"It all started when...": Insights From Students' Math Life Stories

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This mixed-methods study evaluates the mathematical autobiographies (MABs) of STEM students to evaluate their relationship with mathematics and influential actors in their math life stories. 135 MABs were collected from students enrolled in Calculus 1, Abstract Algebra, and Topology, taught by the same instructor. Analysis revealed that students mostly had consistently positive experiences with mathematics (PME). Hypothesis testing showed that students enrolled in upper division courses and math majors had a higher likelihood of describing PMEs and that Asian students described PMEs at a lesser rate than their peers. Instructors and family members were most frequently named as influential actors, with K-12 instructors appearing more often than college instructors. These results indicate that STEM students have had primarily positive mathematical experiences, which aligns with their desire to pursue STEM degrees.

Keywords: mathematics autobiography, students' experiences in math, influential actors

Undergraduate mathematics courses have historically been considered gatekeepers to higher education (Van Dyken, 2016). As a result, researchers have focused on the equitable implementation of instructional activities that engage students in active learning and promote higher order thinking (Freeman et al., 2014; Saxe & Braddy, 2015). Instructional improvements are amiss without also attending to students' experiences in mathematics, as mathematics perception and self-efficacy have been reported as determinants of achievement (Shone et al., 2023). This study is framed by Voigt's (2020) conception of mathematics identity, which are the "dispositions and deeply-held beliefs that individuals develop…about their ability to participate and perform effectively in mathematical contexts" (p. 32). He includes three ways that a student's math identity can be shaped: 1) their perceptions of mathematical participation and ability, 2) their connection to mathematical communities, and 3) the influence of identity resources. A student's mathematics identity is the product of formative educational experiences (Silva & Roddick, 2001), and understanding students' lived experiences is an important platform on which to continue to build positive student identity (Gutiérrez, 2009). One way to understand a student's lived experience is through mathematical autobiographies (MABs) to identify and examine critical points in a student's life story with math.

Student MABs (Cook, 1995) have been essential to gain insight into students' success and struggle in math classes (Moldavan & Mullis, 1998; Williams, 2017). The benefits of MABs are twofold: math educators gain a deeper understanding of students' backgrounds and students engage in an important reflective practice. Prior work with MABs has supported the development of stronger classroom communities (Westrich, 2016) while students have also reported experiencing increased self-awareness regarding their mathematical abilities and a deeper understanding of their own math learning journey (Hauk, 2005).

The current study is focused on overall student experience with mathematics, while looking at differences by student type and influential people in their stories. Our first research question seeks to understand overall math experiences: *How do mathematics students describe their*

relationship with mathematics? We also wondered if MABs from students with different demographics (e.g., race, gender, course enrolled) differ from their peers, leading us to our second research question: *How do mathematics students' relationship with mathematics vary based on their demographics?* One aspect of identity is connection to mathematical communities (Voigt, 2020), yet little work has examined the influential actors present during these formative experiences. Our third research question asks: *How do mathematics students acknowledge influential actors in their math life stories?*

Methods

This study took place at a large public university on the West Coast of the U.S., designated as a Hispanic-Serving Institution and an Asian American, Native American, and Pacific Islander-Serving Institution. Data for this paper were a convenience sample (Creswell & Guetterman, 2019) collected between Spring 2019 and Spring 2022, totaling 133 participants enrolled in calculus 1, abstract algebra or topology taught by the same instructor. Table 1 shows the institutional student demographics. Student majors were mathematics (65%), engineering (17%), science (14%), and non-STEM (5%).

Table 1: Student Demographics (N=133)

Race	**Total**	**%**	**Gender**	**Total**	**%**	**Course**	**Total**	**%**
Latine	61	45.9	Female	56	42.1	Calculus	33	24.8
Black	9	6.8	Male	75	56.4	Abstract Algebra	86	64.6
Asian	25	18.8	Non-Binary	2	1.5	Topology	16	12
White	22	16.5						
Mixed Race	5	3.8						
Unknown	11	8.3						

Throughout the course, students were asked to submit reflection assignments, one of which students were asked to write their math autobiography. Sample prompts included to reflect on their earliest math memory, past math experiences, how they see themselves as math learners, or to reflect on meaningful mentors that impacted them. The prompts were meant to inspire, and students were encouraged to write their narratives however they wanted. 135 math autobiographies form the data set for this study. Note that the total number of MABs is larger than the total number of students as two students had enrolled in two different courses in the data collection time frame and submitted unique assignments.

