Contemporary Educational Psychology 60 (2020) 101838

Contents lists available at ScienceDirect

Contemporary Educational Psychology

journal homepage: www.elsevier.com/locate/cedpsych

Memories of math: Narrative predictors of math affect, math motivation, and future math plans

Jennifer E. John*, Paul A. Nelson, Brittany Klenczar, Rachael D. Robnett

Department of Psychology, University of Nevada, Las Vegas, 4505 S. Maryland Pkwy., Las Vegas, NV 89154-5030, USA

ARTICLE INFO

Keywords:
Expectancy-value theory
Math anxiety
Math
STEM education
Student narrative

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 affect, math motivation, 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 lower math anxiety and 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 affect, math motivation, and plans for pursuing math in the future, even years after the experience has occurred. Implications for math education are discussed.

1. 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.

1.1. 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).

* Corresponding author.
E-mail addresses: johnj4@unlv.nevada.edu (J.E. John), paul.nelson@unlv.edu (P.A. Nelson), klenczar@unlv.nevada.edu (B. Klenczar), rachael.robnett@unlv.edu (R.D. Robnett).

https://doi.org/10.1016/j.cedpsych.2020.101838

Available online 15 January 2020
0361-476X/ Published by Elsevier Inc.

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 outcomesincluding 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 (Crisp et al., 2009; Douglas & Attewell, 2017).

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 an individual's pursuit of 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, Wigfield, Harring, & Eccles, 2015; Lauermann, Tsai, & Eccles, 2017).

Origins of math affect and motivation. Research focusing on math anxiety was initially guided by early work on the validation of a measure for math-specific anxiety (Richardson and Suinn, 1972), whereas research focusing on math expectancies and values has historically been guided by the expectancy-value theory 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 cognitive appraisals of 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). A similar pathway is portrayed 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.

1.2. *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 both the author and listener (Bruner, 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.

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 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; metacognition) 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., 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.

1.3. 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, & Shutz, 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.

1.4. 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).

2. Method

2.1. 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[1] 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 indicated that they were first-generation college students. The sample included 245 women (66%), 124 men (33%), two transgender men (0.5%), and two participants (0.5%) 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

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

Table 1
Narrative sequences in math turning point themes.

Coding category	%	(*n*)	Examples
Consistently 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
Consistently 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.

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.

2.2. 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).

2.3. 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 online supplementary materials. 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 = 0.84, PA = 88%) and narrative content (K = 0.85, 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 = 0.82, PA = 87%) and narrative content (K = 0.87, 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 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.

2.4. Turning points correlates

Math anxiety. Math anxiety was assessed using the abbreviated math anxiety scale (Hopko, Mahadevan, Bare, & Hunt, 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 (α= 0.91).

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

Table 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	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	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.

this semester." Higher scores indicate higher math self-expectancy. This scale had excellent internal reliability ($\alpha = 0.92$).

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 ($\alpha = 0.82$).

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 online supplementary materials). 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 ($K = 0.81$, 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 ($K = 0.79$, PA = 86%). Coders resolved the few disagreements through consensus.

As summarized in Table 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.

3. 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 (0.10–0.30), medium (0.30–0.50), and large (0.50+) effect sizes for Cramer's V. 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).

3.1. 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%, $n = 210$). 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 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, the content domains were not significantly associated with the different narrative sequences, X^2 (9, $N = 154$) = 6.941, $p = .643$, $V = 0.123$). Below, we draw from the 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."

3.2. 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, $\lambda = 0.95$, $F(12, 913.076) = 1.445$, $p = .14$. 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 3, follow-up univariate ANOVAs replicated patterns obtained in prior research: Relative to men, women reported significantly higher math anxiety (Adj. $\eta_p^2 = 0.042$; see Mordkoff, 2019 for discussion of adjusted eta-squared) and significantly lower math self-expectancy (Adj. $\eta_p^2 = 0.012$). 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, $X^2 (2, N = 204) = 1.173$, $p = .556$, $V = 0.076$, or ethnicity, $X^2 (6, N = 197) = 3.208$, $p = .782$, $V = 0.090$.

