a larger role. For example, relationship dynamics between students and their parents, teachers, and peers, can alter motivation (Eccles, 2005; Fan, 2011; Wigfield & Eccles, 2000), and commonplace gender and ethnic ability stereotypes can increase student anxiety in a particular domain (Steele, 1997). It may also be the case that a narrative prompt that elicited participants' experiences with discrimination would have more effectively tapped into how subtle influences (e.g., microaggressions; belongingness threat) accumulate to push underrepresented students away from math-intensive fields (e.g., Walton & Cohen, 2007).

The current study also examined whether participants' turning points sequences were associated with their current math attitudes and their future math plans. Much like identity is shaped through the creation and expansion of a life story (McAdams, 2001), a person's academic self-expectancies, task values, anxieties, and goals are thought to develop in part through their subjective interpretation of past experiences (Eccles, 2005; Gunderson et al., 2012). Findings were generally consistent with this framework. Participants who wrote a consistently positive account of their math turning point reported the lowest math anxiety and highest math self-expectancy of all participants. Similarly, participants who narrated redemptive turning points reported higher math value and higher math self-expectancy than participants whose narratives were consistently negative. In contrast, participants who wrote consistently negative narratives were more likely to report that they planned to avoid math in the future.

These patterns have both theoretical and applied implications. From a theoretical standpoint, the current narrative research complements what has been found using other frameworks. For instance, research in the tradition of future time perspectives (FTP) has indicated a strong link between how individuals think about their futures and their present motivational beliefs, persistence, and achievement (for a review, see Kauffman & Husman, 2004). More specifically, an individual's expectations for future success are often related to present academic outcomes that are positive, whereas a person's anxiety and expectations for failure in the future are often related to present academic outcomes that are negative (Gjesme, 1983; Multon, Brown, & Lent, 1991). The current findings mirror these, but from a theoretical perspective that starts with narrative appraisals of past experiences, rather than imagined future expectations, to explain current outcomes. The parallels between these frameworks might suggest that an individual's memories of past experiences, as well as their thoughts about their future, can simultaneously interact to explain present outcomes and exert influence on future choices. As such, a study that examines how an individual's life story and their future time perspective interact to influence present academic outcomes (e.g., in math or science) would be a worthwhile pursuit for future research.

Findings also raise provocative questions about the role that narratives play in a person's life. Traditionally, life story narratives have been conceptualized as influencing people in broad ways (see McAdams, 2001). For instance, prior research has linked redemption and contamination sequences to domain-general phenomena (e.g., global depression, life satisfaction, well-being) and broad longitudinal outcomes (e.g., general mental health, likelihood to maintain sobriety) with moderate to large effect sizes (Adler et al., 2015; Bauer et al., 2008; Dunlop & Tracy, 2013; McAdams et al., 2001). Our results mirror this work, suggesting that differences in narrative themes account for a large proportion of variance in math affect, math motivation, and future math plans. From an applied standpoint, these findings demonstrate that narratives about turning points can be used more narrowly to better understand domain-specific academic attitudes and career intentions. Future research should examine whether there is consistency in the narrative sequences that people use to describe overall life turning points versus turning points in more specific domains such as career pathways or romantic relationships.

Our findings also underscore the importance of attending to how students appraise their academic experiences. As illustrated by Jenny and Andrea's narratives, the appraisal process helps to explain why two students who experience the same outcome (e.g., failing a test) ultimately follow fundamentally different math trajectories. Given that deepening students' math engagement is a national priority within the U.S. (Committee on STEM

Education, 2018), identifying ways to alter contaminated and "consistently negative" appraisals would be worthwhile. Because parents, teachers, and peers play a key role in socializing academic attitudes (Harackiewicz, Rozek, Hulleman, & Hyde, 2012; Robinson et al., 2019; Robnett & Leaper, 2013), interventions that target the messages they transmit to students may be especially fruitful.

Limitations and Future Directions

Results from the current study should be interpreted in light of several limitations. First, the current study is limited in its reliance on self-report data. Connecting participants' narratives to objective metrics of academic performance (e.g., grades, standardized test scores) would have strengthened our conclusions. Moreover, a longitudinal design would have enabled us to examine whether participants followed through with their plans for using math in the future.

Another limitation pertains to our coarse ethnic comparisons. Specifically, sample size limitations meant that we were only able to conduct comparisons among the four largest ethnic groups (i.e., African American, Asian American, European American, and Latinx). Further, we did not have adequate power to investigate how ethnicity and gender interact to create unique experiences for the individuals in our sample. Given that Women of Color in math-intensive fields may encounter especially high rates of stereotyping and bias (e.g., Williams et al., 2014), it is essential that future narrative research attain a deeper understanding of how individuals navigate these experiences. A good example of this goal is illustrated by Carlone, Scott, and Lowder (2014), who conducted in-depth interviews with diverse students about their science education. Their findings illustrated that various facets of students' identity (e.g., race, class, gender) interacted with their science classroom experiences over time to shape whether or not they ultimately identified with science. The rich and unique insight into student experiences afforded by this type of narrative work provides an additional layer of understanding that purely quantitative data cannot.

Despite the advantages afforded by our mixed-methods approach, our static, computer-mediated method of eliciting narratives has potential limitations relative to more dynamic interview methods. For example, Zavala and Hand (2019) describe a *math achievement-motivation* master narrative that attributes math success to talent and hard work. This master narrative obscures sociohistorical factors that work in concert with individual factors to influence math trajectories. In their prolonged interviews with a handful of Latinx high school students, Zavala and Hand (2019) found that some students were embedded in the master narrative of math achievement, whereas others attempted to create counter-narratives that focused more on social-structural inequities. In contrast, almost all of the stories provided by our participants echoed the master narrative that achievement is due either to effort or to talent, perhaps because our method did not encourage more critical engagement with cultural discourse. We encourage future research to employ a more dynamic interview style of data collection to strategically uncover, or even foster, counter-narratives that acknowledge the role of the social context in shaping math attitudes.

Relatedly, the current method of narrative data collection did not allow us to probe participants for more detail if their statements were ambiguous. As such, we were required to interpret participant narratives at face-value which likely resulted in the loss of some nuance. For example, it is possible that students who stated they plan to avoid math in the future were referencing a preference to avoid the more procedural aspects of math (e.g., algorithmic orientations, computation) as opposed to avoiding broader mathematical thinking, such as problem-solving or pattern-seeking, that is required in much of everyday life and in many non-STEM careers. An interview approach that allows for a dynamic dialogue between researcher and participant may provide increased clarity surrounding what participants aim to convey in their statements. Understanding these types of distinctions will be particularly important for educators and policymakers when conceptualizing interventions and curricula that are aimed at improving math outcomes and participation.

Conclusion

Despite a curricular emphasis on math and a variety of career opportunities in STEM, many students continue to feel uneasy about math, while others lack confidence in their math abilities or struggle to understand the value that math provides. The current research provides unique insight into how appraisals of prior math experiences relate to math affect, math motivation, and future plans to pursue math. Particularly positive or negative experiences that students report having with math can inform both educators and policymakers about targeted ways to improve STEM outcomes and student orientation towards the math domain as a whole. For example, the current study found that students who remember having consistently negative experiences with math had the worst math outcomes overall and were more likely to avoid math in the future. Upon further evidence to support this trend, an emphasis on helping students learn to re-appraise their negative math experiences in a more positive way could be useful for improving math outcomes and expanding STEM participation.

References

Adler, J. M., & Poulin, M. J. (2009). The political is personal: Narrating 9/11 and psychological well-being. *Journal of Personality*, *77*(4), 903-932. https://doi.org/10.1111/j.1467-6494.2009.00569.x

Adler, J. M., Turner, A. F., Brookshier, K. M., Monahan, C., Walder-Biesanz, I., Harmeling, L. H., Albaugh, M., McAdams, D.P., & Oltmanns, T. F. (2015). Variation in narrative identity is associated with trajectories of mental health over several years. *Journal of Personality and Social Psychology*, *108*(3), 476–496. https://doi.org/10.1037/a0038601

Ahmed, W., Minnaert, A., Kuyper, H., & van der Werf, G. (2012). Reciprocal relationships between math self-concept and math anxiety. *Learning and Individual Differences*, *22*(3), 385–389. https://doi.org/10.1016/j.lindif.2011.12.004

American Association of University Women (2008). *Where the girls are: The facts about gender equity in education*. Retrieved from: https://www.aauw.org/files/2013/02/Where-the-Girls-Are-The-Facts-About-Gender-Equity-in-Education.pdf.

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist*, *55*(5), 469–480. https://doi.org/10.1037//0003-066X.55.5.469

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181-185. https://doi.org/10.1111/1467-8721.00196

Ashcraft, M. H. & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology, 130*(2), 224-237. http://dx.doi.org/10.1037/0096-3445.130.2.224

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment*, *27*(3), 197–205. https://doi.org/10.1177/0734282908330580

Bandura, A. (1986). The Explanatory and Predictive Scope of Self-Efficacy Theory. *Journal of Social and Clinical Psychology*, *4*, 359-373. https://doi.org/10.1521/jscp.1986.4.3.359

Bauer, J. J., McAdams, D. P., & Pals, J. L. (2008). Narrative identity and eudaimonic well-being. *Journal of Happiness Studies*, *9*(1), 81-104. https://doi.org/10.1007/s10902-006-9021-6

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bruner, J. S. (1990). *Acts of meaning.* Cambridge, MA: Harvard University Press.

Bruner, J. S. (1994). The remembered self. In U. Neisser & R. Fivush (Eds.), *The remembering self: Construction and accuracy in the self- narrative* (pp. 41–54). New York: Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511752858.005

Carlone, H. B., Scott, C. M., & Lowder, C. (2014). Becoming (less) scientific: A longitudinal study of students' identity work from elementary to middle school science. *Journal of Research in Science Teaching, 51*, 836-869. http://dx.doi.org/10.1002/tea.21150

Chestnut, E. K., Lei, R. F., Leslie, S. J., & Cimpian, A. (2018). The myth that only brilliant people are good at math and its implications for diversity. *Education Sciences*, *8*, 65. https://doi.org/10.3390/educsci8020065

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

Committee on STEM Education, National Science & Technology Council (2018). *Charting a course for success: America's strategy for STEM education.* Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches. Thousand Oaks, CA: Sage.

Crisp, G., Nora, A., Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic Serving Institution. *American Educational Research Journal*, *46*, 924-942. doi: https://doi.org/10.3102/0002831209349460

Di Martino, P., & Zan, R. (2011). Attitude towards mathematics: A bridge between beliefs and emotions. *ZDM: Mathematics Education*, *43*(4), 471-482. https://doi.org/10.1007/s11858-011-0309-6

Douglas, D., & Attewell, P. (2017). School mathematics as gatekeeper. *The Sociological Quarterly*, *58*(4), 648–669. https://doi.org/10.1080/00380253.2017.1354733

Dunlop, W. L., & Tracy, J. L. (2013). Sobering stories: Narratives of self-redemption predict behavioral change and improved health among recovering alcoholics. *Journal of Personality and Social Psychology*, *104*(3), 576. https://doi.org/10.1037/a0031185

Eccles, J. (1983). Expectancies, values and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75-146). San Francisco, CA: Free man.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. Model of Achievement-Related Choices. *Psychology of Women Quarterly*, *18*(4), 585–609. https://doi.org/10.1111/j.1471-6402.1994.tb01049.x

Eccles, J. S. (2005). Studying gender and ethnic differences in participation in math, physical science, and information technology. *New Directions for Child and Adolescent Development*, (110), 7–14. https://doi.org/10.1002/cd.146

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78–89. https://doi.org/10.1080/00461520902832368

Eccles, J. S., & Wang, M.T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106. https://doi.org/10.1177/0165025415616201

Ellsworth, J. Z., & Buss, A. (2000). Autobiographical stories from preservice elementary mathematics and science students: Implications for K–16 teaching. *School Science and Mathematics, 100*(7) 355-364. https://doi.org/10.1111/j.1949-8594.2000.tb18177.x

Fan, W. (2011). Social influences, school motivation and gender differences: An application of the expectancy-value theory. *Educational Psychology*, *31*(2), 157–175. https://doi.org/10.1080/01443410.2010.536525

Faust, M. W., Ashcraft, M. H., & Fleck, D. E. (1996). Mathematics anxiety effects in simple and complex addition. *Mathematical Cognition, 2*(1), 25-62. https://doi.org/10.1080/135467996387534

Findley, M. J., & Cooper, H. M. (1983). Locus of control and academic achievement: A literature review. *Journal of Personality and Social Psychology, 44*, 419-427.

Gjesme, T. (1983). Motivation to approach success (Ts) and motivation to avoid failure (TF) at school. *Scandinavian Journal of Educational Research*, *27*(3), 145–164. https://doi.org/10.1080/0031383830270302

Goetz, T., Bieg, M., Ludtke, O., Pekrun, R., & Hall, N.C. (2013). Do girls really experience more anxiety in mathematics? *Psychological Science 24*(10), 2079-2087. https://doi.org/10.1177/0956797613486989

Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles*, *66*(3–4), 153–166. https://doi.org/10.1007/s11199-011-9996-2

Habermas, T. & Bluck, S. (2000). Getting a life: The emergence of the life story in adolescence. *Psychological Bulletin*, *125*(5), 748-769. https://doi.org/10.1037/0033-2909.126.5.748

Harackiewicz, J. M., Rozek, C. S., Hulleman, C. S., & Hyde, J. S. (2012). Helping parents to motivate adolescents in mathematics and science: An experimental test of a utility-value intervention. *Psychological Science*, *23*(8), 899–906. https://doi.org/10.1177/0956797611435530

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46. https://psycnet.apa.org/doi/10.2307/749455

Hopko, D. R., Mahadevan, R., Bare, R. L. & Hunt, M.K. (2003). The abbreviated math anxiety scale (AMAS): Construction, validity, and reliability. *Assessment*, *10*(2), 178-182. https://doi.org/10.1177%2F1073191103010002008

Kauffman, D. F., & Husman, J. (2004). Effects of time perspective on student motivation: Introduction to a special issue. *Educational Psychology Review*, *16*(1), 1–7. https://doi.org/10.1023/B:EDPR.0000012342.37854.58

Lauermann, F., Tsai, Y.-M., & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.'s expectancy–value theory of achievement-related behaviors. *Developmental Psychology*, *53*(8), 1540–1559. https://doi.org/10.1037/dev0000367

Lenhard, W. & Lenhard, A. (2016). *Calculation of effect sizes.* Retrieved from: https://www.psychometrica.de/effect_size.html. Dettelbach (Germany): Psychometrica. https://doi.org/10.13140/RG.2.1.3478.4245.

LoPresto, K. D., & Drake, C. (2005). What's your (mathematics) story? *Teaching Children Mathematics*, *11*(5), 266– 271.

Ma, X. (1999). A Meta-Analysis of the Relationship between Anxiety toward Mathematics and Achievement in Mathematics. *Journal for Research in Mathematics Education*, *30*(5), 520–540. https://doi.org/10.2307/749772

Maloney, E. A., Ramirez, G., Gunderson, E. A., Levin, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science, 26,* 1480-1488. https://doi.org/10.1177/0956797615592630

Martínez-Hernández, N., & Ricarte, J. (2019). Self-defining memories related to alcohol dependence and their integration in the construction of the self in a sample of abstinent alcoholics. *Memory, 27*(2), 137-146. https://doi.org/10.1080/09658211.2018.1493128

McAdams, D. P. (1998). *Contamination sequence coding guidelines*. Unpublished manuscript, Evanston, IL: Northwestern University.

McAdams, D. P. (1999). *Coding narrative accounts of autobiographical scenes for redemption sequences* (4th rev.). Unpublished manuscript, Evanston, IL: Northwestern University.

McAdams, D. P. (2001). The psychology of life stories. *Review of General Psychology, 5*(2), 100-122. https://doi.org/10.1037/1089-2680.5.2.100

McAdams, D. P. (2006). The redemptive self: Stories Americans live by-revised and expanded edition. Oxford University Press.

McAdams, D. P. (2008). Personal narratives and the life story. In John, Robins, & Pervin (Eds.), *Handbook of Personality: Theory and Research (3rd Ed)*. NY: Guilford Press.

McAdams, D. P., & Bowman, P. J. (2001). Narrating life's turning points: Redemption and contamination. In D. P. McAdams, R. Josselson, & A. Lieblich (Eds.), *Turns in the road: Narrative studies of lives in transition* (pp. 3-34). Washington, DC, US: American Psychological Association. http://dx.doi.org/10.1037/10410-001

McAdams, D. P., & McLean, K. C. (2013). Narrative Identity. *Current Directions in Psychological Science*, *22*(3), 233-238. http://dx.doi.org/10.1177/0963721413475622

McAdams, D. P., Reynolds, J., Lewis, M., Patten, A. H., & Bowman, P. J. (2001). When bad things turn good and good things turn bad: Sequences of redemption and contamination in life narrative and their relation to psychosocial adaptation in midlife adults and in students. *Personality and Social Psychology Bulletin*, *27*(4), 474-485. http://dx.doi.org/10.1177/0146167201274008

McCrudden, M. T., Marchand, G., & Shutz, P. (2019). Mixed methods in educational psychology. *Contemporary Educational Psychology*. Published online ahead of print. https://doi.org/10.1016/j.cedpsych.2019.01.008

McCoy, T. P., & Dunlop, W. L. (2017). Down on the upside: Redemption, contamination, and agency in the lives of adult children of alcoholics. *Memory, 25*(5), 586-594. https://doi.org/10.1080/09658211.2016.1197947

McLean, K. C. (2005). Late adolescent identity development: Narrative meaning-making and memory telling. *Developmental Psychology, 41,* 683– 691. http://dx.doi.org/10.1037/0012-1649.41.4.683

McLean, K. C. (2008). The emergence of narrative identity. *Social and Personality Psychology Compass*, *2*(4), 1685-1702. https://doi.org/10.1111/j.1751-9004.2008.00124.x

McLean, K. C., & Pratt, M. W. (2006). Life's little (and big) lessons: Identity statuses and meaning-making in the turning point narratives of emerging adults. *Developmental psychology*, *42*(4), 714. https://doi.org/10.1037/0012-1649.42.4.714

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology*, *82*(1), 60–70. https://doi.org/10.1037/0022-0663.82.1.60

Mordkoff, J. T. (2019). A simple method for removing bias from a popular measure of standardized effect size: Adjusted partial eta squared. *Advances in Methods and Practices in Psychological Science*, *2*(3), 228–232. https://doi.org/10.1177/2515245919855053

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology*, *38*(1), 30–38. https://doi.org/10.1037/0022-0167.38.1.30

Musu-Gillette, L. E., Wigfield, A., Harring, J. R., & Eccles, J. S. (2015). Trajectories of change in students' self-concepts of ability and values in math and college major choice. *Educational Research and Evaluation*, *21*(4), 343–370. https://doi.org/10.1080/13803611.2015.1057161

Muenks, K., Wigfield, A., & Eccles, J.S. (2018). I can do this! The development and calibration of children's expectations for success and competence beliefs. *Developmental Review, 48*, 24-39. https://doi.org/10.1016/j.dr.2018.04.001.