The data were first analyzed using deductive coding (Creswell & Poth, 2018). Researchers coded for *overall experience with math*, *focal positive/negative moments,* and *influential actors*. Overall experience with math was categorized into five distinct codes, adapted from John et al. (2020): (a) consistently positive, (b) consistently negative, (c) consistently neutral, (d) redemption, and (e) contamination. We marked an MAB as *consistently positive*, *consistently negative*, or *consistently neutral* if their life story with math started and ended as both positive, negative, or neutral (accordingly). Even though an MAB could be coded as consistent, we also recognized that students' stories could contain ups and downs. We define a *speed bump* as a difficult or challenging moment within a student's story labeled as consistently positive/neutral. Similarly, we define a *booster* as a positive or supportive moment within a student's story labeled as consistently negative/neutral. An MAB was marked as *redemption* if their story started out negative and they had an experience that transformed their relationship with math to end

positively while an MAB was marked as *contamination* if their story started out positive and they had an experience that transformed their relationship with math to end negatively. While John et al. (2020) did not provide guidance on what was considered positive or negative in the five codes, as a team, we defined p*ositive, negative,* and *neutral* by the emotions students used to describe their experiences (e.g., "I was really curious and excited by math") as well as their self-evaluation (e.g., "I am really not great at math").

Within each MAB we also coded for any *focal positive* or *negative moment* a student wrote about that stood out as a singularly poignant experience. Within these focal moments, we coded any *influential actors* mentioned (e.g., a specific person or institution), coding whether that actor had a *positive*, *negative*, or *neutral* impact on the student. People were categorized as best as possible, and if they were a professor or mentor, we captured the course or institution type when specified (e.g., 8th grade teacher, community college Calculus 1 professor). Usually, if a student mentioned a person, they would describe a story related to that person (e.g., "Cooking with my grandma helped me count").

The entire research team deductively coded 31 MABs together, discussing coding applications and reaching agreements whenever there was disagreement. Then, three researchers coded the remaining 105 MABs, with double coding of 12 MABs (~11%), producing a reliability of 83%. In instances where there was disagreement or uncertainty, the fourth researcher reviewed and determined the appropriate coding.

Once the data were deductively coded, we utilized mixed methods to analyze the data. Thematic analysis (Braun & Clarke, 2012) was used to summarize themes within *overall experience with math* and *specific actor mentione*d. We also performed one-tailed hypothesis testing for difference of proportions for students' *overall experience with math*. We wanted to know if the difference in proportions of positive math experiences for two similarly related identities was statistically significant. To simplify the calculations, we defined two groups: *positive math experience* (PME) and *negative math experience* (non-PME). Any MAB coded as Consistently Positive or Redemption was coded as a PME, as both experiences result in current positive experience with math. Conversely, any MAB coded as Consistently Neutral, Consistently Negative, or Contamination was defined as a non-PME. We compared specific demographics (course enrolled, gender, race, and major) to determine which identities were reporting PMEs at a higher/lower rate. Our goal was to determine if there was a statistically significant difference in the proportion of PMEs for one identity compared to PMEs of all other respondents without that identity.

Findings

Table 2 shows the breakdown of overall experience with math and key events from students' math life stories. We can see that most students have a consistently positive experience with math. However, of the 87 students coded as consistently positive, we see that 86.2% were coded as having had speed bumps along their journeys. This is important to observe, as it shows the resilience of students who face adversity in their stories yet continue to push through with a positive relationship with mathematics. We also notice that students who are consistently negative or neutral also experience positive focal moments, even though their overall experience with math is negative or neutral. Most all students' MABs that were coded as consistently negative were also coded as containing a booster during their math life story (87.5%).

We wanted to compare proportions of positive math experiences (PME) by different student demographics. First, we wanted to compare lower division students and upper division students. Then we wanted to compare by gender. Because we only had two non-binary students, we

grouped non-binary and female students together as they are the non-majority gender identities in comparison to male students. We also wanted to test by race doing so for Latine, White and Asian students. We were unable to test for Black students, as our population had less than 10 Black students. Finally, we compared students by major.

Table 2: Distribution of Autobiographies as Positive Math Experience and Non-Positive Math Experience by Event

Experience with Math	**Speed Bumps and Boosters**		**Positive Focal Moments**		**Negative Focal Moments**	
Positive Math Exp (PME)						
Consistently Positive ($N = 87$)	75	(86.2%)	79	(90.8%)	59	(67.8%)
Redemption ($N = 21$)	-	-	19	(90.5%)	18	(85.7%)
Non-Positive Math Exp (Non-PME)						
Consistently Negative ($N = 8$)	7	(87.5%)	7	(87.5%)	7	(87.5%)
Consistently Neutral ($N = 15$)	11	(73.3%)	12	(80.0%)	10	(66.7%)
Contamination ($N = 4$)	-	-	4	(100.0%)	4	(100.0%)
Total ($N = 135$)	**93**	**(68.9%)**	**121**	**(89.6%)**	**98**	**(72.6%)**

Table 3 shows the eight different hypothesis tests we ran for difference of proportions. When comparing the rates of PMEs for students enrolled in different math classes, we found that students enrolled in more advanced mathematics courses were more likely to have a positive math experience ($p<0.01$). Similarly, students pursuing a degree in math or engineering were more likely to report having a PME more often than other majors ($p<0.01$). We observed that female and non-binary students had a larger proportion of PMEs but found no statistical evidence to support the idea that either gender experienced PMEs at a greater rate. Next when looking at racial identities, we were unable to find strong evidence to support the idea that Latine and White students experienced PMEs at a different rate than when compared to other races. However, with significant evidence to support, we saw that Asian students experienced PMEs at a lesser rate when compared to other races ($p<0.05$).