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, $X^2 (9, N = 200) = 8.469$, $p = .488$, $V = 0.119$, or gender, $X^2(3, N = 209) = 4.592$, $p = .204$, $V = 0.148$. 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, $\lambda = 0.682$, $F(9, 496.633) = 9.395$, $p < .001$. As detailed in Table 4, follow-up univariate ANOVAs revealed significant differences in math anxiety (Adj. $\eta_p^2 = 0.120$), math self-expectancy (Adj. $\eta_p^2 = 0.252$), and math value (Adj. $\eta_p^2 = 0.145$) 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

Table 3
Mean gender differences in math attitudes.

	Female	Male	ANOVA test statistics		
	M (*SD*)	*M* (*SD*)	*F*	*p*	*Adj.* η_p^2
Math Anxiety	2.70 (0.91)	2.30 (0.82)	17.103	< 0.001	0.042
Math Self-Expectancy	2.80 (1.20)	3.10 (1.03)	5.586	0.019	0.012
Math Value	3.47 (1.03)	3.36 (1.09)	0.851	0.357	0.001

Note. $N = 367$.

pairwise comparisons (0.05/12 = 0.004). 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, $p < .001$, $V = 0.388$. 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.

4. 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.

4.1. 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, Levin, & 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 et al., 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

Table 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*	*Adj.* η_p^2
Math Anxiety	2.57_a (0.89)	2.66_a (0.78)	1.84_b (0.67)	3.05_a (1.00)	10.578	< 0.001	0.120
Math Self- Expectancy	2.86_a (1.11)	2.66_{ab} (1.00)	4.31_c (0.91)	2.12_b (1.01)	24.455	< 0.001	0.252
Math Value	3.60_{ab} (0.90)	3.08_{bc} (0.94)	4.12_a (1.12)	2.79_c (1.03)	12.784	< 0.001	0.145

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

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 & Dunlop, 2017).

4.2. 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, Bieg, Ludtke, Pekrun, & Hall, 2013; Hembree, 1990; Riegle-Crumb, Moore, & Ramos-Wada, 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 (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, Ramirez, Levine, & Beilock, 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, Perez, Carmel, & Linnenbrink-Garcia, 2019; Robnett & Leaper, 2013), interventions that target the messages they transmit to students may be especially fruitful.

4.3. 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, likely resulting 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 broader mathematical thinking (e.g., problem-solving, pattern-seeking) that is required in much of everyday life and in many careers. Future research should consider an interview approach that allows for a more dynamic dialogue between researcher and participant. This could increase clarity surrounding what participants aim to convey in their statements. Understanding these distinctions will be particularly important for educators and policymakers when conceptualizing interventions that are aimed at improving math outcomes.

5. Conclusion

Despite a curricular emphasis on math and a variety of career opportunities in STEM, many students continue to feel uneasy about math, 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 current 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 whose narratives emphasized consistently negative experiences with math had the worst math outcomes overall and were more likely to report that they planned 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.

Acknowledgements

We are grateful to Mallory Constantine for her assistance with the qualitative coding process, as well as the students at the institution for their time and participation in the current research.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The authors declare no conflicts of interest.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cedpsych.2020.101838.

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., ... 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. https://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. doi: 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. https://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. 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. doi: 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 doi: 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. Dettelbach (Germany): Psychometrica. Retrieved from: < https://www.psychometrica.de/effect_size.html > . doi: 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.* Evanston, IL: Northwestern University Unpublished manuscript.
McAdams, D. P. (1999). *Coding narrative accounts of autobiographical scenes for redemption sequences (4th rev.).* Evanston, IL: Northwestern University Unpublished manuscript.
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 Robins John, & 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. https://doi.org/10.1037/10410-001.
McAdams, D. P., & McLean, K. C. (2013). Narrative Identity. *Current Directions in Psychological Science, 22*(3), 233–238. https://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. https://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. doi: 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. https://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., 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. https://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. doi: 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.