National Science Foundation, National Science Board. (2016). *Science and engineering indicators*. Retrieved from: https://www.nsf.gov/statistics/2016/nsb20161/#/report.

Ramirez, G., Gunderson, E. A., Levine, S.C. & Beilock, S.L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*(2), 187-202. https://doi.org/10.1080/15248372.2012.664593

Ramirez, G., Shaw, S. T., & Maloney, E. A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational Psychologist*, *53*(3), 145–164. https://doi.org/10.1080/00461520.2018.1447384

Reisenzein, R. (2006). Arnold's theory of emotion in historical perspective. *Cognition & Emotion*, *20*(7), 920–951. https://doi.org/10.1080/02699930600616445

Richardson, F. C. & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554. http://dx.doi.org/10.1037/h0033456

Riegle-Crumb, C., Moore, C., & Ramos-Wada, A. (2011). Who wants to have a career in science or math? Exploring adolescents' future aspirations by gender and race/ethnicity. *Science Education, 95*(3), 458–476. https://doi.org/10.1002/sce.20431

Robinson, K. A., Perez, T., Carmel, J. H., & Linnenbrink-Garcia, L. (2019). Science identity development trajectories in a gateway college chemistry course: Predictors and relations to achievement and STEM pursuit. *Contemporary Educational Psychology*, *56*, 180–192. https://doi.org/10.1016/j.cedpsych.2019.01.004

Robnett, R. D. (2016). Gender Bias in STEM Fields: Variation in Prevalence and Links to STEM Self-Concept. *Psychology of Women Quarterly*, *40*(1), 65–79. https://doi.org/10.1177/0361684315596162

Robnett, R. D., & Leaper, C. (2013). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence*, *23*, 652-664. https://doi.org/10.1111/jora.12013

Schwartz, S. J., Zamboanga, B. L., Luyckx, K., Meca, A., & Ritchie, R. A. (2013). Identity in emerging adulthood: Reviewing the field and looking forward. *Emerging Adulthood*, *1*(2), 96-113. https://doi.org/10.1177/2167696813479781

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Math and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology*, *42*(1), 70–83. https://doi.org/10.1037/0012-1649.42.1.70

Solomon, Y. (2007). Not belonging? What makes a functional learner identity in the undergraduate mathematics community of practice? *Studies in Higher Education*, *32*(1), 79–96. https://doi.org/10.1080/03075070601099473

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist*, *52*(6), 613–629. https://doi.org/10.1037/0003-066X.52.6.613

Syed, M., Pasupathi, M., & McLean, K. C. (2019). Master narratives, ethics, and morality. To appear in L. Jensen (Ed.), *The Oxford handbook of moral development: An interdisciplinary perspective*. New York: Oxford University Press. https://doi.org/10.31234/osf.io/urja3

The New York Times (2017). *Economic diversity and student outcomes at the University of Nevada, Las Vegas.* Retrieved from: https://www.nytimes.com/interactive/projects/college-mobility/university-of-nevada-las-vegas

Towers, J., Hall, J., Rapke, T., Martin, L. C., & Andrews, H. (2017). Autobiographical accounts of students' experiences learning mathematics: A review. *Canadian Journal of Science, Mathematics and Technology Education*, *17*(3), 152-164. https://doi.org/10.1080/14926156.2016.1241453

Walton, G. M., & Cohen, G. L. (2007). A question of belonging: Race, social fit, and achievement. *Journal of Personality and Social Psychology*, *92*, 82–96. https://doi.org/10.1037/0022-3514.92.1.82

Wang, M., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy-value perspective to understand individual and gender differences in STEM fields. *Developmental Review, 33*, 304-340. https://doi.org/10.1016/j.dr.2013.08.001

Wang, M.-T., Degol, J., & Ye, F. (2015). Math achievement is important, but task values are critical, too: Examining the intellectual and motivational factors leading to gender disparities in STEM careers. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.00036

Watt, H. M. G. (2004). Development of adolescents' self-perceptions, values, and task perceptions according to ender and domain in 7th- through 11th-grade Australian students. *Child Development, 75*, 1556-1574. https://doi.org/10.1111/j.1467-8624.2004.00757.x

Watt, H. M. G., Shapka, J. D., Morris, Z. A., Durik, A. M., Keating, D. P., & Eccles, J. S. (2012). Gendered motivational processes affecting high school mathematics participation, educational aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. *Developmental Psychology*, *48*(6), 1594–1611. https://doi.org/10.1037/a0027838

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Williams J. C., Phillips K. W., & Hall E. V. (2014). *Double jeopardy? Gender bias against women of color in science*. Retrieved from http://www.uchastings.edu/news/articles/2015/01/williams-double-jeopardy-report.php

Zavala, M. D. R., & Hand, V. (2019). Conflicting narratives of success in mathematics and science education: Challenging the achievement-motivation master narrative. *Race Ethnicity and Education*, *22*(6), 802-820.

Table 4.1: Narrative Sequences in Math Turning Point Themes

Coding Category	%	(n)	Examples
All Positive	14%	(29)	A turning point for me was when I realized I wanted to teach math. I noticed that I found myself looking forward to class and even doing homework. I decided, since I enjoy it so much, I want to keep doing it and turn it into a career. That inspired me to work towards becoming a teacher.
Redemption	53%	(112)	An important turning point in my life with math was definitely my college prep class. I really saw the difference of when I studied vs when I didn't. I was so mad at myself for slacking at the end of the year because the material would have been so easy for me to learn if I just paid attention. Because of this turning point I never wanted to feel like that again. So that’s why in Math 120 I studied for every test and passed with an A.
Contamination	16%	(34)	Up until 8th grade when I got into Algebra I would always receive As and Bs in math, but when I got into the 8th grade and had an awful teacher my relationship with math changed. He did not know how to teach the course and almost half the class was having trouble and wanted to get out of the class. I think this event changed my relationship with math because I had fully given up after taking his class.
All Negative	17%	(35)	Now that I am in Pre-Calculus it has made a huge impact on my thoughts of math. This class has made me hate math more than ever before.

Note: N = 210 participants (56% of full sample) provided a codable math turning point story.

Table 4.2: How Participants Expect to Use Math in the Future Parsed by Turning Point Themes

Coding Category	%	(*n*)	N_{TP}	C_{TP}	R_{TP}	P_{TP}	Examples
Willingly Pursue Math	72%	(148)	5%	13%	64%	18%	I see myself using math for more application type problems for my future engineering classes. I expect to use everything I know to make sure that I understand new topics presented to me and so that I may help my classmates in them. I believe I will be happy and proud of the math I have learned.
Reluctantly Pursue Math	13%	(26)	39%	28%	33%	0%	I am going to take Math 124 at a community college and attempt to get it out of the way as soon as possible. I will probably use math in my career but hope that it is minimal.
Avoid Math	15%	(31)	50%	5%	45%	0%	I really hope I never have to see a math equation after this semester because it lowers my self-esteem and makes me feel dumb when I know I am not.

Note: 205 participants (55% of full sample) provided a codable account of their future math use. N_{TP} = All Negative Turning Point, C_{TP} = Contamination Turning Point, R_{TP} = Redemption Turning Point, P_{TP} = All Positive Turning Point.

Table 4.3: Mean Gender Differences in Math Attitudes

	Female	Male	ANOVA Test Statistics		
	M (*SD*)	*M* (*SD*)	F	p	η_p^2
Math Anxiety	2.70 (.91)	2.30 (.82)	17.103	<.001	.045
Math Self-Expectancy	2.80 (1.20)	3.10 (1.03)	5.586	.019	.015
Math Value	3.47 (1.03)	3.36 (1.09)	.851	.357	.002

Note: *N* =367. Means with different subscripts are significant at the $p < .05$ level.

Table 4.4: Mean Turning Point Narrative Differences in Math Attitudes

	Redemption	Contamination	Positive	Negative	ANOVA Test Statistics		
	M (*SD*)	*M* (*SD*)	M (SD)	M (SD)	F	p	η_p^2
Math Anxiety	2.57_a (.89)	2.66_a (.78)	1.84_b (.67)	3.05_a (1.00)	10.578	<.001	.133
Math Self-Expectancy	2.86_a (1.11)	2.66_{ab} (1.00)	4.31_c (.91)	2.12_b (1.01)	24.455	<.001	.263
Math Value	3.60_{ab} (.90)	3.08_{bc} (.94)	4.12_a (1.12)	2.79_c (1.03)	12.784	<.001	.157

Note *N*=209. Means with different subscripts are significant at the $p < .004$ level.

Appendix 4A: Your Life Story about your Experiences with Math

Adapted from McAdams' Life Story Prompt

Please begin by thinking about your relationship to math over the course of your life as if it were a book or novel. Imagine that the book has several main chapters that describe key scenes or experiences you have had with math. Consider your experiences with learning math, performing math, being evaluated on your math abilities, and using or doing math outside of school environments. Think about your experiences with math teachers, your friends, and peers, as well as emotions you felt while studying, being in class, or taking exams.

I would like you to focus on a few of these key scenes having to do with math that stand out over the course of your life. A key scene would be an event or specific incident that took place at a particular time and place. Consider a key scene to be a moment in your life story about math that stands out for a particular reason – perhaps because it was especially good or bad, particularly vivid, important, or memorable.

For each of the four chapters and key scenes we will consider over the next few pages of this survey, I ask that you describe in detail what happened, when and where it happened, who was involved, and what you were thinking and feeling during the event. In addition, I ask that you tell me **why you think this particular scene is important or significant in your life**. What does the scene say about you as a person? Please be specific.

A Math Turning Point[3]

In looking back over your life and relationship to math, it may be possible to identify certain key moments that stand out as turning points—episodes that marked an important

[3] Participants also responded to three open-ended questions that were not the focus of the current research. Specifically, they described a math low point (i.e., a particularly negative experience); a math high point (i.e., a particularly positive experience); and their experiences receiving help with math.

change in your relationship to math. Please identify a particular episode in your life story that you now see as a turning point in your relationship to math. If you cannot identify a key turning point that stands out clearly, please describe some event in your life wherein you went through an important change of some kind in relation to math. Again, for this event please describe what happened, where and when, who was involved, and what you were thinking and feeling. Also, please say a word or two about what you think this event says about you as a person or your life and your relationship to math.

The Next Math Chapter

Your relationship to math includes key chapters and scenes from your past, as you have described them, and it also includes how you see or imagine your future. Please describe what you see to be the next chapter in your life with respect to math. For example, in what ways, if at all, do you expect to study or use math in your future life? What emotions or thoughts do you expect to experience and associate with math in the future? Do you expect your relationship to math will change, or stay the same?

Chapter 5: Manuscript 2 Summary & Bridge

John and colleagues (2020) relied heavily on prior narrative work (McLean & Pratt, 2006; McAdams et al., 2001) to inform their mixed-methods exploration of how undergraduates narrate math-specific turning points, as well as how differences in these narrations are related to current math outcomes and future math plans. Quantitative results support prior work indicating significant gender differences in math self-expectancy and math anxiety. Results from mixed-methods analyses indicated that turning point themes were related to current math outcomes. For instance, participants who wrote consistently positive math turning point narratives also reported better math outcomes. Participants who wrote consistently negative narratives not only reported worse math outcomes but were also more likely to indicate that they planned to avoid math in their futures. These findings provide compelling evidence that how individuals interpret their past math experiences is related to their current math outcomes and motivation to pursue math-related careers. John et al. (2022) sought to understand these relationships more deeply by focusing on how students with particularly high or low math self-concept narrate a past low point, or particularly negative experience, in math. We were interested in exploring similarities and differences in the types of experiences remembered as low points in addition to identifying interpretation patterns that might reveal potential for future classroom intervention.

Chapter 6: "I have cried in almost all of my math classes." Relations between math self-concept, gender, and narrative appraisals of past low points in math

Jennifer E. John
University of Nevada, Las Vegas

Kristin D. Vierra
University of Nevada, Las Vegas

Rachael D. Robnett
University of Nevada, Las Vegas

Abstract

Math self-concept is strongly associated with a range of academic and career outcomes in math. The current research sought to identify factors that distinguish between undergraduates with particularly low or high math self-concept. A sample of 754 college students were asked to recall a low point they had with math as well as respond to questionnaires measuring math self-concept, value, and anxiety. Focal analyses were conducted on a subsample of participants who reported either high (n = 90) or low (n = 94) math self-concept. Relative to participants who were high in math self-concept, those who were low tended to be women, were higher in math anxiety, and valued math less. Thematic analysis also revealed similarities and differences in how undergraduates from these two groups appraised challenges, or low points, that they encountered in their history with math. Although there were similarities in the types of low points described by members of these two groups, these experiences were often appraised in distinct ways. Unique themes also emerged for each group, indicating that narrative interpretations of math experiences vary with current levels of math self-concept. Implications for future research and math education are discussed.

Keywords: Expectancy-Value Theory, Math, STEM, Gender, Narrative Identity

Introduction

Over the past several decades, research has sought to understand the reasons for the dearth of women in science, technology, engineering, and math (STEM) fields (see Wang & Degol, 2017). This work has led to a variety of interventions aimed at increasing the number of women in STEM (e.g., Master & Meltzoff, 2020; Prieto-Rodriguez, 2020; van den Hurk, 2019), which has contributed to an overall increase in the number of women in STEM occupations over the past two decades (NSF, 2018; 2020). There has also been an overall reduction in achievement differences between girls and boys in STEM education, with gender differences in STEM achievement now nearly nonexistent (Hyde et al., 2008; O'Dea, 2018; Reilly et al., 2015).

Despite these improvements in STEM education and employment, women still make up only about 29% of the STEM workforce, even though they comprise over half of the US population and workforce (NSF, 2020). Further, although women have reached parity with men in the social and life sciences, gender disparities remain in the most math-intensive STEM fields, where women comprise only 27% of computer science and math occupations, 16% of engineering occupations, and 29% of physical science occupations (NSF, 2018; 2020). These stubborn gaps in math-intensive STEM fields are concerning for several reasons. First, from a social justice standpoint, gender inequities in STEM are a problem for girls and women who seek to enter STEM but are made to feel as though they do not belong or cannot succeed (e.g., Master & Meltzoff, 2020; Starr & Simpkins, 2021). Second, given that careers in math-intensive STEM fields are lucrative and people with STEM skills are in high demand (Beede et al., 2011; Committee on STEM Education, 2018), these inequities also prevent women from climbing the economic ladder and reaching wage parity with men (Gharehghozli & Atal, 2020). Finally, from a business and economic standpoint, diversity in the workplace has been found to improve innovation, suggesting that workplaces inclusive of all genders may be more successful than those without such diversity (Chrobot-Mason & Aramovich, 2013; Østergaard et al., 2011). For these reasons, it remains a critical task to understand why women remain underrepresented in math-intensive STEM fields.

To address this question, the current research focuses on math self-concept, which has been theoretically and empirically linked to women's underrepresentation in STEM (see Eccles & Wigfield, 2020). Specifically, we sought to identify factors that distinguish between participants who are particularly low versus high in math self-concept. Using a mixed-methods approach, we examined whether members of these two groups differ in their math motivation and affect as well as in their narrative appraisals of significant challenges, or low points, in their prior history with math. Below, we review the relevant research on math motivation and affect followed by a synthesis of this literature with existing work on narrative identity development.

Self-Concept, Values, and Achievement Emotions

Although gender differences in math achievement have all but disappeared (e.g., Reilly et al., 2015), significant gender differences remain in math self-concept, which influences motivation and persistence in math (e.g., Dietrich & Lazarides, 2019; Jiang et al., 2020; Lauermann et al., 2017) and contributes to STEM career aspirations (Kwon et al., 2019; Seo et al., 2019; Willie et al., 2020). *Academic self-concept* refers to an individual's overall perception of their competence in a domain (Bong & Skaalvik, 2003; Wigfield & Eccles, 2000). Therefore, *math self-concept* may refer to a person's perception of their own math abilities. In general, higher academic self-concept is related to higher valuation of a domain (Arens et al., 2019; Nagy et al., 2007; Wang et al., 2021), and is also consistently associated with better outcomes in a domain, such as pursuit, persistence, and performance (Eccles, 1983; Wigfield & Eccles, 2020; Wigfield & Eccles, 2000). Regarding the math domain, boys consistently report higher math self-concept than do girls (Pajares, 2002; 2005).

These gender differences typically emerge during early adolescence and increase with age. Interestingly, even when they report higher math achievement relative to boys and men, girls and women rarely report higher math self-concept (Huang, 2013; Robnett & Thoman, 2017; Skaalvik & Skaalvik, 2004).

According to situated expectancy-value theory (SEVT) (Eccles & Wigfield, 2020), self-concept is determined by a variety of contextual forces. These forces include stereotypes, societal expectations, the attitudes of important socializers (e.g., parents, teachers, and peers), and an individual's own interpretations of what these contextual forces mean. SEVT also proposes that self-concept is informed by cognitive and affective interpretations (i.e., appraisals) of past achievement experiences. These appraisals often focus on performance relative to the peer group as well as performance within and across different academic domains (e.g., math vs. English; Bong & Skaalvik, 2003; Gaspard et al., 2018).

The control-value theory of achievement emotions (CVT; Pekrun et al., 2007) expands upon the affective interpretation process proposed in SEVT by explaining how individual differences in emotion appraisal mediate the relations between self-concept, values, and achievement outcomes. More specifically, according to CVT, self-concept and related expectancies for success directly influence how much *control* an individual feels they have over an achievement outcome. The *value* a person attributes to an achievement outcome is dependent on both how much interest an individual has in a particular domain (e.g., intrinsic value) and how important it is for the individual to be successful in the domain (e.g., extrinsic value, Frenzel et al., 2007). For instance, feelings of high control and high value are generally related to positive emotions about a task and subsequent positive outcomes on the task. These positive experiences then strengthen feelings of control and value for future tasks. On the other hand, feelings of low control and low value are generally related to negative emotions about a task and, subsequently, more negative outcomes on the task. These negative experiences then further reduce feelings of control and value for future tasks.

CVT can help to explain the gender differences typically seen in math-related emotions and math outcomes. For example, Frenzel and colleagues (2007) found that the association between gender and emotions toward math was mediated by both math self-concept and value. More specifically, girls' greater negative emotions toward math could be explained by low competence beliefs and low intrinsic value in math, as well as high levels of extrinsic value in math. In other words, for girls, low confidence in their math skills and low interest in math, combined with the acknowledgement that math skills are important, increased their negative emotionality toward math. According to CVT, this negative emotionality toward math is likely to result in more negative math outcomes for girls.