Table 3: One-sided Hypothesis Test for the Difference of Proportions for Positive Math Experiences

Demographic	**Test Performed**	**Test Statistic**
Class Enrolled	(Abstract Algebra & Topology) vs. (Calculus)	4.71***
Gender Identity	(Female & NB) vs. (Male)	0.87
Racial Identity	Latine vs. Other Races	1.47*
	Other Races vs. Asian	2.22**
	White vs. Other Races	1.49*
Major	Math vs. Engineering	2.11**
	Math vs. Non-Mathematics	3.99***
	(Math & Eng) vs. (Non-Math & Non-Eng)	4.05***

*p<0.1, ** p<0.05, *** p<0.01

Because so many students were coded as having consistently positive MABs (N=87), we wanted to categorize the ways students were describing their positive experience with math. Seven major themes emerged from the analysis of student responses. Table 4 shows each theme, a description of the theme, and their frequencies. MABs could be coded with multiple themes.

Easy and Fun (43.6%) and *Appreciation of Math* (34.4%) were the most common themes. For example, a female Latina math major reflected on a previous experience in middle school,

> I was doing simple algebra but I think this specific day was when I had an epiphany and really was so happy about doing math and in my 7th grade mind I was thinking wow I really love this is so easy and fun to do I can do 20 of these problems.

Many students' positive relationships with mathematics were also affected by good performance, community and support, and its perceived utility.

Table 4: Themes found in Consistently Positive Math Autobiographies N=87

Theme	Description	Count
Easy and Fun	Referenced an overall enjoyment of mathematics	38
Appreciation of Math	Found material "beautiful" or "fascinating"	30
Good Performance	Performed well on exams, assignments, or overall course grade	28
Community and Support	Received support and encouragement from teachers, peers, etc.	25
Utility	Found math useful and practical.	10
Personal Growth and Intellect	Found that mathematics helped them grow intellectually.	9
Appreciation of Difficulty and Challenge	Enjoyed solving challenging problems.	6

Of the 87 consistently positive autobiographies, 75 (86.2%) of the MABs were coded as having speed bumps. Table 5 shows the seven themes that emerged from the analysis of the speed bumps including their frequency. *Difficulty with Material* (50.6%) and *Poor Teacher Experiences* (29.3%) were the most common themes; there were times when both overlapped, meaning that sometimes if students had negative experiences with teachers and instructors, they also expressed that they found the material difficult or got low scores on exams. A Latino male math major recounted his experience entering middle school: "I struggled a lot when it came to math. Things that were considered to be easy were very complicated and I lost a lot of my confidence." A Black female engineering major in calculus wrote about when she took precalculus with the hardest teacher at her school:

> I did struggle a bit in the class and did not have the motivation to ask my teacher for help because she seemed to not want to help me when I approached her the first few times. I failed her class because one, I did not seek for help else[where] and because I lost motivation and felt as if my teacher saw me as an individual who has no skills in math and could not be successful in that field.

It was common to see that students struggled because they were unable to receive support from their teachers, or that students' confidence decreased because a teacher made them feel less than capable of doing mathematics.

Table 5: Themes found in Speed Bumps from Consistently Positive Math Autobiographies (N=75)

Theme	Description	Count

Difficulty with Material	Struggled in the course and got low scores	38
Poor Teacher Experiences	Had a negative interaction with teachers	22
Poor Study Habits	Had poor study habits that affected performance	15
Personal Reasons	Faced personal life issues or complications	12
Failing Classes	Failed their courses	10
Uncertainty of Major/ Career Choices	Uncertain about their career choices, causing stress	5
Virtual Classes	Struggled with online classes resulting from COVID	4

122 MABs (85.9%) mentioned an influential actor. We grouped these mentions into five distinct categories: (a) K-12 instructor, (b) college instructor, (c) family, (d) other support, and (e) peers. The *college instructor* category accounts for all mentions of a post-secondary instructor, regardless of the institution type. The *other support* category captured infrequently mentioned actors (e.g., mentors, college advisors, tutoring centers, clubs). Table 6 shows the distribution of mentions by positive, negative, and neutral. These counts exceed our total number of MABs because a student may have mentioned more than one actor in more than one context (e.g., a positive, negative, or neutral experience). We found that the mentions of influential actors were overwhelmingly positive (70.3%) and primarily discussed K-12 or college instructors.