This notion is also corroborated by the literature on math anxiety, which is a well-known type of negative emotionality towards math. More specifically, *math anxiety* is a fear of situations involving math that may be present in both academic and everyday settings (Ashcraft, 2002). Notably, there are consistent gender differences in self-reported math anxiety, with girls reporting higher math anxiety than boys (Ma, 1999). In addition, higher math anxiety is consistently associated with poorer math outcomes, including a significant reduction in math performance, self-concept, and value (Ahmed et al., 2012; Hembree, 1990; Barroso et al., 2021) as well as a reduced likelihood of pursuing STEM careers (Ahmed, 2018).

Narrative Appraisals

SEVT and CVT help to explain the process by which self-concept, values, and emotion appraisals are reciprocally related and ultimately influence achievement outcomes and future aspirations. However, the narrative identity literature provides a framework to more deeply consider how these experiences become incorporated into a person's identity over time and may ultimately influence their future plans. According to McAdams (2001), a person's identity typically takes the form of a narrative, or story, that provides the individual with a coherent sense of purpose. The construction of a life story begins during late adolescence, which is when individuals are first cognitively able to meaningfully reflect on their past experiences, attend to their present situations, and use this knowledge to anticipate their futures. During this time, adolescents and young adults use narratives to consolidate their beliefs and experiences into a personal ideology that they can use to make future plans such as choosing a career. A key component of narrative identity development is the process of assigning meaning to past experiences to create a coherent account of their identity over time (McAdams & McLean, 2013). The meaning-making process is also heavily influenced by broader cultural values, norms, and stereotypes (McAdams, 2008). These sociocultural components of identity give rise to "master narratives," which serve as rigid prototypes for how a person's life should play out, given their own personal characteristics (McLean & Lilgendhal, 2019; McLean et al., 2019).

Traditional master narratives typically uphold conventional gender roles and systems of gender inequity (McLean et al., 2016). Given the pervasiveness of gendered math-ability stereotypes in the U.S., a traditional master narrative likely exists where men are favored as more naturally suited for math-intensive careers than are women (Cerva, 2019; Zavala & Hand, 2019). Though it is possible to resist master narratives by creating alternate narratives, master narratives provide a straightforward way for an individual to structure a coherent life story. In this way, aligning one's identity with a master narrative requires less psychological labor; individuals who resist the master narrative are required to engage in substantively more difficult identity work (McLean et al., 2020).

Emotion plays a key role in how narrative identity is created. In particular, emotions and personal goals are closely linked in the theory of narrative identity development

(McAdams, 2001). For instance, when a person feels an emotion during a life experience, they make an appraisal of what the event might mean for them in terms of achieving some goal (or not). These appraisal patterns are highly individual and allow a person to create their narrative identity either through a matching or re-alignment of past experiences with current personal goals (Roseman & Smith, 2001). *Personal event memories* are vivid, detailed, and emotionally charged recollections of specific events, and are most often remembered when an individual attaches some symbolic meaning to the event (McAdams, 2001). For instance, if an adolescent girl experiences anxiety and performs poorly on a math test, she may interpret the event as meaning that she is bad at math, which aligns with the larger master narrative of gendered math abilities. If similar experiences and emotions continue over time, they can create *self-defining memories* (Singer, 1995). Given that a core component of narrative identity is to integrate past experiences with future goals (McAdams & McLean, 2013), these self-defining memories likely compel a re-evaluation of existing personal goals. For instance, the adolescent girl may use her unpleasant past experiences and emotions towards math to re-evaluate her confidence in the math domain and re-align her goals with a future that does not involve math. In doing so, she increases the coherence of her life story (Habermas & Bluck, 2000).

The process of narrative identity development helps to establish the reciprocal relation between an individual's interpretation of their contextualized experiences and outcomes. This work, alongside SEVT and CVT, can also explain why people who experience similar events might interpret them in distinct ways. For instance, in a culture with traditional master narratives about gendered math ability, a girl who has had difficulties with math in the past may appraise her anxiety about a math task as an indicator that she lacks math ability and cannot succeed, whereas a boy who has not had difficulty with math may appraise his anxiety about the same task as motivation to succeed (e.g., Pekrun & Stephens, 2010). Relatedly, a girl who succeeds on a math task may attribute her success to external factors, such as hard work, whereas a boy who succeeds on the same math task might attribute his success to internal factors, such as natural ability (Meece et al., 2006).

A Mixed-Methods Approach

Decades of theoretical and empirical work have established reciprocal associations among self-concept, values, emotions, and achievement outcomes in various domains (e.g., Frenzel et al., 2007; McAdams & Mclean, 2013; Wigfield & Eccles, 2000). However, despite its theoretical value, only a handful of prior studies have investigated how an individual's narrative interpretation of their past experiences might influence these variables (see Eccles & Wigfield, 2020). In one of these studies, John and colleagues (2020) asked undergraduates about significant turning points in their prior history with math. Findings showed that participants whose narratives reflected a longstanding positive orientation toward math tended to have more positive math attitudes compared to participants who wrote other types of narratives. In addition, some qualitative work on the influence of master narratives regarding gender roles and gendered ability beliefs suggests that using a narrative identity framework to understand the gender gaps in math-intensive STEM may be particularly illuminating (McLean et al., 2016; McLean et al., 2019; Zavala & Hand, 2019).

The current study builds on this emergent body of work by using a mixed-methods design to examine (1) how participants remember and narrate a past math experience and (2) whether these narratives are associated with participants' current level of math self-concept. In the current study, we examine how participants narrate especially negative experiences ("low points") in their history with math. Analyses focus on participants with particularly low or high math self-concept. By comparing low points among participants on differing ends of the math self-concept continuum, the current study attempts to shed light on how differences in math self-concept relate to individual differences in narrative interpretation of past math events. Given the existing quantitative work on SEVT and CVT, as well as the qualitative work on narrative identity, a mixed-methods approach provides an ideal way to bridge these complementary perspectives. In addition, a strength of mixed methods lies in its ability to maximize the strengths of both qualitative and quantitative methodologies while also minimizing the weaknesses of each (McCrudden et al., 2019).

The decision to compare participants with particularly high versus low levels of math self-concept was informed by the growing person-centered literature on math achievement motivation. Traditional variable-centered approaches assume that all individuals derive from a single population, whereas person-centered approaches identify groups of individuals who may derive from different sub-populations (see Howard & Hoffman, 2018; Marsh et al., 2009 for a review). Person-centered research that examines achievement motivation in math has been fruitful in helping to explain individual variation in a range of important academic outcomes such as interest, performance, and persistence in math-related fields (Chow et al., 2012; Lazarides et al., 2020; Lin et al., 2018). By extension, the current study's approach of comparing participants with differing levels of math self-concept should provide insight into specific events and appraisal patterns that contribute to qualitatively different math outcomes. In addition to building on existing empirical work, insights gleaned from the current study's comparative approach may be useful in designing tailored interventions that support students who display particularly low levels of math self-concept.

Current Study

The current mixed-methods study examines how participants with particularly high or low math self-concept narrated their memories of a low point in math. Given the theoretical and empirical work associating math self-concept with important math outcomes, as well as recent work suggesting that narrative appraisals of past math experiences are associated with current math outcomes, we were interested in examining how participants' narrative interpretations of a math low point might vary with their current level of math self-concept. We not only aimed to uncover gender differences in these responses, but also sought to identify particularly poignant themes in the narration of these math experiences that might serve as engines for further research and intervention in math education. More specifically, we proposed the following hypotheses and research questions:

H1: There will be gender differences in the composition of the high and low math self-concept groups;

H2: Participants in the high math self-concept group will report lower math anxiety and higher math value than participants in the low math self-concept group;

RQ1: What are the similarities and differences in how participants with high and low math self-concepts narrate their math low points?

RQ2: Are there gender differences in the themes participants mention while narrating their math low points?

In examining these hypotheses and research questions, we conducted exploratory analyses testing for mean ethnic-racial differences when the sample size was sufficient. Although race and ethnicity were not a focal point in the current research, we reasoned that these exploratory analyses could help to inform future work that aims to understand racial-ethnic differences in STEM outcomes.

Method

Participants

A total of 754 undergraduates were recruited from a large, public university in the Southwestern U.S. Participants completed an online survey for course credit during the spring and fall semesters of 2018. All participants were enrolled in introductory psychology, which is a general education course taken by students from a variety of majors. Nearly all participants (97%) were between the ages of 18 and 34. Forty-six percent of the sample indicated that they were first generation college students. The full sample included 487 women (65%), 257 men (34%), three transgender men (<1%) and two transgender women (<1%). Five participants (<1%) did not indicate their gender identity. With respect to ethnic background, 244 participants (32%) identified as White, 210 participants (28%) identified as Hispanic/Latinx, 175 participants (23%) identified as Asian/Pacific Islander, 81 participants (11%) identified as Black/African American, 32 participants (4%) identified as "other", and 8 participants (1%) identified as Native American/American Indian, and four participants (<1%) did not indicate their race. Multiracial participants who identified with ethnic groups that are both underrepresented and overrepresented in STEM (e.g., Hispanic/Latinx and White) were grouped into the underrepresented category in the exploratory analyses. The full sample was used to confirm the two-factor structure of the abbreviated math anxiety scale, as well as to test for mean gender differences in math self-concept, math value, and math anxiety. As described below, the focal analyses for this paper were conducted on a subset ($n = 184$) of the full sample with particularly low or high math self-concept.

Procedure

Participants were recruited to participate in one of two anonymous online surveys through the university's introductory psychology subject pool. Some of the participants who took part in the current study also participated in a prior study focusing on past math experiences (Author et al., 2020). The survey used to collect data for both studies was first administered in spring of 2018 and again in spring of 2019. Participants from 2018 were prohibited from participating again in 2019. The data used for Author and colleagues (2020) were from the 2018 survey only, whereas the data for the current study include participants from both administrations of the survey. In addition to having a substantively different conceptual focus, the current study differs from Author and colleagues (2020) in terms of its analytic approach. Informed consent was obtained from all participants prior to beginning the survey. The survey included a demographic questionnaire, scales assessing math-related outcomes and general resilience, and several open-ended questions pertaining to participants' math-related experiences. The quantitative measures used in the current study are described below, followed by a description of the qualitative method for prompting participants to narrate a low point they had with math. The corresponding qualitative coding process is also discussed.

Quantitative Measures

Math Self-Concept. Math self-concept was assessed using the corresponding nine items from Watt and colleagues' (2012) math-specific expectancy-value measure. This measure asked participants to rate their agreement with the items on a scale from 1 (*disagree strongly*) to 6 (*strongly agree*). Sample items include "I am better at math than I am at other academic subjects" and "Math is fairly easy for me," with higher scores indicating higher math self-concept. This scale had excellent internal reliability ($\alpha = .92$).

Math Value. Math value was assessed using six items from Watt and colleagues' (2012) math-specific expectancy-value measure. This measure asked participants to rate their agreement with the items on a scale from 1 (*disagree strongly*) to 6 (*strongly agree*). Sample items include "I find it interesting to work on math projects and assignments" and "What I learn in math is useful for my daily life outside of school," with higher scores indicating higher math value. This scale had good internal reliability ($\alpha = .81$).

Math Anxiety. Two components of math anxiety were assessed using the abbreviated math anxiety scale (Hopko et al., 2003). The nine-item measure includes scenarios that are intended to capture the degree of anxiety caused by both learning and evaluation contexts involving math. Participants were asked to rate the amount of anxiety caused by each scenario on a scale of 1 (*low anxiety*) to 5 (*high anxiety*). Five items assess learning math anxiety (e.g., "Listening to a lecture in math class") and four items assess evaluation math anxiety (e.g., “Taking an examination in a math course”), with higher scores reflecting higher levels of math anxiety. The learning math anxiety subscale had good internal reliability ($\alpha = .86$), and the evaluation math anxiety subscale had excellent internal reliability ($\alpha = .90$).

Math Low Point

The current study sought to understand how participants recall a “low point” in their math education. We employed a math-specific version of McAdams (2008) life story approach, wherein all participants were encouraged to share a low point they had experienced with math in the past. The instructions began by asking participants to describe a past math-related episode that stood out as a particularly negative experience and asked them to elaborate in detail about when the event occurred, who was involved, and what they were thinking and feeling at the time. Instructions for the math-specific life story approach can be found in Appendix 6A.

Our analysis of math low points is focused on 184 participants who scored either one standard deviation above (*n* = 90, 12%) or one standard deviation below (*n* = 94, 12.5%) the calculated mean for math self-concept in the full sample (*M* = 2.92, *SD* = 1.38), resulting in one group with relatively high math self-concept (*High MSC*, M ≥ 4.30) and one group with relatively low math self-concept (*Low MSC*, M ≤ 1.54). Full demographic details for the two groups can be found in Table 6.1.

Qualitative coding. We used the steps for thematic analysis outlined by Braun and Clarke (2006) to examine common themes in participants’ qualitative responses. To begin, the first author read the full corpus of data and developed two coding manuals using a primarily inductive (i.e., data-driven) approach. Throughout the process of familiarizing themselves with the data, the first author noticed that there were both commonalities and uniqueness in the themes identified within the high and low self-concept groups. As such, two separate coding manuals were developed to best capture the qualitative data from each group. Themes from each coding manual were not mutually exclusive, meaning that participant responses could be coded under multiple themes. Following several revisions to the coding manuals, the second author and two trained research assistants used the manuals to separately code approximately 20% of the qualitative responses. Although Braun and Clarke (2006) do not require testing for interrater reliability in thematic analysis, other researchers have argued that interrater reliability is important for establishing replicability and rigor in qualitative data analysis (Syed & Nelson, 2015). Interrater reliability, indexed by Cohen's kappa (K), was high for both coding manuals: High MSC (K = 0.86-0.91); Low MSC (K = 0.84-1.00). Once interrater reliability was achieved, the two research assistants separately coded the remaining qualitative data. The second author and research assistants included an additional test of interrater reliability on the remaining data to ensure that agreement remained high throughout the coding process (K = 0.78-1.00). Disagreements were resolved through dialogue until consensus was reached.

Regarding the High MSC group, the qualitative coding process yielded five themes (for a summary of qualitative themes, see Table 6.2a). Valid percentages are reported for all coding categories. The most common theme for this group was *negative affective experience* (n = 42, 52%), followed by *teacher* (n = 23, 28%), *first time ability challenge* (n = 16, 20%), *bad grade* (n = 13, 16%), and *geometry* (n = 12, 15%). Regarding the Low MSC group, the qualitative process yielded six themes (see Table 6.2b). The most common theme for this group was *negative affective experience* (n = 53, 65%), followed by *bad grade* (n = 37, 46%), *teacher* (n = 34, 42%), *math aversion* (n = 31, 38%), *critical realization* (n = 15, 19%), and *upward comparisons* (n = 10, 12%). The themes for both groups are described in more detail below.

Results

Preliminary Analyses

A confirmatory factor analysis (CFA) established the expected two-factor dimensionality of the AMAS in the full sample, indicating one factor for learning math anxiety and a second factor for evaluation math anxiety (for a similar pattern, see Hopko et al., 2003). Preliminary quantitative analyses replicated gender differences that have been obtained in prior work in that men, when compared to women, reported significantly higher math self-concept and significantly lower learning and evaluation math anxiety. We found no gender differences with respect to overall math value in the full sample. A summary of these results can be found in the online supplemental material.

Our core findings are presented below in three sections. First, we present a preliminary analysis of gender differences in high and low math self-concept (MSC) group composition, in addition to group differences in math value and math anxiety. We also include an exploratory analysis of racial differences in high and low MSC group composition as well as racial differences in math value and math anxiety. Next, we provide a qualitative analysis detailing how participants in the high and low MSC groups narrated their math low points. Finally, we present a mixed-methods analysis of gender differences in the themes used to describe math low points for the high and low MSC groups. Cohen's (1988) heuristics are used when discussing small (0.10-0.30), medium (0.30-0.50), and large (0.50+) effect sizes for Cramer's V. Valid percentages are reported for all chi-square analyses, and inspection of standardized residuals was used to determine which group was driving any significant differences. With respect to partial eta squared, Cohen's effect size ranges correspond to values of 0.01-0.06 (small), 0.06-0.14 (medium), and 0.14+ (large; Lenhard & Lenhard, 2016). Due to power constraints, all quantitative gender analyses were completed using participants who identified within the gender binary (e.g., man or woman); however, responses from nonbinary participants in the high and low MSC groups were included in the qualitative analysis.

Quantitative Comparisons Between High and Low MSC Groups

Our first hypothesis (H1) predicted that there would be gender differences in the composition of the high and low MSC groups. Chi-square analysis and the evaluation of standardized residuals supported this hypothesis, with men comprising only 18.5% of the low MSC group, $\chi^2(1, N = 172) = 6.99$, $p = .008$, $V = .197$. This result indicates a small effect that aligns with gender differences found in prior research on math self-concept as well as the gender differences found in math self-concept in the full sample.

Given the diversity of our sample, we explored whether racial differences existed in the composition of the high and low MSC groups. Chi-square analysis and the evaluation of standardized residuals indicated no racial differences in the composition of the high and low MSC groups, $\chi^2(3, N = 176) = 4.544$, $p = .208$, $V = .161$. In contrast, a four-group MANOVA using the four largest ethnic groups from the full sample (White, Hispanic/Latinx, Asian/Pacific Islander, and African American/Black) revealed significant racial differences in the linear combination of learning math anxiety, evaluation math anxiety, math self-concept, and math value, $\Lambda = .853$, $F\ (4, 12) = 2.313$, $p = .004$. Follow-up univariate ANOVAs indicated a significant racial difference in math value only, $F\ (3, 172) = 2.689$, $p = .048$, Adj. $\eta_p{}^2 = .028$ (see Mordkoff, 2019 for a discussion of adjusted eta-squared), which constitutes a small effect. However, inspection of Bonferroni corrected pairwise comparisons indicated that Asian/Pacific Islander participants only reported marginally higher math value (M = 3.938) than did White (M = 3.320, p = .074) and Hispanic/Latinx participants (M = 3.285, p = .078), but not African American/Black participants (M = 3.540, p = 1.00). Overall, our analysis is not indicative of racial differences in math self-concept and related math outcomes in the current sample.

Our second hypothesis (H2) predicted that participants in the high MSC group would report lower math anxiety and higher math value than participants in the low MSC group. A two-group MANCOVA with gender specified as a covariate revealed significant group differences on the linear combination of learning math anxiety, evaluation math anxiety, and math value, Hotelling's $T^{2} =$ 314.035, $F(3, 176) = 101.759$, $p < .001$. As illustrated in Table 6.3, follow-up univariate ANOVAs indicated that participants in the high MSC group reported significantly lower learning math anxiety (Adj. $\eta_p^2 = .321$), lower evaluation math anxiety (Adj. $\eta_p^2 = .495$), and higher math value (Adj. $\eta_p^2 = .433$), than did participants in the low MSC group. These results constitute large effect sizes, although they are likely inflated due to the focus on high and low MSC groups. Importantly, gender was not a significant covariate, Hotelling's $T^{2} =$ 7.783, $F(3, 176) = 2.503$, $p = .061$, indicating that the gender binary does not explain additional variance in the linear combination of learning math anxiety, evaluation math anxiety, and math value after accounting for high and low levels of math self-concept. Overall, these results support our second hypothesis, but they do not shed light on why such disparate math outcomes exist between participants with high and low MSC. Our qualitative analyses aim to identify possible explanations for these outcomes.

Qualitative Comparisons Between High and Low MSC Groups

A key goal of the current study was to better understand how participants remember and narrate a particularly negative experience they had with math and examine whether different types of narratives are associated with participants' current level of math self-concept (RQ1). As previously mentioned, a primarily inductive approach was used to analyze the qualitative data, which allowed the researchers to identify themes in the data without prior theory or expectation. First, we present themes that were similar in content but differed in how they were discussed by the participants in each of the two groups. Next, we detail themes that were unique to each group.

Similar Low Point Themes. The narrative data yielded some "low point" themes that were similar in content across both High MSC and Low MSC groups. Importantly, however, these themes often differed in terms of emotional valence or outcome. The themes that were similar between both groups included the following: *bad grade*, *negative affective experiences*, and *teacher*.

The *bad grade* theme identified students who at least partially attributed their low point to receiving either (a) an objectively bad grade (e.g., failing) or (b) a lower grade than they expected to receive. High MSC students primarily discussed this theme in terms of receiving a lower grade than they expected, rather than what might more objectively be considered a "bad" grade (e.g., failing). Second, High MSC students often attributed the cause of their bad grade to two internal factors: a lack of effort in their own attempts to learn the material or overconfidence in their knowledge of the subject matter at the time. For example, Demi (all names are pseudonyms) explained how her high math confidence undermined her performance in a college math course: "I believed, since I had always done well in math, it would be the one class I didn't have to try as hard in... I ended up with a B in that class, which was the first time I had received anything less than an A in math." This response exemplifies how High MSC students often considered a lower-than-expected grade (e.g., receiving a "B"), as opposed to a failing grade, to be a low point. Another participant, Roman, indicated how his lack of studying contributed to a failing test grade:

> "We were finishing a chapter with topics that I did not feel completely comfortable with, but I decided I did not need to study as I thought I would be fine. The next day we had our chapter test and I felt confident in my abilities, however when taking the test, I realized I did not know how to do most of the problems. I was thoroughly disappoint[ed] in myself that I did not study and that test ended up being the first and only math test I have ever failed."

Whereas High MSC participants typically attributed receiving a poor or lower-than-expected grade to low effort or overconfidence, Low MSC participants not only discussed failing grades more often, but also provided a wider range of internal attributions for their disappointing grades. These attributions included low effort, frustration, and difficulty understanding the material, which are exemplified in Eric's response: "I quickly fell behind [in algebra]. This failure to understand topics led to a disheartening feeling towards homework. A lack of desire to do homework led to a failure to understand topics. This cycle ensued for my entire sophomore school year. This algebra class was the first ever time I received a C grade in a class." Interestingly, several low MSC participants referenced *math aversion* alongside the *bad grade* theme, sometimes as an attribution for why they received a bad grade. For example, Esme described a difficult experience with a math course that contributed to her math aversion:

> "… I was extremely nervous, especially since math is not my strong suit at all. As soon as the class began, the professor immediately jumped into the lesson with no hesitation. Being that math is a hard subject for me to grasp, I became very overwhelmed by all the new material being thrown at me ... As the quarter went on, I still wasn't understanding anything and I was also failing every test and quiz. Though [my friend] tried to teach me the lessons herself after class, I still wasn't able to grasp the material. I stopped going to the class and ended up with an F on my transcript."

In addition, some Low MSC participants mentioned receiving a bad grade despite their concerted efforts to study or understand the material. For instance, Katie mentioned the amount of effort she put into studying for an exam, only to receive a failing grade: "On my first math test I studied day and night and I had my friend try to tutor me because it was really hard. I felt so confident about how I wanted to do so I took my math test and it felt like no struggle at all. Then when I got my results, I saw that I failed my first math test." Another participant mentions failing a course, even after studying hard and asking for help: "It was the first class I was failing in ever. It seemed like no matter how much I studied [or] how much I asked for help, I couldn't get it right." This same participant also notes that this experience directly influenced her dislike for math when she says, "…ever since then, it seems like I still can't stand math. I will try my best to avoid it."

The *negative affective experiences* theme encompassed responses that included a negative emotional component, which was frequent across both High MSC and Low MSC groups when discussing math low points. For High MSC participants, the most referenced negative emotions included feelings of frustration (e.g., "The whole class was just extremely frustrating"), stress (e.g., "it stressed me out so much"), embarrassment, (e.g., "I was so embarrassed with myself"), and more generally feeling "upset." For example, Nadia recalled an experience where she struggled to understand the material, stating "I was extremely upset with myself because I truly did not understand the concepts that we were learning in class…" Another participant recalled, "I have never been so upset by math in all my life." Interestingly, High MSC participants typically referenced these emotions in reference to feeling confused about the material, or with regard to taking a particularly difficult exam. Amy's response exemplifies this tendency:

> "For the final last semester, I felt extremely rushed and I thought I knew what I was doing. For the whole [two] hours I was typing numbers in my calculator frantically and I still did not finish the exam ... Probably the most stress I have ever felt on an exam and especially a math class. I was extremely stressed, mad, and angry at myself for not understanding it."

The *negative affective experiences* reported by Low MSC participants were similar to those mentioned most frequently by the High MSC students, including references to feelings of frustration (e.g., "I became very frustrated"), stress (e.g., "this class really stresses me out"), and embarrassment (e.g., "I felt embarrassed in front of my peers). Notably, Low MSC participants elaborated on their negative emotions more than did High MSC participants, often referencing more than one negative emotion in their responses and providing more context for why the negative emotions occurred. Low MSC participants also made more references to anxiety, specifically, than did High MSC participants. For example, Mya recalled a particularly difficult test experience, where she felt aggravated, dejected, embarrassed, and anxious:

> "Seeing everyone around me doing fine with the exam made my struggle with it that much more aggravating … I felt so dejected ... I considered writing a note to my teacher on the exam, apologizing and explaining why most of the exam was blank. Instead, I tried to ignore my warm face and embarrassment as I wrote down answers that I knew were probably wrong. I strained myself, trying to remember every lecture up to that point, in order to solve the problems before me…That has basically been my experience with math my entire life – getting anxious and dejected when I can't figure the problems out..."

Another participant clearly details her lived experience with math anxiety, and how it has affected her *math aversion* over time:

> "In every math class I have taken I have ALWAYS experienced this issue and traumatic event. I will prepare myself for an exam a week prior ... When the exam day hits, I get major test anxiety, and I have to take a few deep breathes before starting. I start my test with my heart racing because I have anxiety. My test anxiety heightens as I see my peers get up from their seats, and hand in their tests. I tend to get jittery at this point because I am not sure if I am slower or faster than my peers who are taking the test. My heart is still racing as I finish my exam, and I look over my answers one to two times … My anxiety … heightens once I get home, as I lay thinking about my score. I check my grade, and it is not the grade I wanted to have after studying. I cry, and my negative thoughts spread … I always felt like math wasn't my strongest suit, and I had to work harder than others to understand … I question what I did wrong as a person or if I am just stupid. Math in general gives me bad vibes as I am scared to try or even answer simple math problems without doubting the answer."

Low MSC participants also referenced behaviors that typically accompany negative emotions, such as crying, more often than did High MSC participants. This can be seen in the example above, in addition to another participant who stated, "The most stressful experience I had with math was taking Algebra 2 Honors. In that class, I felt like crying all the time." Another student mentioned feeling "so discouraged" and "worthless" because of her math exam performance that she went home and cried afterward. In general, the *negative affective experiences* theme encompassed a wide range of negative emotions that participants felt in their math low points for both High MSC and Low MSC participants. Although there was quite a bit of overlap in the types of negative emotions mentioned by both groups, the ways in which the emotions were described and explained indicates that Low MSC individuals experienced a wider breadth of negative emotions as well as a wider variety of experiences that caused those negative emotions.

Finally, both High MSC and Low MSC participants referenced *teachers* as key components in their math low points. The *teachers* theme included responses that mentioned a teacher or professor, specifically, who contributed to the participants' math low points. This typically involved a teacher who created a bad experience for the participant through ineffective teaching or negative interpersonal interactions. Mentions of ineffective teaching were particularly prominent for High MSC participants. For instance, Ian discussed how his teacher provided material but did not explain it well: "In my first semester of college, my first math teacher was horrendous. She did not teach, rather just gave us notes and gave us brief explanations of each topic. It was horrible that our first test average was a 66 percent…" Shayla recalled a teacher who seemed uninterested in teaching the material, explaining that "the teacher was not helpful … he would explain the bare minimum then sit at his desk for the rest of the class period." Other participants expressed similar sentiments about teachers who they felt were ineffective, with statements such as, "the way [the teacher] taught made it hard to learn the material," and "the teacher didn't teach very well." Relatively few High MSC participants recalled negative interpersonal interactions with their teachers, but those that did typically recalled experiences that related back to their grades or status in comparison to others. For instance, Talia recalled how the consequences of not being recommended for an advanced math class in elementary school followed her throughout the rest of her education:

> "… Believing that I was among the smartest students in my grade, I thought I would be recommended for the algebra class. Sadly I wasn't, but many of my friends were. Because of this, I felt particularly unintelligent ... This day has stuck with me all this time because all throughout middle school and high school I was one grade level of math behind many of my close friends, but I shouldn't have been…"

Another participant recalled a negative interaction when a teacher accused her of cheating, "… [the teacher] made a point to come over to my desk and write a large zero on the top of my quiz. I was humiliated and confused as to what I had done to deserve that, so I asked my teacher "I'm confused, why did I get a zero?" And she accused me of cheating in front of the entire class."

Whereas High MSC participants mentioned ineffective teaching more often than negative interactions with their teachers, the opposite was true for Low MSC participants. The few Low MSC participants who did mention ineffective teaching had similar sentiments as the High MSC participants. However, in contrast to High MSC participants, Low MSC participants who mentioned negative interpersonal interactions seemed to recall more personally distressing scenarios that also included references to *negative affective experiences*. These often included being made to feel "stupid" or feeling humiliated by their teacher. For instance, Angela recalled being chastised by the professor in front of her class:

> "… I was called on to answer a math question on our homework. Although I got the answer correct, I didn't read the problem the way the professor wanted me to and although I don't think he meant to, I felt like he humiliated me in front of my whole class. He basically said that me not knowing how to read the math problem is the fault in the American education system, like I'm the epitome of what's wrong with this country's education."

Another participant, James, recalled a teacher who not only singled him out, but also laughed at him for not knowing an answer:

> "The teacher, who had prior to this incident made fun of me in front of the class, asked me to answer the problem. I hadn't raised my hand, but I was paying attention; though still confused on how to solve the problem on the board. I don't remember exactly what the problem was, but I told my teacher that I didn't know the answer. She then told me to guess just to make it go faster. I guessed something completely wrong and my teacher laughed. Then yelled at me in front of the class. Another student yelled out the answer and she was immediately praised and I was told to be more like the other student and to get my act together. I was so humiliated that I just put my head down and cried for the rest of the day."

Unfortunately, a few Low MSC participants recalled particularly troubling experiences, such as being explicitly discouraged from pursuing math. For instance, Ava explained:

> "When I was a sophomore in high school my high school math teacher told me no matter how hard I try to be good at math I never will be, and I should just give up. I personally always knew I was never strong in math but I never believed in giving up. This moment was by far the worst because I had a mentor in my life telling me I would never be good enough."

Generally, the *teacher* theme included participants whose math low point was partially due to their math teacher. Although there was overlap between High MSC and Low MSC responses when discussing ineffective teaching, the types of experiences and emotional valence between the High MSC and Low MSC groups were notably different when discussing negative interpersonal interactions with teachers.

Unique High Math Self-Concept Themes. Narrative data from the High MSC group yielded two unique themes that were not present in the Low MSC group: *first time ability challenge* and *geometry.* The *first time ability challenge* theme included participants who mentioned that their low point originated from some struggle with the math material being taught at the time. These participants often mentioned that this experience was the first time they had ever struggled with math or academics more generally. For example, Charlotte explained her shock at failing a math test when she had performed so well in her previous math classes: "… I saw that I [failed] and my heart just dropped to my stomach. I could not believe that I had done so awful … All through high school I was amazing at math. I understood everything the first time and I would get an A on every test. Last semester I took Math 126 and I almost got 100% on every exam…" Olivia mentioned a classroom experience during which she felt lost with the math content being reviewed:

> "… I was really confused. I saw [the teacher] writing things on the board and I heard her explaining those things, but I did not know how to arrive to the same solution when doing things on my own… I had always been good at

> math, the lowest grade I ever earned was a B in Algebra 2, so I felt that I would somehow figure it out on my own, but that never happened."

In general, the *first time ability challenge* theme reflected participants who were surprised and frustrated by their struggles with math.

Another theme unique to the High MSC group was *geometry*. These students mentioned that their low point occurred when they were learning geometry for the first time. For instance, Josie noted, "A low point in math for me was learning geometry my first year of high school… This particular moment was bad because it was an entire class dedicated to my weakest subject in math." Another student recalled how geometry, in particular, was the first time she had struggled with math, also resulting in a code for *first time ability challenge*: "A negative experience was when I took geometry sophomore year… and I had trouble grasping the topic; I have never had a hard time with math ever and it put a strain on me that I did not like at all; I would get very emotional… because I wasn't getting it." In general, the *geometry* theme reflected participants who, despite their high math self-concept, recall geometry as their lowest point with math.

Unique Low Math Self-Concept Themes. Narrative data from the Low MSC group yielded three unique themes that were not presented in the high MSC group: *math aversion, upward comparisons,* and *critical realization*. The *math aversion* theme included participants who referenced any long-term struggle with math, lack of natural math ability, or strong dislike for math in general. For example, Mia mentioned, "I have cried in almost all of my math classes… I have always been bad at [math] and feel as if I will never improve," whereas Elizabeth succinctly stated, "Math has always been a low point for me." One student, Margaret, even referenced the memory of when she began to have trouble with math:

> "I strongly dislike math and can actually remember the exact instant in which I began to dislike the subject. It was eighth grade and I was in an advanced math; I was struggling all year, something I was not used to … although I would stay and get tutored after school, it was still not enough …

> I still did poorly on the exams [and] my teacher's horrific attitude made me hate [math] and feel very discouraged in the subject."

In general, the *math aversion* theme reflects participants who have continuously struggled with math during their education, including those who reported an enduring dislike of the subject.

Narratives that included the *upward comparisons* theme referenced feelings of fear or pressure that surfaced when participants made comparisons between themselves and their peers in math. For instance, one participant recalled an experience where she compared herself to a male classmate who did not seem to work as hard in the math class: "We took the test and I felt I did okay on it, and the boy next to me who didn't even know we had a test thought it was super easy… [he] got a really high B without even studying, while on the other hand I tried understanding the topic and I got a D." Another participant, Lily, recalled an experience while taking a college math class with her friend: "…I was failing every test and quiz. This was really upsetting to me because my friend was also in the class and she seemed to understand the material enough to get C's on the tests and quizzes." In general, the *upward comparisons* theme encompassed responses where participants reflected on feeling disappointed because they were not performing as well as their peers or did not feel as capable as their peers in math.

Finally, the *critical realization* theme occurred when participants alluded to their low point experience as a critical moment in their relationship with math. These responses often mentioned some type of realization or discovery about their negative feelings towards math, or about their future with math. For instance, Audrey mentioned remembering the exact moment she began feeling anxious about math, and how this experience determined her future with math:

> "I remember the exact moment I started having what is called "math anxiety." I was in the third grade, 1983, and we started having timed math tests … When the test was handed out, I specifically felt very unprepared. I

> wasn't ready to be timed, I was still learning, and it was upsetting to me. I knew that I would do poorly because I wasn't ready to be tested ... I felt shame when I handed my test in. This was also the first time I perceived tests as being intimidating. Instead of seeing learning math as an ongoing process, learning at my own pace, it became "either you get it or you don't." I put math in the, 'it's just not for me category.'"

Another participant recalled a particularly bad experience that led her to believe that she would never do well in math:

> "… I felt as though I was the only student who didn't understand what was going on. Whenever we went over the homework, I always got a majority of the questions wrong and always needed help. Alongside needing help, I felt as though other people thought it was silly that I couldn't catch up… I ended up failing the first semester of the class. I was devastated [and] it was horrifying knowing that I was going to have to retake this math course. I tried getting help from my friends and those who were excelling… but I could never grasp the content. It was such a bad experience because in that moment, I labeled myself as a horrible math student and that I would never ever excel in a math course as long as I'm in school."

In general, the *critical realization* theme encompassed responses wherein Low MSC participants clearly identified their low point with math as a critical moment that determined either the expectation for a continued struggle with math, or a desire to abandon math altogether.

Mixed-Methods Comparative Analysis

In addition to examining the variation in math low point themes, we were also interested in whether gender differences would occur in the themes used to narrate math low points (RQ2). Chi-square analyses were only completed for the themes that had adequate sample sizes and statistical power for each group. With regard to the High MSC group, chi-square analyses revealed no gender differences in mention of the *negative affective experiences* theme ($\chi^2(1, N = 80) = .083, p = .773,\ V = .032$), or the *first time ability challenge* theme, ($\chi^2(1, N = 80) = .000, p = 1.000,\ V = .000$). With regard to the Low MSC group, chi-square analyses revealed no gender differences in mention of the *negative affective experiences* theme ($\chi^2(1, N = 79) = 1.858,\ p = .173,\ V = .153$), the *math* *aversion* theme ($\chi^2(1, N = 79) = 1.434, p = .231,\ V = .135$), or the *bad grade* theme ($\chi^2(1, N = 79) = .081, p = .776,\ V = .032$).

In contrast to these null effects, a chi-square analysis indicated a significant gender difference in the *teacher* theme for the Low MSC group. More specifically, an inspection of standardized residuals indicated that men in the Low MSC group were significantly less likely than women in the Low MSC group to mention teachers as the source of their math low point, $\chi^2(1, N = 79) = 4.37, p = .037, V = .235$, which constitutes a medium effect. We did not have adequate power to run exploratory chi-square analyses regarding differences in theme by racial group.

Discussion

Findings from the current research reveal key differences and similarities between participants with high and low math self-concept. In particular, the current findings offer insight into how narrative appraisals of a past low point in math are associated with current math self-concept and provide novel evidence to support the reciprocal relation between past achievement experiences and achievement motivation outcomes that is theorized in situated expectancy-value theory (SEVT; Eccles & Wigfield, 2020). In addition, the current study joins an emerging body of work that highlights the importance of considering individual differences in affective attributions and narrative interpretation when exploring math outcomes. Specifically, qualitative analysis of participants' narrations of a math low point provided key insight into how components of both situated expectancy-value and control-value theories play out in education, as well as how narrative interpretations vary with current math self-concept. Analyses revealed expected gender differences in levels of math self-concept and provide novel insight into how interactions with key socializers may be particularly important for girls as they learn math.