Table 6: Distribution of Mentions of Actors by Positive, Negative, and Neutral

Actors	**Positive**		**Negative**		**Neutral**	
K-12 Instructor ($N = 97$)	57	(58.8%)	32	(33.0%)	8	(8.3%)
College Instructor ($N = 65$)	48	(73.8%)	14	(21.5%)	3	(4.6%)
Family ($N = 48$)	36	(75.0%)	4	(8.3%)	8	(16.7%)
Other Support ($N = 36$)	31	(86.1%)	0	(0.0%)	5	(13.9%)
Peers ($N = 13$)	10	(76.9%)	3	(23.1%)	0	(0.0%)
Total ($N = 259$)	**182**	**(70.3%)**	**53**	**(20.5%)**	**24**	**(9.3%)**

Table 7 shows the distribution of positive and negative mentions of K-12 teachers, college instructors, and family members across students experiencing PMEs and non-PMEs. We found that the frequency of positive narratives of K-12 instructors was similar among students who experienced PMEs (42.6%) and non-PMEs (40.7%). The relative frequency of positive narratives of college instructors was higher for students who experienced PMEs (38.9%) than those who experienced non-PMEs (22.0%). The relative frequency of negative narratives also differed by instructor type. We found that students experiencing PMEs and non-PMEs spoke about negative experiences with college instructors at similar rates, however more students with PMEs talked about negative experiences with K-12 teachers than non-PMEs. Interestingly, students with non-PMEs did not have more negative experiences as compared to students with PMEs. We found that students experiencing non-PMEs only mentioned one positive experience with family (3.7%), while students experiencing PMEs had 35 positive mentions (32.4%).

Table 7: Distribution of Instructor and Family Mentions by Positive and Non-Positive Math Experience in MABs

Actor	**Positive Math Experience ($N = 108$)**		**Non-Positive Math Experience ($N = 27$)**	
	Positive	**Negative**	**Positive**	**Negative**

K-12 Instructor	46	(42.6%)	27	(25.0%)	11	(40.7%)	5	(18.5%)
College Instructor	42	(38.9%)	11	(10.2%)	6	(22.2%)	3	(11.1%)
Family	35	(32.4%)	4	(3.7%)	1	(3.7%)	0	(0.0%)

Discussion

Our study showed that a majority of students had consistently positive experiences in their math autobiographies. Our analysis showed that this was more likely to take place with math and engineering majors and for students enrolled in upper division math courses. While seemingly sensical, it is important that our analysis verified this, as in other papers, the same students have shared traumatic experiences during their academic journeys (Cawley & Wilson, 2024). We acknowledge that due to the convenience sample, participants in this study were students who already "made it" to courses like calculus and upper division math. This is known as survivorship bias (Elston, 2021), which can overshadow the narratives of students who may have been filtered out of such courses. Future work will investigate MABs from other courses that support non-STEM majors. Interestingly, we also saw that Asian students described positive math experiences at a lesser rate than their peers, which we would like to investigate further.

Students in this study with consistently positive autobiographies often shared that they enjoyed and appreciated the subject or performed well in it. In contrast, most of the speed bumps were caused by moments in their stories where they faced difficulty with material, self-expressed poor teacher experience, and poor study habits. It is important to share with our students that even those who have a positive relationship with math face challenges, highlighting the notion of productive struggle (Baker et al., 2020) and a growth mindset (Boaler et al., 2021).

Students overwhelmingly acknowledged instructors as positive influential actors in their math life stories. Prior research suggests that students' relationship with mathematics is a direct product of the learning environment created by their instructor (Moldavan & Mullis, 1998). Our study found that MABs labeled as an overall positive mathematics experience cited their college instructors at a higher rate than the MABs labeled as non-PME. The trends in our data show that STEM-focused students' early experiences with math may not appear to shape their overall relationship with mathematics, as a high proportion of positive K-12 instructor experiences was present for both students with positive relationships with math and those with negative relationships. While these rates were similar, we did notice that students with negative relationships with math simply did not write as often about specific people or institutions in their narratives. This may indicate that those with more positive experiences have stronger memories tied to those people who impacted them. This may be evidenced by the result that students with PMEs wrote more about their interactions with family members – both positive and negative experiences. Studies have shown that family members can help shape students' math identities in meaningful ways (Cunningham, 2021). We argue that more work should be done to evaluate the out-of-classroom experiences that impact students' relationship with math.

Overall, our data demonstrate snapshots of positive and negative math identities as supported by the nature of the math experiences evidenced in the students' math autobiographies.

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