Math Low Points: Similar Themes

Several themes were present across both the High and Low MSC groups: *bad grades, negative affective experiences*, and *teachers*. This suggests that certain types of math experiences are generally interpreted as unpleasant, regardless of individual math self-concept. However, despite broad thematic similarities across these low points, the way in which they were narrated often varied with level of math self-concept. For instance, participants in both groups mentioned *teachers* as key actors in their low point experiences. However, High MSC participants more often referenced ineffective teaching or a dislike for how a math course was managed as the reason for their low point. In contrast, Low MSC participants more often referenced negative interpersonal interactions with their math teachers as the key factor in their low point. This aligns with research suggesting that student perceptions of interaction quality with their math teachers are associated with their math self-concept and engagement (Perera & John, 2020; Rimm-Kaufman et al., 2014). Other qualitative research has suggested that negative affective components of teacher-student interactions in the math classroom can create interactional patterns that constrain students towards failure in math (Heyd-Metzuyanim, 2013). In other words, negative interpersonal encounters in the math classroom are likely to be more memorable and impactful for students' math self-concept. This may explain why low MSC participants often referenced negative interpersonal interactions with their math teachers as key factors in their low point stories, whereas High MSC participants did not.

Within the *bad grade* theme, participants in the High MSC group tended to elaborate on how their performance on some math task failed to meet their own expectations. Interestingly, participants often interpreted these experiences by accepting that their own overconfidence or lack of effort resulted in a poorer grade than anticipated. On the other hand, participants in the Low MSC group more often narrated objective failures, provided more detailed descriptions of their emotions, and elaborated on the consequences of the *bad grade* experience for their future with math. The discrepancies in how similar experiences with bad grades are interpreted by participants with high and Low MSC further illustrate the importance of understanding how narrative appraisal patterns are related to academic outcomes (Eccles & Wigfield, 2020).

The responses from the Low MSC group for the *bad grade* theme also clearly depict the reciprocal relationships between self-concept, emotions, and outcomes that are theorized by the control value theory of achievement emotion (CVT; Pekrun et al., 2007). As quoted earlier, Eric's narrative described a cycle whereby his confusion with the course material led to negative emotions towards the coursework, thereby exacerbating his poor performance in the class. This only led to more confusion, negative emotions, and worse performance. Allison described a similar experience, in which she repeatedly tried, failed, and ultimately became disheartened by math, "It was eighth grade year and I was in an advanced math class, I was struggling all year … Although I would stay and get tutored after school, it still was not enough and I still did poorly on the exams. That made me hate [math] and feel very discouraged in the subject." A related pattern was also present in the *negative affective experiences* theme, where participants in the Low MSC group referenced math anxiety more often than participants in the High MSC group. This aligns with our quantitative results which suggest a negative association between math self-concept and math anxiety. Given the reciprocal relations that have been found between math self-concept, math anxiety, and math outcomes (Ahmed et al., 2012; Pekrun et al., 2007), it is unsurprising that participants with low math self-concept often detailed how their repeated experiences with math anxiety contributed to their math aversion.

Math Low Points: Unique Themes

Although participants with both High and Low MSC reflected on some similar experiences, unique themes were also identified within each group, indicating that certain types of low point experiences may influence the development of high or low math self-concept over time. Two unique themes were identified for participants with High MSC: *First time ability challenge* and *geometry*. Interpretation patterns for these themes mirror those from other themes for High MSC participants. More specifically, participants who *mentioned first time ability challenge* and *geometry* most often referred to an experience in which their expectations for themselves were not realized. From a narrative identity standpoint, negative events require more “storytelling” than positive ones. Although some individuals may avoid processing deeply negative events, those who can engage in causal reasoning to explain the event are more likely to come to understand it as redemptive: an event in which something bad can lead to something good (McAdams, 2008). Future work should explore whether participants with high levels of math self-concept are more likely to engage in redemptive storytelling and appraise their experiences with failure as motivation to improve.

Three unique themes were identified for participants with Low MSC: *math aversion*, *upward comparisons*, and *critical realization.* The *math aversion* and *critical realization* themes likely tapped the notion of self-defining memories, or recurring experiences that trigger a re-evaluation of one’s identity. For these Low MSC participants, it was often not just a single bad experience, but consistently negative experiences with math over time that led to the realization that they should no longer pursue the domain. This aligns with findings from John and colleagues (2020), who found that consistently negative narrations of a math experience were associated with a greater likelihood to avoid math in the future. Future research should explore how consistently bad experiences with math relate to fluctuations in math self-concept over time, and whether similarities in appraisal patterns or negative experiences with math are related to these fluctuations. In addition, while academic self-concept is an important component of both achievement and pursuit, some research suggests that the combination of self-concept and values in a domain is a better predictor of pursuit (Eccles, 1994; Eccles & Wang, 2016; Lauermann et al., 2017). As such, future research interested in predictors of math or STEM career pursuit might consider how math narratives are related to profiles of both math self-concept and value.

The *upward comparisons* theme demonstrates the social component of self-concept, as theorized by SEVT. Within this theme, participants were primarily concerned with how their performance on a math task would compare with their peers. The mention of socializers for participants in the Low MSC group is unsurprising, given the common gender stereotypes surrounding math ability and that women were overrepresented in the Low MSC group. Because stereotypes are socially reinforced (Bigler & Liben, 2006; Koenig & Eagly, 2014; Starr & Simpkins, 2021), socializers become acutely important in the development of math self-concept and future career interests (Riegle-Crumb & Morton, 2017; Robnett & Leaper, 2012). Some prior research on social comparisons indicates that upward comparisons result in lower academic self-concept (Pulford et al., 2018; Wolff et al., 2018). This aligns with the current results, which suggest that upward social comparisons contribute to math low point experiences for students with low math self-concept. However, other research indicates that the effect of social comparisons on academic self-concept is moderated by a variety of factors including choice (whether the comparison is imposed or chosen) and approach or avoidance tendencies (see Boissicat et al., 2021 for a review). Future qualitative and mixed-methods research should more deeply explore how students with different levels of math self-concept appraise social comparison situations in math.

Gender Differences: The Role of Teachers

Few gender differences surfaced in the themes, suggesting that despite the gender differences found in average levels of math self-concept, participants with similarly high or low levels of math self-concept tend to interpret their math low point experiences in comparable ways. However, this was not true for the *teachers* theme with low MSC participants. More specifically, men in the Low MSC group were significantly less likely to mention *teachers* than were women in the same group. This, combined with the tendency for Low MSC participants to mention negative interpersonal interactions when discussing teachers, suggests that teachers may be particularly important socializers for girls in math-specific contexts.

Given the low number of men in the low MSC group, this singular gender difference should be interpreted with caution. However, prior research does provide evidence to support this result. Indeed, prior work has found that girls are more likely to be harmed by low teacher expectations and teachers' own gender stereotypes in math than are boys (Ketenci et al., 2020; Wang, 2012), and research has consistently found that teachers' own expectations for student success can affect student self-expectancies and performance (see Wang & Degol, 2013). For example, teachers tend to believe that boys have more natural math ability than do girls (Gunderson et al., 2012; Jaremus et al., 2020; Tiedemann, 2002) and these beliefs can influence how they interact with students in the math classroom. These teachers may ask fewer questions of girls and provide less praise to girls in the math classroom, which can reinforce the stereotype that girls do not belong in math (Becker, 1981). Ava's recollection of a math teacher telling her that she would never be good at math most clearly exemplifies the impact that negative interpersonal interactions with math teachers can have on girls and women. However, participants also referenced other types of negative experiences with teachers, often noting how they were embarrassed or publicly mocked. For example, Zoe notes: “I asked the professor a question, to which he replied in front of the entire class that I needed to use my brain and think about it for a while. I never got the answer to my question and because of that I never asked that professor anymore questions…” Savannah recalls a similar experience, in which her math teacher would “ridicule [her] in front of the class for not being able to answer questions correctly.”

Person-centered work also supports the notion that teachers are critical socializers for students in math. For instance, Lazarides and colleagues (2020) found that students who reported higher levels of teacher fairness and friendliness in math were less likely to move out of a high math motivation profile over the course of the academic year. Another study by Lazarides and colleagues (2019) found that students who perceived greater teacher support were more likely to move from a medium math motivation profile to a high math motivation profile. By suggesting that positive teacher classroom behaviors can improve and sustain math motivation over time, these studies compliment the current findings, which suggest that negative teacher behaviors may be detrimental to students’ math self-concept over time. Future work should continue to explore common types of negative teacher behaviors that might contribute to low math self-concept, in addition to understanding whether certain teacher behaviors might influence math self-concept differently for girls and boys.

Limitations and Future Directions

Results from the current study should be interpreted with the consideration of several limitations. First, by focusing only on participants with relatively low and high math self-concept, we were unable to gather an understanding of what math low point narratives and appraisal patterns might look like for individuals with moderate levels of math self-concept. Some person-centered work indicates that membership in profiles characterized by moderate levels of math self-concept is less stable over time (see Lazarides et al., 2020), which suggests that people with average levels of math self-concept may be most susceptible to experiences that can enhance or harm their math self-concept. As such, these individuals may benefit most from interventions designed to enhance math self-concept. The current research has illuminated how narrative appraisals of past math low points are related to high and low levels of math self-concept, and a logical next step for future research would be to explore the content of math life story narratives and appraisal patterns for individuals with moderate levels of math self-concept.

Another limitation pertains to the cutoff points used to determine membership in the High and Low MSC groups. Given the developmental nature of math self-concept, as well as the various scales used to measure the construct across the literature, there is no global determination for what constitutes “high” or “low” math self-concept. Our choice to use one standard deviation above and below the mean as the determinants for belonging to the high and low MSC groups, respectively, was guided by our interest in understanding the similarities and differences in appraisals of math low points for participants who had higher or lower than average math self-concept. More specifically, we wanted to ensure that the measured levels self-concept for our focal groups were different enough from the sample average, while also ensuring that we did not inadvertently perform an outlier analysis, the results of which would not be generalizable. However, future mixed methods work in this domain should consider using person-centered approaches for determining typologies of math achievement motivation alongside narrative accounts of past math experiences.

It should also be noted that, given the reciprocal nature of how affective interpretations of past experiences influence achievement motivation outcomes, and that identity development is a lifelong process whereby past experiences are constantly being used to adjust and cohere a sense of self (McAdams, 2008), we cannot be sure if participants’ narrative interpretations influence their current math outcomes, or if participants’ current math outcomes influence how they interpret past events. Future work in this arena should employ longitudinal methods to explore the directionality of these associations. In addition to providing insight into how these past low point experiences might have influenced participants' math self-concept, the patterns present in both groups could also suggest that participants are motivated to understand their past low point experiences in ways that align with their current self-concepts (Wilson & Ross, 2003). For instance, participants with High MSC can maintain a coherent sense of self by interpreting their low point as some type of learning experience, or a past mistake that has since been corrected. In contrast, participants with Low MSC can maintain their current identities by interpreting their low point confirmation that they lack math abilities or should avoid math altogether. Indeed, despite the wealth of quantitative literature suggesting clear gender differences in math experiences and outcomes, results from the current study suggest that there are more similarities than differences in how men and women interpret their past low points in math. This may be an indicator that current levels of math self-concept influence how past events are interpreted and incorporated into the current sense of self.

Finally, the current research was focused primarily on the gender binary and excluded the three nonbinary participants from quantitative analysis due to inadequate power. However, an increasing amount of research indicates that there are more similarities between men and women than there are differences, and that the gender binary is increasingly becoming an outdated construct (see Hyde et al., 2019). If exploring gender is critical to the research, future work should, at a minimum, ensure that there is adequate statistical power to include the experiences of transgender and nonbinary individuals in all analyses.

Conclusion

The current study builds on an emerging body of literature that suggests narrative appraisals of past math experiences can provide a nuanced glimpse into the events that participants believe have influenced their math self-concept. Results from the current work suggest that although there are many similarities in the types of experiences participants have with math during their education, appraisal patterns and interpretations of these experiences differ with current levels of math self-concept. Indeed, participants with relatively high math self-concept often took a more positive approach to a past math low point by seeing the negative event as opportunities for growth and betterment. On the other hand, participants with relatively low math self-concept were more inclined to reference repeated negative experiences, focus more on negative emotions, and indicate how the negative events fostered an aversion to math. The current research also pinpoints certain experiences that may contribute to reduced math self-concept, such as upwards comparisons to peers in the math classroom and negative interpersonal interactions between math teachers and students. Mixed-methods analysis revealed that bad experiences with math teachers were most memorable for girls with relatively low math self-concept. Results from the current research clearly illuminate paths for future educational interventions. In addition, the current study underscores the value of qualitative and mixed-methods research in moving towards a more comprehensive understanding of the factors that contribute to the gender gap in math-intensive STEM careers.

References

Arens, A.K., Schmidt, I., & Preckel, F. (2019). Longitudinal relations among self-concept, intrinsic value, and attainment value across secondary school years in three academic domains. *The Journal of Educational Psychology*, *111*(4), 663-684.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181–185.

Ahmed, W., Minnaert, A., Kuyper, H., & Van der Werf, G. (2012). Reciprocal relationships between math self-concept and math anxiety. *Learning and Individual Differences*, *22*(3), 385–389. https://doi.org/10.1016/j.lindif.2011.12.004

Ahmed, W. (2018). Developmental trajectories of math anxiety during adolescence: Associations with STEM career choice. *Journal of Adolescence*, *67*, 158–166. https://doi.org/10.1016/j.adolescence.2018.06.010

Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin, 147*(2), 134-168. https://doi.org/10.1037/bul0000307

Beede, D., Julian, T., Langdon, D., McKittrick, G., Khan, B., & Doms, M. (2011). Women in STEM: A gender gap to innovation. Retrieved from: https://files.eric.ed.gov/fulltext/ED523766.pdf

Becker, J.R. (1981). Differential treatment of females and males in mathematics classes. *Journal for Research in Mathematics Education, 12*(1), 40-53. https://doi.org/748657

Bigler, R. S., & Liben, L. S. (2006). A developmental intergroup theory of social stereotypes and prejudice. *Advances in child development and behavior*, *34*, 39-89. https://doi.org/10.1016/S0065-2407(06)80004-2

Boissicat, N., Fayant, M., Nurra, C., & Muller, D. (2021). Social comparison in the classroom: Priming approach/avoidance changes the impact of social comparison on self-evaluation and performance. *British Journal o f Educational Psychology,* 1-16. https://doi.org/10.1111/bjep.12466

Bong, M. & Skaalvik, E.M. (2003). Academic self-concept and self-efficacy: How different are they really? *Educational Psychology Review, 15*(1), 1-40.

Cerva, S. (2019). Looking gender and science at micro level: Narrative identity and the socialization of master narratives. *International Journal of Social Sciences and Education, 9*(3), 37-52.

Chow, A., Eccles, J., & Salmela-Aro, K. (2012). Task value profiles across subjects and aspirations to physical and IT-related sciences in the United States and Finland. *Developmental Psychology, 48*(6), 1612-1628. https://psycnet.apa.org/doi/10.1037/a0030194

Chrobot-Mason, D., & Aramovich, N. P. (2013). The psychological benefits of creating an affirming climate for workplace diversity. *Group & Organization Management, 38*(6), 659–689. https://doi.org/10.1177/1059601113509835

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

Committee on STEM Education, National Science & Technology Council (2018). *Charting a course for success: America's strategy for STEM education*. Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

Dietrich, J. & Lazarides, R. (2019). Gendered development of motivational belief patterns in mathematics across a school year and career plans in math-related fields. *Frontiers in Psychology, 10,* 1-5. https://doi.org/10.3389/fpsyg.2019.01472

Eccles, J.S. (1983). Expectancies, values, and academic behaviors. In Spence, J.T. (Ed.), *Achievement and Achievement Motives: Psychological and Sociological Approaches* (pp. 75-146). W.H. Freeman.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. Model of Achievement-Related Choices. *Psychology of Women Quarterly*, *18*(4), 585–609. https://doi.org/10.1111/j.1471-6402.1994.tb01049.x

Eccles, J. S., & Wang, M. T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106. https://doi.org/10.1177/0165025415616201

Eccles, J.S. & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on achievement motivation. *Contemporary Educational Psychology, 61,* 1-13. https://doi.org/10.1016/j.cedpsych.2020.101859

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Girls and mathematics —A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education*, *22*(4), 497–514. https://doi.org/10.1007/BF03173468

Gaspard, H., Wigfield, A., Jiang, Y., Nagengast, B., Trautwein, U. & Marsh, H.W. (2018). Dimensional comparisons: How academic track students' achievements are related to their expectancy and value beliefs across multiple domains. *Contemporary Educational Psychology*, *52,* 1-14. https://doi.org/10.1016/j.cedpsych.2017.10.003

Gharehgozli, O., & Atal, V. (2020). Revisiting the gender wage gap in the United States. *Economic Analysis and Policy, 66,* 207-216. https://doi.org/10.1016/j.eap.2020.04.008

Gunderson, E.A., Ramirez, G., Levine, S.C., & Beilock, S.L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles, 66*, 156-166. https://doi.org/10.1007/s11199-011-9996-2

Habermas, T. & Bluck, S. (2000). Getting a life: The emergence of the life story in adolescence. Psychological Bulletin, 125(5), 748-769. https://doi.org/10.1037/0033-2909.126.5.748

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33–46. https://psycnet.apa.org/doi/10.2307/749455.

Heyd-Metzuyanim, E. (2013). The co-construction of learning difficulties in mathematics-teacher-student interactions and their role in the development of a disabled mathematical identity. *Educational Studies in Mathematics, 83*, 341-368. https://doi.org/10.1007/s10649-012-9457-z

Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS): Construction, validity, and reliability. *Assessment, 10*(2), 178–182 doi: 10.1177%2F1073191103010002008.

Howard, M., & Hoffman, M. (2018). Variable-centered, person-centered, and person-specific approaches: Where theory meets the method. *Organizational Research Methods, 21*(4), 846-876. https://doi.org/10.1177%2F1094428117744021

Huang, C. (2013). Gender differences in academic self-efficacy: A meta-analysis. *European Journal of Psychology of Education*, *28*(1), 1–35. https://doi.org/10.1007/s10212-011-0097-y

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). Gender similarities characterize math performance. *Science, 321*(5888), 494–495. https://doi.org/10.1126/science.1160364

Hyde, J.S., Bigler, R.S., Joel, D., Tate, C.C., van Anders, S.M. (2019). The future of sex and gender in psychology: Five challenges to the gender binary. *American Psychologist, 74*(2), 171-193. http://dx.doi.org/10.1037/amp0000307

Jaremus, F., Gore, J., Prieto-Rodriguez, E., & Fray, L. (2020). Girls are still being “counted out”: Teacher expectations of high-level mathematics students. *Educational Studies in Mathematics, 105*, 219-236. https://doi.org/10.1007/s10649-020-09986-9

Jiang, S., Simpkins, S. D., & Eccles, J. S. (2020). Individuals’ math and science motivation and their subsequent STEM choices and achievement in high school and college: A longitudinal study of gender and college generation status differences. *Developmental Psychology*, *56*(11), 2137–2151. https://doi.org/10.1037/dev0001110

John, J.E., Nelson, P.A., Klenczar, B., & Robnett, R.D. (2020). Memories of math: Narrative predictors of math affect, math motivation, and future math plans. *Contemporary Educational Psychology*, *60,* 1-11. https://doi.org/10.1016/j.cedpsych.2020.101838

Ketenci, T., Leroux, A., Renken, M. (2020). Beyond student factors: A study of the impact on STEM career attainment. *Journal for STEM Education Research, 3,* 368-386. https://doi.org/10.1007/s41979-020-00037-9

Koenig, A. M., & Eagly, A. H. (2014). Evidence for the social role theory of stereotype content: observations of groups’ roles shape stereotypes. *Journal of personality and social psychology*, *107*(3), 371. https://doi.org/10.1037/a0037215

Kwon, H., Vela, K., Williams, A., & Barroso, L. (2019). Mathematics and science self-efficacy and STEM careers: A path analysis. *Journal of Mathematics Education*, *12*(1), 74–89. https://doi.org/10.1002/ss.333

Lauermann, F., Tsai, Y. M., & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.'s expectancy–value theory of achievement-related behaviors. *Developmental Psychology*, *53*(8), 1540–1559. https://doi.org/10.1037/dev0000367

Lazarides, R., Dietrich, J., & Taskinen. P. (2019). Stability and change in students' motivational profiles in mathematics classrooms: The role of perceived teaching. *Teaching and Teacher Education, 79,* 164-175.

Lazarides, R., Dicke, A., Rubach, C., & Eccles, J. (2020). Profiles of motivational beliefs in math: Exploring their development, relations to student-perceived classroom characteristics, and impact on future career aspirations and choices. *Journal of Educational Psychology*, *112*(1), 70-92. https://doi.org/10.1037/edu0000368

Lenhard, W. & Lenhard, A. (2016). Calculation of effect sizes. Dettelbach (Germany): Psychometrica. Retrieved from: https://www.psychometrica.de/effect_size.html. doi: 10.13140/RG.2.1.3478.4245.

Lin, L., Lee, T., & Snyder, L. (2018). Math self-efficacy and STEM intentions: A person-centered approach. *Frontiers in Psychology, 9,* 1-13. https://doi.org/10.3389/fpsyg.2018.02033

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30*(5), 520–540. https://doi.org/10.2307/749772.

Marsh, H., Ludtke, O., Trautwein, U., & Morin, A. (2009). Classical latent profile analysis of academic self-concept dimensions: synergy of person- and variable-centered approaches to theoretical models of self-concept. *Structural Equation Modeling: A Multidisciplinary Journal, 16*(2), 191-225. https://doi.org/10.1080/10705510902751010

Master, A., & Meltzoff, A.N. (2020). Cultural stereotypes and sense of belonging contribute to gender gaps in STEM. *International Journal of Gender, Science, and Technology, 12*(1), 152-198.

McAdams, D. P. (2001). The psychology of life stories. Review of General Psychology, 5(2), 100-122. https://doi.org/10.1037/1089-2680.5.2.100

McAdams, D. P. (2008). Personal narratives and the life story. In John, Robins, & Pervin (Eds.) *Handbook of Personality: Theory and Research* (3rd ed., pp. 242–262). Guilford Press.

McAdams, D. P., & McLean, K. C. (2013). Narrative Identity. *Current Directions in Psychological Science*, *22*(3), 233–238.

McCrudden, M. T., Marchand, G., & Schutz, P. (2019). Mixed methods in educational psychology inquiry. *Contemporary Educational Psychology*, *57*, 1-8. https://doi.org/10.1016/j.cedpsych.2019.01.008

McLean, K.C., Shucard, H., & Syed, M. (2016). Applying the master narrative framework to gender identity development in emerging adulthood. *Emerging Adulthood,* 1-13. DOI: 10.1177/2167696816656254

McLean, K.C., & Lilgendahl, J. (2019). Narrative identity in adolescence and adulthood: Pathways of development. In D. P. McAdams, J. Tackett, & R. Shiner (Eds.), *The Handbook of Personality Development* (pp. 418 – 432). New York: Guilford.

McLean, K. C., Boggs, S., Haraldsson, K., Lowe, A., Fordham, C., Byers, S., & Syed, M. (2019). Personal identity development in cultural context: The socialization of master narratives about the gendered life course. *International Journal of Behavioral Development*, *44*(2), 116–126. https://doi.org/10.1177/0165025419854150

Meece, J. L., Glienke, B. B., & Burg, S. (2006). Gender and motivation. *Journal of School Psychology*, *44*(5), 351–373. https://doi.org/10.1016/j.jsp.2006.04.004

Mordkoff, J. T. (2019). A simple method for removing bias from a popular measure of standardized effect size: Adjusted partial eta squared. *Advances in Methods and Practices in Psychological Science, 2*(3), 228–232. https://doi.org/10.1177/2515245919855053.

Nagy, G., Trautwein, U., Baumert, J Koller, O., & Garrett, J. (2006). Gender and course selection in upper secondary education: Effects of academic self-concept and intrinsic value. *Educational Research and Evaluation, 12*(4), 323-345. https://doi.org/10.1080/13803610600765687

National Science Foundation, National Science Board. (2020). *The State of U.S. Science & Engineering*. Retrieved from: https://ncses.nsf.gov/pubs/nsb20201

National Science Foundation, National Science Board. (2018). Science & Engineering Indicators. Retrieved from: https://www.nsf.gov/statistics/2018/nsb20181/assets/nsb20181.pdf

O'dea, R.E., Lagisz, M., Jennions, M.D., & Nakagawa, S. (2018). Gender differences in individual variation in academic grades fail to fit expected patterns for STEM. *Nature Communications,* 1-8. doi: 10.1038/s41467-018-06292-0

Østergaard, C. R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research Policy*, *40*(3), 500–509. https://doi.org/10.1016/j.respol.2010.11.004

Pajares, F. (2002). Gender and perceived self-efficacy in self-regulated learning. *Theory Into Practice*, *41*(2), 116-125. https://doi.org/10.1207/s15430421tip4102_8

Pajares, F. (2005). Gender differences in mathematics self-efficacy beliefs. In A.M. Gallagher & J.C. Kaufman (Eds.) *Gender Differences in Mathematics: An Integrative Psychological Approach,* (pp. 294-315). Cambridge University Press.

Pekrun, R., Frenzel, A. C., Goetz, T., & Perry, R. P. (2007). The control-value theory of achievement emotions: An integrative approach to emotions in education. In P.A. Schutz & R. Pekrun (Eds.) *Emotion in Education,* (pp. 13–36). Academic Press.

Pekrun, R., & Stephens, E. J. (2010). Achievement emotions: A control-value approach. *Social and Personality Psychology Compass*, *4*(4), 238–255. https://doi.org/10.1111/j.1751-9004.2010.00259.x

Perera, H.N. & John, J.E. (2020). Teacher's self-efficacy beliefs for teaching math: relations with teacher and student outcomes. *Contemporary Educational Psychology, 61,* 1-13. https://doi.org/10.1016/j.cedpsych.2020.101842

Prieto-Rodriguez, E., Sincock, K., & Blackmore, K. (2020). STEM initiatives matter: results from a systematic review of secondary school interventions for girls. *International Journal of Science Education, 42*(7), 1144-1161, doi:10.1080/09500693.2020.1749909

Pulford, B., Woodward, B., & Taylor, E. (2018). Do social comparisons in academic settings relate to gender and academic self-confidence? *Social Psychology in Education, 21,* 677-690. https://doi.org/10.1007/s11218-018-9434-1

Reilly, D., Neumann, D. L., & Andrews, G. (2015). Sex differences in mathematics and science achievement: A meta-analysis of National Assessment of Educational Progress assessments. *Journal of Educational Psychology, 107*(3), 645–662. https://doi.org/10.1037/edu0000012

Riegle-Crumb, C., & Morton, K. (2017). Gendered expectations: Examining how peers shape female students' intent to pursue STEM fields. *Frontiers in Psychology, 8,* 1-11. https://doi.org/10.3389/fpsyg.2017.00329

Rimm-Kaufman, S. E., Baroody, A. E., Larsen, R. A. A., Curby, T. W., & Abry, T. (2014). To what extent do teacher–student interaction quality and student gender contribute to fifth graders' engagement in mathematics learning? *Journal of Educational Psychology*. Advance online publication. http://dx.doi.org/10.1037/a0037252

Robnett, R.D., & Leaper, C. (2012). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence, 23*(4), 652-664. https://doi.org/10.1111/jora.12013

Robnett, R. D., & Thoman, S. E. (2017). STEM success expectancies and achievement among women in STEM majors. *Journal of Applied Developmental Psychology*, *52*, 91-100. doi: 10.1016/j.appdev.2017.07.003

Roseman, I., & Smith, C. A. (2001). Appraisal theory: Overview, assumptions, varieties, controversies. In K.R. Scherer, A. Schorr, & T. Johnstone (Eds.) *Appraisal Processes in Emotion: Theory, Methods, Research* (pp. 3–19). Oxford University Press.

Seo, E., Shen, Y., & Alfaro, E.C. (2019). Adolescents' beliefs about math ability and their relations to STEM career attainment: Joint consideration of race/ethnicity and gender. *Journal of Youth and Adolescence, 48,* 306-325. https://doi.org/10.1007/s10964-018-0911-9

Singer, J. A. (1995). Seeing one's self: Locating narrative memory in a framework of personality. *Journal of Personality, 63,* 429-457. https://doi.org/10.1111/j.1467-6494.1995.tb00502.x

Skaalvik, S., & Skaalvik, E. M. (2004). Gender differences in math and verbal self-concept, performance expectations, and motivation. *Sex Roles; New York, 50*(3–4), 241–252. http://dx.doi.org/10.1023/B:SERS.0000015555.40976.e6

Starr, C.R., & Simpkins, S.D. (2021). High school students' math and science gender stereotypes: Relations with their STEM outcomes and socializers' stereotypes. *Social Psychology of Education, 24,* 273-298. https://doi.org/10.1007/s11218-021-09611-4

Syed, M. & Nelson, S.C. (2015). Guidelines for establishing reliability when coding narrative data. *Emerging Adulthood, 3*(6), 375-387. https://doi.org/10.1177%2F2167696815587648

van den Hurk, A., Meelissen, M., & van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education, 41*(2), 150-164. https://doi.org/10.1080/09500693.2018.1540897

Wang, M.T. (2012). Educational and career interests in math: A longitudinal examination of the links between classroom environment, motivational beliefs, and interests. *Developmental Psychology, 48*(6), 1643-1657. DOI: 10.1037/a0027247

Wang, M.T. & Degol, J.L. (2017). Gender gap in science, technology, engineering, and mathematics (STEM): Current knowledge, implications for practice, policy, and future directions. *Educational Psychology Review,* 29**,** 119–140. https://doi.org/10.1007/s10648-015-9355-x

Wang, Z., Borriello, G.A., Oh, W., Lukowski, S., & Malanchini, M. (2021). Co-development of math anxiety, math self-concept, and math value in adolescence: the roles of parents and math teachers. *Contemporary Educational Psychology, 67,* 1-14. https://doi.org/10.1016/j.cedpsych.2021.102016

Watt, H. M. G., Shapka, J. D., Morris, Z. A., Durik, A. M., Keating, D. P., & Eccles, J. S. (2012). Gendered motivational processes affecting high school mathematics participation, education aspirations, and career plans: A comparison of samples from Australia, Canada, and the United States. *Developmental Psychology, 48,* 1594-1611. doi: 10.1037/a0027838

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Wigfield, A., & Eccles, J. S. (2020). 35 years of research on students' subjective task values and motivation: A look back and a look forward. In A.J. Elliot (Ed.), *Advances in Motivation Science* (pp. 161-198). Elsevier.

Willie, E., Stoll, G., Gfrorer, T., Cambria, J., Nagengast, B., & Trautwein, U. (2020). It takes two: Expectancy-value constructs and vocational interests jointly predict STEM major choices. *Contemporary Educational Psychology, 61,* 1-18. https://doi.org/10.1016/j.cedpsych.2020.101858

Wilson, A., & Ross, M. (2003). The identity function of autobiographical memory: Time is on our side. *Memory*, *11*(2), 137–149. https://doi.org/10.1080/741938210

Wolff, F., Helm, F., Zimmermann, F., Nagy, G., & Möller, J. (2018). On the effects of social, temporal, and dimensional comparisons on academic self-concept. *Journal of Educational Psychology*, *110*(7), 1005-1025. https://doi.org/10.1037/edu0000248

Zavala, M. D. R., & Hand, V. (2019). Conflicting narratives of success in mathematics and science education: Challenging the achievement-motivation master narrative. *Race* Ethnicity and Education, 22(6), 802–820.

Table 6.1: Demographics for High and Low MSC Groups

Demographic Variable	High MSC		Low MSC	
	n	%	*n*	%
Age				
18-24	83	92	84	90
25-34	7	8	7	7
35-44	0	0	3	3
Gender				
Male	32	36	17	18
Female	57	63	75	80
Trans Male	0	0	1	1
Trans Female	1	1	1	1
Race				
White	29	32	37	39
Hispanic/Latinx	21	23	28	30
Asian/Pacific Islander	25	28	15	16
Black/African American	9	10	12	13
Other	6	7	2	2
Education Level				
1st Year College Student	43	48	37	40
2nd Year College Student	19	21	18	19
3rd Year College Student	16	18	22	23
4th Year College Student	8	9	7	7
5th Year College Student or Beyond	2	2	8	9
Bachelor's Degree	1	1	1	1
Other	1	1	1	1
First Generation Status				
Yes	39	44	47	50
No	50	56	47	50

Note: N = 90 for the High MSC group and N = 94 for the Low MSC group. Valid percentages are reported.

Table 6.2a: High Math Self-concept: Low Point Themes

Theme	Definition	Example Quote
Negative Affective Experience	Participants mention some type of negative emotionality related to their math low point.	"By the end of the study session, I was on the verge of tears… I sat [stayed] behind with the teacher, and asked her what I was doing wrong… I cried to her, and I was vulnerable to my emotions."
Teacher	Participants attribute at least a portion of their low point to their teacher. These responses often include feeling discouraged or unsupported by their teacher.	"In my first semester of college, my first math teacher was horrendous. She did not teach rather just gave us notes…This made me think that all math courses in college were a waste and that no one could truly pass math successfully."
First Time Ability Challenge	Participants mention having their math abilities challenged for the first time, often while struggling to understand the material.	"I was in Calculus class my freshmen year in college and it was the first time taking a college math class and I believed that it would be fairly similar to high school… I have never struggled in math…I became extremely frustrated as to why I couldn't retain the information like I used to."
Bad Grade – Low Effort/Overconfident	Participants attribute at least part of their low point to receiving a bad grade or a lower grade than they expected. These participants also often mention that their bad grade was due to low effort or overconfidence.	"I can easily say that I was one of the smartest kids in the class… the unpleasant event, it was a test… I did not study at all because I believed that I was going to get an A regardless. I just thought I was that good… but there were some…word problems that I completely forgot how to solve. It stressed me out so much…"

Geometry	Participants mention that Geometry contributed to a particular low point in their math experience.	“My freshmen year of high school math was extremely hard purely because of the existence of geometry.”

Table 6.2b: Low Math Self-concept: Low Point Themes

Theme	Definition	Example Quote
Negative Affective Experience	Participants mention some type of negative emotionally related to their low point.	"My grades were doing fairly well up until I took the first exam of the class. It had completely destroyed my grade …This took a toll on me mentally. I would suffer anxiety before every class especially before tests to the point where sometimes I would even cry while studying because I knew that there was no way I could do well on it."
Bad Grade	Participants attribute at least part of their low point to receiving a bad or lower grade than they expected in a math class, math test or assignment.	It was about the time to take my last exam in class before the final. I studied so hard, every night, and even got a tutor…I saw the next week, I received an F. I cried in class because I was stressed."
Teacher	Participants explain at least a portion of their low point was caused by their teacher not being supportive or creating a bad experience for the participants in some way.	"My teacher was basically a bully… I asked a question [and] he would make me feel like I was pretty stupid in front of the class. I was super shy in middle school and extremely intimidated by him. He would praise those who were excelling and berate those or get offended by those who just didn't understand."
Math Aversion	Participants mention some type or fixed or long-term lack of math ability, struggle with math, or dislike of math.	"I had always had trouble with math and even when I tried to get better at it, I still could not do it."

Critical Realization	Participants allude to the notion that their low point was a critical moment in their relationship with math. These responses often mention some type of realization or discovery regarding their feeling about math or their future with math.	“I was trying to get some help… on my math homework… I could feel myself getting worse and worse at the problems… This eventually led to me developing a hate and high stress in relation to math, because every other subject I had ever learned I did well in… this moment was specifically a low point is because it made me realize that I wasn't a ‘super, above average student’ anymore.
Upwards Comparisons	Participants mention external pressure caused by comparing themselves to others. Participants often mentioned feeling as though they were not performing as well or were not as capable as their peers.	“During an exam in my pre-calculus class… I glanced around at my peers, who were scribbling their answers without breaking a sweat… Seeing everyone around me doing fine with the exam made my struggle with it that much more. I felt so dejected…”

Table 6.3: Mean Gender Differences in Math Outcome Variables

	Men	Women	MANOVA Test Statistics		
	M (*SD*)	*M* (*SD*)	F	p	η_p^2
Learning Math Anxiety	1.44_a (.62)	2.64_b(.99)	101.76	<.001	.632
Evaluation Math Anxiety	2.61_a (1.15)	4.50_b (.63)			
Math Value	4.31_a (1.23)	2.71_b (.96)			

Note: N = 181. Means with different subscripts are significant between men and women at the *p* < .001 level.

Appendix 6A: Your Life Story about your Experiences with Math

Adapted from McAdams' Life Story Prompt

Please begin by thinking about your relationship to math over the course of your life as if it were a book or novel. Imagine that the book has several main chapters that describe key scenes or experiences you have had with math. Consider your experiences with learning math, performing math, being evaluated on your math abilities, and using or doing math outside of school environments. Think about your experiences with math teachers, your friends, and peers, as well as emotions you felt while studying, being in class, or taking exams.

I would like you to focus on a few of these key scenes having to do with math that stand out over the course of your life. A key scene would be an event or specific incident that took place at a particular time and place. Consider a key scene to be a moment in your life story about math that stands out for a particular reason – perhaps because it was especially good or bad, particularly vivid, important, or memorable.

For each of the four chapters and key scenes we will consider over the next few pages of this survey, I ask that you describe in detail what happened, when and where it happened, who was involved, and what you were thinking and feeling during the event. In addition, I ask that you tell me **why you think this particular scene is important or significant in your life**. What does the scene say about you as a person? Please be specific.

A Math Low Point[4]

Please describe a math-related scene, episode, or moment in your life that stands out as an especially negative experience. Even though this event is unpleasant, I would appreciate

[4] Participants also responded to four open-ended questions that were not the focus of the current research. Specifically, they described a math high point (i.e., a particularly positive experience); their experiences receiving help with math, a math turning point, and how they envision their future relationship with math.

your providing as much detail as you can about it. What happened in the event, where and when, who was involved, and what were you thinking and feeling? Also, please say a word or two about why you think this particular moment was so bad and what the scene may say about you as a person or your life and how you relate to math.

Online Supplemental Material

Preliminary Quantitative Analyses

A correlated two-factor confirmatory factor analysis (CFA) was performed using Mplus (Muthén & Muthén, 2017) to test the expected dimensionality of responses to the items from the Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003) in the full sample. Each math anxiety item was specified to load onto the factor it was designed to measure, with the correlation between the two factors estimated freely. Five items were specified to load onto the factor measuring learning math anxiety, and the remaining four items were specified to load onto the factor measuring evaluation math anxiety. The specified factors (learning and evaluation math anxiety) were well-defined with moderate to strong and uniformly statistically significant loadings (λ = .567 to .888; see Table S1). As expected, the two subscales were also significantly correlated (r = .655, p < .001). Given these results, the correlated two-factor CFA in the current sample aligns with the expected item dimensionality of the AMAS.

In the full sample, correlations among continuous variables of interest were in the expected directions. More specifically, math value was positively correlated with math self-concept (r = .664) and negatively correlated with both learning (r = -.346) and evaluation (r = -.510) math anxiety. Math self-concept was also negatively correlated with both learning (r = -.752) and evaluation (r = -.611) math anxiety. Full correlations can be seen in Table S2.

A two-group MANOVA was conducted to replicate prior findings regarding gender differences in the math outcomes of interest. Effect sizes for partial eta squared correspond to values of 0.01-0.06 for small, 0.06-.014 for medium, and 0.14+ for large effect sizes (Lenhard & Lenhard, 2016). The omnibus MANOVA indicated that there was a significant gender difference on the linear combination of math self-concept, math value, learning math anxiety, and evaluation math anxiety, Hotelling's T^2 = 36.02, F(4, 732) = 8.979, p < .001. As illustrated in Table S3, follow-up univariate ANOVAs indicated that relative to men, women report significantly lower math self-concept (Adj. $\eta_p^2 = .013$, see Mordkoff, 2019 for discussion of adjusted eta-squared), a medium effect. In addition, women reported significantly higher learning (Adj. $\eta_p^2 = .017$) and evaluation (Adj. $\eta_p^2 = .041$) math anxiety than did men, indicating large effects. There were no significant gender differences in math value.

References

Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS): Construction, validity, and reliability. *Assessment*, *10*(2), 178–182 doi: 10.1177%2F1073191103010002008.

Mordkoff, J.T. (2019). A simple method for removing bias from a popular measure of standardized effect size: Adjusted partial eta squared. Advances in Methods and Practices in Psychological Science, 2(3), 228–232. doi:10.1177/2515245919855053.

Muthén, L.K. and Muthén, B.O. (1998-2017). Mplus User's Guide. Eighth Edition. Los Angeles, CA: Muthén & Muthén.

Table S1: Parameter Estimates for the AMAS Two-Factor CFA Model

	USTDλ	CSTDλ	CTSD Var(δ)
Learning Math Anxiety			
Item 1	1.000	.567	.027
Item 3	1.609	.786	.017
Item 6	1.568	.855	.014
Item 7	1.475	.770	.018
Item 9	1.589	.740	.019
Evaluation Math Anxiety			
Item 2	1.000	.866	.012
Item 4	1.091	.888	.011
Item 5	0.893	.745	.019
Item 8	0.976	.811	.015

Note: USTD = unstandardized; CSTD = completely standardized

Table S2: Full Sample Means, Standard Deviations, and Correlations

Variable	*M*	*SD*	1	2	3	4
1. Math Value	3.52	1.03	--			
2. Learning math anxiety	1.89	0.89	-.346**	--		
3. Evaluation math anxiety	3.53	1.12	-.510**	.711**	--	
4. Math self-concept	2.92	1.14	.664**	-.611**	-.752**	--

Note: M and SD indicate mean and standard deviation for each variable, respectively. ** = $p < .01$.

Table S3: Mean Gender Differences in Math Outcome Variables

	Male	Female	MANOVA Test Statistics		
	M (*SD*)	*M* (*SD*)	F	p	η_p^2
Learning Math Anxiety	1.72_a (.78)	1.97_b(.93)	8.98	<.001	.047
Evaluation Math Anxiety	3.21_a (1.13)	3.69_b (1.08)			
Math Value	3.52_a (1.07)	3.52_a (1.00)			
Math Self Concept	3.11_a (1.05)	2.83_b (1.17)			

Note: N=737. Means with different subscripts are significant at the p =/< .001 level.

Chapter 7: Manuscript 3 Summary

John et al. (2022) aimed to explore how participants with high and low math self-concept narrate their lowest points with math. Although the experiences considered to be low points were similar across groups with high and low math self-concept, the ways in which these groups narrated their low points were distinct. Participants with low math self-concept were more likely than participants with high math self-concept to provide additional detail about the event and their emotions surrounding the experience. This indicates that participants with low math self-concept may have a tendency towards deeper reflection on their math low points, which often occurs when attempting to make meaning out of negative experiences (McAdams, 2008). Women were overrepresented in the low math self-concept group, supporting prior work on gender differences in math self-concept (e.g., Eccles & Wang, 2016), and these women were more likely than men to mention teachers as important contributors to their math low point. More specifically, participants in the low math self-concept group often mentioned feeling humiliated, embarrassed, and discouraged by their teachers. This indicates that for students in general, and perhaps girls in particular, the ways in which math teachers interact with their students may have lasting effects on how they view themselves and their futures with math.

Chapter 8: Discussion & Implications

The current program of research was designed to better understand the socio-contextual factors that contribute to the persistent dearth of women in math-intensive STEM careers. The first manuscript aimed to understand how emerging adults think and reason about this gap in STEM. The second and third manuscripts focused more specifically on personal experiences with math and factors that have been found to influence math outcomes and plans to pursue math-intensive courses or careers. To build upon existing work, the current program of research used mixed-methods to connect theoretical frameworks that are often dominated by either quantitative or qualitative methods. For instance, expectancy-value theory (EVT) is often studied using quantitative methods. However, an important – and often neglected – component of EVT suggests that past experiences in a domain, and how these experiences are interpreted by individuals, exert an influence on achievement motivation in the domain (Eccles, 1983; Eccles & Wigfield, 2020). Math anxiety is also typically studied using quantitative methods, but the recently theorized *interpretation account* of math anxiety suggests that understanding how individuals interpret their math experiences might be useful for understanding how math anxiety develops and persists over time (Ramirez et al., 2018). Narrative identity theory provides one option for investigating how the interpretation of past experiences can be integrated into a person’s identity and influence their goals and behaviors (McAdams, 2001). Given that narrative identity theory is often studied using qualitative methods, it is well-suited for a mixed-methods research agenda that aims to fill gaps in the existing quantitative literature on math anxiety and math achievement motivation. In addition, given that the ability to begin creating a narrative identity only emerges during late adolescence (McLean & Lilgendahl, 2019), narrative identity theory also provides a developmentally appropriate way to understand how the interpretation of past experiences might play a role in the major life choices that emerging adults are often required to make.

Taken together, the three focal manuscripts (Kent et al, 2020; John et al., 2020; and John et al., 2022) highlight the importance of using mixed-methods research to explore gender inequities in math-intensive STEM fields. This body of work not only solidifies paths for future research but provides findings that can begin to inform the development of unique, evidence-based interventions aimed at improving women's representation in STEM. First, results from Kent and colleagues (2020) suggest that men, as compared to women, may be less aware of the challenges facing women in STEM. Future interventions for college students might include tailored curricula for men and women, aimed at meeting these groups where they are in their development of critical consciousness and encouraging developmentally appropriate actions for improving STEM equity. Second, John and colleagues (2020) found that narrative interpretations of past math experiences predict current math outcomes and future math plans. Future interventions might take a developmental approach toward helping young students develop more positive or growth-oriented mindsets surrounding math. These improved mindsets may then influence more positive interpretation patterns surrounding their math experiences once they begin creating a narrative identity during later adolescence and emerging adulthood. Third, John and colleagues (2022) found that participants with low math self-concept reported more negative emotions – including anxiety – when describing their math low point, and that negative interactions with math teachers may be particularly detrimental for girls with low math self-concept. Future interventions might seek to improve student-teacher relationships to facilitate higher math self-concept and mitigate negative emotionality in the math classroom.

The current program of research provides some insight into the qualitative and quantitative gender differences regarding math experiences and outcomes. However, it is somewhat striking that women participants only raised the issue of gendered ability stereotypes when specifically asked to consider STEM disparities (Kent et al., 2020), and did not explicitly discuss gender stereotypes when asked to reflect on their own math experiences. This is puzzling, given the wealth of research indicating that girls are aware of, and even endorse, math-gender stereotypes (Cvencek et al., 2011). The limited discussion of math-gender stereotypes (and related phenomena such as sexism) may be driven by the still-emerging developmental capacity for reflection and narrative coherence during emerging adulthood. For instance, much like the ability to create a life story only emerges during late adolescence and emerging adulthood, the capacity for critical consciousness is also just beginning to develop during this time (see Tyler et al., 2020 for a review). *Critical reflection* is often considered the first step in the development of critical consciousness and refers to a person's ability to reflect on social inequities, morally reject social injustices, and understand such inequities as systemic (Watts et al., 2011). Given the early stage of development for both life stories and critical consciousness, it is possible the ability engage in critical reflection may not occur organically and instead may require intentional prompting. This could explain why participants raised issues of stereotyping in their responses to the prompt asking about STEM inequities in Kent et al. (2020), whereas participants did not mention stereotyping in their responses to the more general life story prompts in John et al. (2020; 2022).

The phenomenon of *denial of personal discrimination* may also explain why participants are more likely to describe issues of stereotyping when discussing inequities in STEM, but not when discussing their own personal experiences. Indeed, research has found that people from disadvantaged groups will typically acknowledge the existence of discrimination against their group more generally; however, they often deny that they have experienced such discrimination themselves unless the discrimination is very overt (Crosby, 1984; Taylor et al., 1990). More recent work has found that denial of gender discrimination altogether is associated with greater subjective well-being for women, in part because it allows them to believe that the current system is fair (Napier et al., 2020). Although this type of individual coping mechanism may help women function in an unequal society, it also perpetuates gender inequity by allowing such discrimination to continue unchecked. Some research on critical consciousness has found that personal experiences with inequity, oppression, or discrimination predict greater critical reflection and action (e.g., Mathews et al., 2020; Roy et al., 2019; Tyler et al., 2020), suggesting that encouraging women to acknowledge, understand, reflect upon their experiences with stereotypes and discrimination in math might create the catalyst for change in math-intensive STEM that has yet to be seen. Given the importance of socio-contextual factors such as stereotypes, expectations, and inequity to EVT and narrative identity theory, as well as the importance of critical consciousness for feelings of efficacy and action (Mathews et al., 2020; Tyler et al., 2020), future research should seek to explore how emerging adults naturally come to understand their own math experiences as being influenced by broader sociocultural stereotypes, expectations, and systemic injustices. Future work might also investigate how to encourage a deeper understanding of these experiences at the outset of emerging adulthood in an effort to reduce denial of discrimination and increase critical consciousness. Finally, future research should also explore how women's understanding of their own experiences with inequity or discrimination might impact the ways in which their narrative identity develops and influences their future career choices.

Chapter 9: Conclusion

Despite decades of research and corresponding interventions aimed at bolstering women's participation in STEM, the field has largely missed the mark when it comes to women's representation in math-intensive STEM fields. This may be due, in part, to a heavy reliance on quantitative research methodologies that, while enlightening, cannot provide the level of detail that is necessary to fully understand such a complex issue. The current program of research sought to build upon the wealth of literature exploring gender inequities in STEM by using mixed research methodologies and integrating related qualitative and quantitative theories. The resulting work has not only replicated prior research showing evidence of gender differences in quantitative math outcomes, but has illuminated new paths for research and intervention that account for important differences in personal experiences, emotion, interpretation patterns, and stages of identity development.

References

Ahmed, W. (2018). Developmental trajectories of math anxiety during adolescence: Associations with STEM career choice. *Journal of Adolescence, 67,* 158-166. https://doi.org/10.1016/j.adolescence.2018.06.010

Ahmed, W., Minnaert, A., Kuyper, H. & van der Werf, G. (2012). Reciprocal relationships between math self-concept and math anxiety. *Learning and Individual Differences, 22*(3), 385-389. https://doi.org/10.1016/j.lindif.2011.12.004

Ahmed, W., Minnaert, A., van der Werf, G., & Kuyper, H. (2010). Perceived social support and early adolescents' achievement: The mediational roles of motivational beliefs and emotions. *Journal of Youth and Adolescence, 39,* 36-46. https://doi.org/10.1007/s10964-008-9367-7

Arnett, J. J. (2000). Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist, 55*(5), 469–480. https://doi.org/10.1037/0003-066X.55.5.469

Ashcraft, M. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185. https://doi.org/10.1111/1467-8721.00196

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences, 107*(5), 1860–1863. https://doi.org/10.1073/pnas.0910967107

Beilock, S.L., & Maloney, E.A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain sciences, 2*(1), 4-12. https://doi.org/10.1177/2372732215601438

Bieg, M., Goetz, T., Wolter, I., & Hall, N.C. (2015). Gender stereotype endorsement differentially predicts girls' and boys' trait-state discrepancy in math anxiety. *Frontiers in Psychology, 6,* 1-8. https://doi.org/10.3389/fpsyg.2015.01404

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Casad, B.J., Hale, P., & Wachs, F.L. (2015). Parent-child math anxiety and math-gender stereotypes predict adolescents' math education outcomes. *Frontiers in Psychology, 6,* 1-21. https://doi.org/10.3389/fpsyg.2015.01597

Casanova, S., Vukovic, R.K., & Kieffer, M.J. (2021). Do girls pay an unequal price? Black and Latina girls' math attitudes, math anxiety, and mathematics achievement. *Journal of Applied Developmental Psychology, 73,* 1-11.

Ceci, S.J. & Williams, W.M. (2011). Understanding current causes of women's underrepresentation in science. *Proceedings of the National Academy of Science, 108*(8), 3157-3162.

Chang, H., & Beilock, S.L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: A review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Sciences, 10,* 33-38. https://doi.org/10.1016/j.cobeha.2016.04.011

Chrobot-Mason, D., & Aramovich, N. P. (2013). The psychological benefits of creating an affirming climate for workplace diversity. *Group & Organization Management*, *38*(6), 659–689. https://doi.org/10.1177/1059601113509835

Committee on Integrated STEM Education (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research.* Retrieved from: https://www.nap.edu/initiative/committee-on-integrated-stem-education

Committee on STEM Education, National Science & Technology Council (2018). *Charting a course for success: America's strategy for STEM education.* Retrieved from: https://www.whitehouse.gov/wp-content/uploads/2018/12/STEM-Education-Strategic-Plan-2018.pdf

Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches. Thousand Oaks, CA: Sage.

Crosby, F. (1984). The denial of personal discrimination. *American Behavioral Scientist, 27*(2), 371-386.

Cundiff J. L., Vescio T. K., Loken E., Lo L. (2013). Do gender–science stereotypes predict science identification and science career aspirations among undergraduate science majors? *Social Psychology of Education*, 16, 541–554. doi:10.1007/s11218-013-9232-8

Cvencek, D., Meltzoff, A.N., & Greenwald, A.G. (2011). Math-gender stereotypes in elementary school children. *Child Development, 82*(3), 766-779. https://doi.org/10.1111/j.1467-8624.2010.01529.x

Cvencek, D., Nasir, N.S., O'Connor, K., Wischnia, S., & Meltzoff, A.N. (2014). The development of math-race stereotypes: "They say Chinese people are the best at math." *Journal of Research on Adolescence, 25*(4), 630-637. https://doi.org/10.1111/jora.12151

Eccles, J.S. (1983). Expectancies, values, and academic behaviors. In Spence, J.T. (Ed.), *Achievement and Achievement Motives: Psychological and Sociological Approaches* (pp. 75-146). W.H. Freeman.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. Model of Achievement-Related Choices. *Psychology of Women Quarterly, 18*(4), 585–609. https://doi.org/10.1111/j.1471-6402.1994.tb01049.x

Eccles, J. S., & Wang, M. T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106. https://doi.org/10.1177/0165025415616201

Eccles, J.S. & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology, 61,* 1-13. https://doi.org/10.1016/j.cedpsych.2020.101859

Garba, A., Ismail, N., Osman, S., & Rameli, M. R. M. (2020). Exploring peer effect on math anxiety among secondary school students in Sokoto State, Nigeria through Photovoice approach. *Eurasia Journal of Mathematics, Science and Technology, 16*, em1815. https://doi.org/10.29333/ejmste/112622

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46. https://doi.org/10.5951/jresematheduc.21.1.0033

Huang, C. (2013). Gender differences in academic self-efficacy: A meta-analysis. *European Journal of Psychology of Education, 28*(1), 1–35. https://doi.org/10.1007/s10212-011-0097-y

John, J.E., Nelson, P.A., Klenczar, B., & Robnett, R.D. (2020). Memories of math: Narrative predictors of math affect, math motivation, and future math plans. *Contemporary Educational Psychology, 60,* 1-11. https://doi.org/10.1016/j.cedpsych.2020.101838

John, J.E., Vierra, K.D., & Robnett, R.D. (2022). “I have cried in almost all of my math classes.” Relations between math self-concept, gender, and narrative appraisals of pasat low points in math. *Contemporary Educational Psychology, 70,* 1-14. https://doi.org/10.1016/j.cedpsych.2022.102094

Kent, S.R., John, J.E. & Robnett, R.D. (2020). “Maybe these fields just don’t interest them:” Gender and ethnic differences in attributions about STEM inequities. *International Journal of Gender, Science, and Technology, 12*(1), 97-121.

Lauermann, F., Tsai, Y.-M., & Eccles, J. S. (2017). Math-related career aspirations and choices within Eccles et al.’s expectancy–value theory of achievement-related behaviors. *Developmental Psychology*, *53*(8), 1540–1559. https://doi.org/10.1037/dev0000367

Ma, X. (1999). A Meta-Analysis of the Relationship between Anxiety toward Mathematics and Achievement in Mathematics. *Journal for Research in Mathematics Education*, *30*(5), 520–540. https://doi.org/10.2307/749772

Maloney, E.A., Schaeffer, M.W., & Beilock, S.L. (2013). Mathematics anxiety and stereotype threat: shared mechanisms, negative consequences, and promising interventions. *Research in Mathematics Education*, *15*(2), 115-128. https://doi.org/10.1080/14794802.2013.797744

Maloney, E. A., Ramirez, G., Gunderson, E. A., Levin, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents’ math anxiety on children’s math achievement and anxiety. *Psychological Science, 26*, 1480-1488. https://doi.org/10.1177/0956797615592630

Mathews, C.J., Medina, M.A., Banales, J., Pinetta, B.J., Marchand, A.D., Agi, A.C., … Rivas-Drake, D. (2020). Mapping the intersections of adolescents' ethnic-racial identity and critical consciousness. *Adolescent Research Review, 5,* 363-379. https://doi.org/10.1007/s40894-019-00122-0

McAdams, D. P. (2001). The psychology of life stories. *Review of General Psychology, 5*(2), 100-122. https://doi.org/10.1037/1089-2680.5.2.100

McAdams, D. P. (2008). Personal narratives and the life story. In John, Robins, & Pervin (Eds.) *Handbook of Personality: Theory and Research* (3rd ed., pp. 242–262). Guilford Press.

Mcrudden, M.T., Marchand, G. & Schultz, P. (2019). Mixed methods in educational psychology inquiry. *Contemporary Educational Psychology, 57,* 1-8. https://doi.org/10.1016/j.cedpsych.2019.01.008

McLean, K. C., & Lilgendahl, J. (2019). Narrative identity in adolescence and adulthood: Pathways of development. In D. P. McAdams, J. Tackett, & R. Shiner (Eds.), *The Handbook of Personality Development* (pp. 418 – 432). New York: Guilford.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology*, *82*(1), 60–70. https://doi.org/10.1037/0022-0663.82.1.60

Nasir, N.S. & Shah, N. (2011). On defense: African American males making sense of racialized narratives in mathematics education. *Journal of African American Males in Education, 2*(1), 24-45.

National Science Foundation (2022). *The state of U.S. science and engineering 2022.* Retrieved from: https://ncses.nsf.gov/pubs/nsb20221

National Science Foundation (2020). *STEM Education for the Future: A visioning report.* Retrieved from: https://www.nsf.gov/ehr/Materials/STEM%20Education%20for%20the%20Future%20-%202020%20Visioning%20Report.pdf

National Science Foundation (2019a). *Women, minorities, and persons with disabilities in science and engineering.* Retrieved from: https://ncses.nsf.gov/pubs/nsf19304/digest/about-this-report.

Okeke, N.A., Howard, L.C., Kurtz-Costes, B. & Rowley, S.J. (2009). Academic race stereotypes, academic self-concept, and racial centrality in African American youth. *Journal of Black Psychology, 35*(3), 366-387. https://doi.org/10.1177/0095798409333615

Østergaard, C. R., Timmermans, B., & Kristinsson, K. (2011). Does a different view create something new? The effect of employee diversity on innovation. *Research Policy*, *40*(3), 500–509. https://doi.org/10.1016/j.respol.2010.11.004

Paschall, K.W., Gershoff, E.T., & Kuhfeld, M. (2018). A two decade examination of historical race/ethnicity disparities in academic achievement by poverty status. *Journal of Youth and Adolescence, 47*, 1164-1177.

Ramirez, G., Shaw, S.T., & Maloney, E.A. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational Psychologist, 53*(3), 145-164. https://doi.org/10.1080/00461520.2018.1447384

Robnett, R. D., & Thoman, S. E. (2017). STEM success expectancies and achievement among women in STEM majors. *Journal of Applied Developmental Psychology*, *52*, 91-100. https://doi.org/10.1016/j.appdev.2017.07.003

Roy, A.L., Raver, C., Masucci, M.D., & DeJoseph, M. (2019). "If they focus on giving us a chance in life we can actually do something in this world": Poverty, inequality, and youths' critical consciousness. *Developmental Psychology, 55*(3), 1-22. doi:10.1037/dev0000586

Saw, G., Chang, C., & Chan, H. (2018). Cross-sectional and longitudinal disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and socioeconomic status. *Educational Researcher, 47*(8), 525-532.

Seo, E., Shen, Y. & Alfaro, E. (2018). Adolescens' beliefs about math ability and their relations to STEM career attainment: Joint consideration of race/ethnicity and gender. *Journal of Youth and Adolescence, 48,* 306-325.

Skaalvik, S., & Skaalvik, E. M. (2004). Gender differences in math and verbal self-concept, performance expectations, and motivation. *Sex Roles; New York*, *50*(3–4), 241–252. http://dx.doi.org/10.1023/B:SERS.0000015555.40976.e6

Taylor, D.M., Wright, S.C., Moghaddam, F.M., & Lalonde, R.N. (1990). The persona/group discrimination discrepancy: Perceiving my group, but not myself, to be a target for discrimination. *Personality and Social Psychology Bulletin, 16*(2), 254-262.

Tsui, L. (2007). Effective strategies to increase diversity in STEM fields: A review of the research literature. *The Journal of Negro Education, 76*(4), 555-581.

Tyler, C.P., Olsen, S.G., Geldhof, G.J., & Bowers, E.P. (2020). Critical consciousness in late adolescence: Understanding if, how, and why youth act. *Journal of Applied Developmental Psychology, 70,* 1-13. https://doi.org/10.1016/j.appdev.2020.101165

U.S. Census Bureau (2019). *Income and poverty in the united states: 2019*. Retrieved from: https://www.census.gov/library/publications/2020/demo/p60-270.html.

Wang, M. T., & Degol, J. (2013). Motivational pathways to STEM career choices: Using expectancy–value perspective to understand individual and gender differences in STEM fields. *Developmental Review, 33*(4), 304–340. https://doi.org/10.1016/j.dr.2013.08.001

Watts, R.J., Diemerr, M.A., & Voight, A.M. (2011). Critical consciousness: Current status and future directions. In C.A. Flanagan & B.D. Christens (Eds.), Youth civic development: Work at the cutting edge. *New Directions for Child and Adolescent Development 134,* 43-57.

Zavala, M. D. R., & Hand, V. (2019). Conflicting narratives of success in mathematics and science education: Challenging the achievement-motivation master narrative. *Race* Ethnicity and Education, 22(6), 802–820.

Curriculum Vitae

Jennifer John Buck, MSW, MA
Jennifer.e.buck@gmail.com
www.jenniferjohnbuck.com
https://orcid.org/0000-0001-7797-889X

Education

2022 (exp.) **Doctoral Candidate in Quantitative/Experimental Psychology**, University of Nevada, Las Vegas (UNLV), Las Vegas, NV

2019 **M.A. in Quantitative/Experimental Psychology**, University of Nevada, Las Vegas (UNLV), Las Vegas, NV

Thesis: *Consequences of Math Anxiety and Stereotype Threat: An Intersectional Perspective* (Committee: Rachael Robnett, PhD, Jennifer Rennels, PhD, Mark Ashcraft, PhD, & Gwen Marchand, PhD)

2013 **M.S.W** (Human Services Management Certificate), Boston University School of Social Work, Boston, MA

2010 **B.A. in Psychology** (*Magna Cum Laude* and Full College Scholar) North Central College, Naperville, IL

Relevant Work Experience

FrameWorks Institute
Principal Researcher & Asst Director for Quantitative Research 4/2022 – Present
Principal Researcher 1/2022 – 4/2022
Senior Researcher 5/2021 – 12/2021

Nevada Department of Health and Human Services 6/2020 – 11/2020
Division of Child and Family Services (DCFS)
Planning and Evaluation Intern, Quality Assurance Contract

LGBT Aging Project, Boston, MA 8/2012 – 5/2013
Macro Social Work Intern

Awards & Honors

2018 GPSA Summer Sponsorship Award, UNLV

2018 Summer Stipend Research Award Recipient, UNLV College of Liberal Arts

2017 Summer Stipend Research Award Recipient, UNLV College of Liberal Arts

2010 Outstanding Major in Psychology, North Central College, Psychology Department

Publications

Peer Reviewed Journal Articles

John, J.E., Insouvanh, K., & Robnett, R.D. (2022). The Roles of Gender Identity, Peer Support, and Math Anxiety in Middle School Math Achievement. *Jourrnal of Research on Adolescence*. Published online ahead of print.

John, J.E., Vierra, K., & Robnett, R.D. (2022). "I have cried in almost all of my math classes." Relations between math self-concept, gender, and narrative appraisals of past low points in math. *Contemporary Educational Psychology, 70,* 1-14. https://doi.org/10.1016/j.cedpsych.2022.102094

Perera, H.N. & **John, J.E.** (2020). Teachers' Self-Efficacy Beliefs for Teaching Math: Relations with Teacher and Student Outcomes, *Contemporary Educational Psychology, 61,* 1-13. https://doi.org/10.1016/j.cedpsych.2020.101842

Kent, S., **John, J.E**., & Robnett, R.D. (2020). "Maybe These Fields Just Don't Interest Them." Gender and Ethnic Differences in Attributions about STEM Inequities. *International Journal of Gender, Science, and Technology, 12*(1), 97-121.

John, J.E., Nelson, P., Klenczar, B., & Robnett, R.D. (2020). Memories of Math: Narrative Predictors of Math Affect, Motivation, and Future Math Plans. *Contemporary Educational Psychology, 60,* 1-11. https://doi.org/10.1016/j.cedpsych.2020.101838

Robnett, R.D., & **John, J.E.** (2020). "It's wrong to exclude girls from something they love." Adolescents' attitudes about sexism in science, technology, engineering, and math fields. *Child Development, 91*(1), 231-248. https://doi.org/10.1111/cdev.13185

Wooten, N.R., Al-Barwani, M.B., Chmielewski, J.A., **Buck, J.E**., Hall, T.L., Moore, L.L., Woods, A.C. (2014). A Case Study of Social Media and Remote Communications in Military Research: Examining Military and Deployment Experiences of Army Women. *SAGE Research Methods Cases.* http://dx.doi.org/10.4135/978144627305014540257

Chapters in Edited Books

Robnett, R. D., **John, J. E.,** Underwood, C. R., & Thoman, S. E. (2020). Sexism and gender stereotyping. In S. Hupp & J. Jewell (Eds.), *The Encyclopedia of Child and Adolescent Development*. West Sussex: Wiley. 4600 words. https://doi.org/10.1002/9781119171492.wecad482

Chaired Conference Symposia

John, J.E. & Thoman, S.E. (2018, August). *From the Inside Out: Evidence for Ecological Influences on Girls and Women in STEM.* Symposium conducted at the Gender and STEM Network Conference, Eugene, OR.

Conference Talks

John, J.E. & Robnett, R.D. (2018, August). *One Size does not Fit All: Gender and Ethnic Variation in Math Anxiety and Stereotype Threat.* Presented at the Gender and STEM Network Conference, Eugene, OR.

Robnett, R.D. & **John, J.E.** (2018, August). *Are Adolescents Concerned about Sexism in STEM Fields? A Mixed-Methods Analysis.* Presented at the Gender and STEM Network Conference, Eugene, OR.

Conference Posters

Gutierrez, D., John, J.E., Kent, S., & Robnett, R.D. (2022, July). *Attitudes about gender inequity in STEM: Variation on the basis of racist and sexist attitudes.* Accepted for presentation at the 2022 Network Gender & STEM Conference.

John, J.E., Vierra, K., & Robnett, R.D. (2022, July). "I have cried in almost all of my math classes." Relations between math self-concept, gender, and narrative appraisals of past low points in math. Accepted for presentation at the 2022 Network Gender & STEM Conference.

Bellucci, B., Denecker, L., Vierra, K., **John, J.E.**, Robnett, R.D. (2021, May). *"My math teacher said I must be low-achieving": The effect of classroom experiences on math self-efficacy*. Presented at the Annual National Meeting of the Association Psychological Science, Virtual.

Insouvanh, K., **John, J.E.,** DeSouza, L., & Robnett, R.D. (2021, February). *Attitudes Toward Social Change*. Presented at the Annual Conference of the Society for Personality and Social Psychology, Virtual.

Cowley, J., Despres, J., Vierra, K., **John, J.** & Robnett, R.D. (2020, October). *Sources and Distribution of Math Anxiety and Confidence in Middle School Students.* Presented at the Annual Conference of the Western Psychological Association, Virtual.

John, J.E., Klenczar, B., & Robnett, R.D. "I felt humiliated in front of the entire class." The Role of Teachers and Peers in Narrative Memories of Students with Low Math Self-Concept. Accepted for presentation at the 2020 10th SELF International Conference, Québec, Canada. Unable to deliver, meeting canceled due to COVID-19 outbreak.

Perera, H.N., **John, J.E.,** Barber, D., Part, R., & Maghsoudlou, A. *Math and Science Expectancy-Value Beliefs in Secondary School Students: A Person-Centered Approach.* Accepted for presentation at the 2020 American Educational Research Association Conference, San Francisco, CA. *Unable to deliver, meeting canceled due to COVID-19 outbreak.*

John, J.E, Klenczar, B., Nelson, P., & Robnett, R.D. (2019, February). *Memories of Math: Narrative Predictors of Math Outcomes and Future Math Plans.* Presented at the UNLV Graduate & Professional Student Research Forum, Las Vegas, NV.

Lovitt, A., **John, J.E**., & Millar, M. (2019, February). *The Impact of Positive Assessments on Interpersonal Behavior.* Presented at the Society for Personality and Social Psychology Conference, Portland, OR.

John, J.E., Chaidez, H., Tang, G., & Robnett, R.D. (2019, February). *Perspective-Taking Effects on Bias and Support for Social Activism.* Presented at the Society for Personality and Social Psychology Conference, Portland, OR.

John, J.E, Klenczar, B., Nelson, P., & Robnett, R.D. (2018, October). *Math Life Stories Predict Gendered Outcomes and Future Plans.* Presented at the Gender Development Conference, San Francisco, CA.

Robnett, R.D. & **John, J.E**. (2018, October). *"It's wrong to exclude girls from something they love:" Adolescents' attitudes about sexism in STEM.* Presented at the Gender Development Conference, San Francisco, CA.

Kent, S., **John, J.E**., Klenczar, B., Smith, C., & Robnett, R.D. (2018, October). *"These Fields Just Don't Interest Them": Gender Differences in Attributions about STEM Inequities.* Presented at the Gender Development Conference, San Francisco, CA.

Thoman, S.E., Underwood, C.R., Stephens, A.K., **Buck, J.E**. & Robnett, R.D. (2016, October). *Test Tubes or Soccer Practice: Retention and Work-Life Balance among Women in STEM.* Poster presented at the Gender Development Conference, San Francisco, CA.

Underwood, C.R., Thoman, S.E., **Buck, J.E.**, Robnett, R.D. & Barakat, M. (2016, October). *Redefining Tradition: Generational Differences in Same-Sex Couples' Surname Decisions.* Poster presented at the Gender Development Conference, San Francisco, CA.

Sawyer, T., **John, J.E**., & O'Connor, M. (2010, April). *The Effects of Priming on Perceptions of Facial Features.* Poster presented at the Midwestern Psychological Association Annual Meeting, Chicago, IL.

John, J.E. (2010, April). *Perceptions of Parenting Styles and Personality.* Poster presented at the Midwestern Psychological Association Annual Meeting, Chicago, IL.

Teaching

University of Nevada, Las Vegas
PSY 210: Introduction to Statistical Methods
Average Evaluation: 4.54/5

PSY 360: Foundations of Social Psychology
Average Evaluation: 4.44/5

PSY 101: General Psychology
Average Evaluation: 4.56/5

North Central College
Teaching Assistant, PSY 250: Statistics (Spring 2009)

Mentoring

2020-22	Mentor, Outreach for Undergraduate Mentorship Program (OUMP)
	UNLV Department of Psychology
2018-19	UNLV Research and Mentorship Program (RAMP): B. Klenczar
	Project: Gender Variance in Positive Memories of Math
	Presented at the 2019 Society for Personality and Social Psychology Conference
2018-19	**UNLV Undergraduate Research Mentor:** J. Cowley, P. Green & B. Gorsakul
	Project: Objective-Focus and Perspective-Taking Approaches to Evaluating Racial Biases
	Presented at the 2019 Western Psychological Association Convention
2018-19	**UNLV Undergraduate Research Mentor**: S. Kent, B. Klenczar, & C. Smith
	Project: Themes of STEM Inequity
	Presented at the 2018 UNLV Spring Undergraduate Research Forum
2017	UNLV Undergraduate Research Mentor: H. Chaidez & G. Tang
	Project: Associations between Perspective-Taking, Racial Bias, and Social Activism
	1st Place: 2017 UNLV Spring Undergraduate Research Forum
2016-17	Mentor, Outreach for Undergraduate Mentorship Program (OUMP)
	UNLV Department of Psychology
2012-13	Mentor, First Year MSW Student, Boston University

Professional Development

Mediation and Moderation (2022, February), Todd Little's Stats Camp, Remote.

"Great Graphs" Data Visualization Course (2020, October), Depict Data Studio.

Mentorship Certificate (2019), UNLV Graduate College

Theory and Practice of Bayesian Inference using JASP (2019, February), SPSP Annual Convention, Portland, OR.

Multilevel Modeling (2018, June), Todd Little's Stats Camp, Albuquerque, NM.

Service

Intramural

President, Experimental Student Committee (ESC), Department of Psychology, University of Nevada, Las Vegas (2017-19)

Graduate Student Representative, Graduate Enrollment Management Committee, University of Nevada, Las Vegas (2017-18)

Invited Presenter, Involving Undergraduates in Research Workshop, University of Nevada, Las Vegas (February 2017)

Graduate Student Judge, Office for Undergraduate Research (OUR) Forum, University of Nevada, Las Vegas (November 2016)

Psychology Department Representative, Graduate and Professional Student Association (GPSA), University of Nevada, Las Vegas (2016-17)

GPSA Representative, Graduate Enrollment Management Committee, University of Nevada, Las Vegas (2016-17)

Extramural

Strategic Planning and Evaluation Consultant, Uprise Theatre, San Diego, CA (2020 – 2021)

Invited Reviewer, American Education Research Association (AERA) Annual Meeting 2020

- Mixed Methods SIG
- Division C: Learning and Instruction, Section 1c: Mathematics

Student Advisory Board Member, Psychology of Women Quarterly (2017- Present)

Graduate Student Panel Member, Nevada State College (October 2016)

Development Committee Member, Think Dignity (2016-18)

Macro Concentration Committee Chair, Boston University School of Social Work (2012-13)

Ad Hoc Reviewer

International Journal of Gender, Science, and Technology