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The Mathematical Autobiographies of College Faculty Participating in a Quantitative Reasoning Faculty Development Program: Stories of Trauma and Triumph

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Abstract

This study evaluates the mathematical autobiographies of college and university faculty in order to identity (1) barriers that hinder success in mathematics, especially among groups underrepresented in STEM, and (2) strategies to reduce existing inequalities and promote effective pedagogy in both mathematics and quantitative reasoning (QR) education. From 2013 to 2019, 61 faculty from a wide range of disciplines participated in a multidisciplinary QR faculty development program. The results of a mathematical autobiographical activity demonstrate the exercise's utility as a pedagogical tool that both encourages students to confront their mathematical anxieties and helps instructors promote success in mathematics by responding to students' diverse experiences. The autobiographies center on three broad themes: negative experiences with mathematics (e.g., mathematics trauma, fear of bad grades, ineffective mathematics teachers, gender bias), positive experiences (using mathematics to better understand the world, effective teachers, success in mathematics courses), and the importance of making mathematics relevant. These narratives show how both mastery goals and performance goals can serve as incentives for learning mathematics. They also demonstrate the importance of viewing mathematics achievement through a positional lens (e.g., gender) that is conditioned by both structural variables (e.g., teachers) and agency variables (e.g., growth mindset).

Key words: discrimination; faculty development; mathematical autobiography; numeracy, quantitative reasoning.

Introduction

For at least three decades, researchers have investigated the mathematical autobiographies or "mathographs" (Cook, 1995) of faculty and students to gain insights into effective strategies for mathematics education (Moldavan & Mullis, 1998, Ring et al., 2000; Towers et al., 2019; Westrich, 2016; Williams, 2017). The evidence shows that explicit attention to students' beliefs and feelings about mathematics can help build their confidence and improve their performance (Hersh & John-Steiner, 2011; Lee et al., 1996). For example, teachers' understanding of their students' backgrounds can lead to improved communication (Hauk, 2005) and to the development of stronger classroom communities (Westrich, 2016). The disclosure of stressful experiences through writing is often beneficial (Cameron & Nicholls, 1998; Lyubomirsky et al., 2006), and mathematical autobiographies can encourage students to engage in the metacognitive thinking that is necessary for effective learning (Lerch et al., 2006). Nonetheless, attitudes toward mathematics are often difficult to alter, since they develop and are reinforced over long periods through exposure to multiple courses and teachers (Ring et al., 2000).

Access and equity are essential to successful mathematics education. Mathematical autobiographies are therefore important not just because of the potential benefits to participating students and faculty but as a source of information about the impact of gender, race, and other factors on perceived mathematical ability over the lifecourse. For instance, the mathematical autobiographies of African American undergraduates reveal the importance of role models and culturally responsive teaching (Williams 2017). Conversely, negative stereotypes can result in harmful preconceptions that hinder learning and lead students to avoid tasks, courses, and careers that require quantitative proficiency (Williams, 2017). Recent studies of the mathematical biographies of teachers in Canada and the US have emphasized the need for strong support of all students, the importance of the belief that everyone can learn mathematics, and the influence of dedicated teachers in helping students reach their potential (Moldovan & Mullis, 1998; Towers et al., 2019).

Achievement Goal Theory

Achievement goal theory asserts that students' motivation to learn mathematics is often grounded in either (a) a desire to master a set of skills or (b) a desire to perform well (Dweck & Elliott, 1983; Dweck & Leggett, 1988; Harkness et al., 2007; Liu, 2021). We can therefore identify two distinct types of achievement goals. *Mastery goals* are based on the acquisition of knowledge or skills, with an emphasis on learning, development, and personal growth. In contrast, *performance goals* are oriented toward demonstrating competence or outperforming others, with an emphasis on external validation, outcomes, and rewards.

A substantial body of research has demonstrated the importance of mastery goals in shaping individuals' behavior and performance. Some authors have suggested that focusing on performance goals (competence judgments) may create a vulnerability to learned helplessness, whereby individuals avoid challenges and have difficulty with obstacles, while an orientation toward mastery goals (competence enhancement) can help students embrace challenges and persist in the face of failure (Dweck & Leggett, 1988). However, more recent research suggests that these relationships are not quite so straightforward. Darnon and colleagues (2012) report on a number of studies which show that both mastery and performance goals can be associated with positive outcomes, with the former a more effective predictor of interest and the latter more closely tied to achievement.

The relative importance of mastery goals and performance goals may vary with individuals' characteristics, and especially with their social status and gender. For instance, several authors have highlighted the importance of positional level of analysis—of "social status as a potential moderator of goal effects" (Darnon et al., 2012, p. 765). Darnon and colleagues have shown that in comparison with men, women are more likely to benefit from an emphasis on mastery goals and more likely to underachieve when motivated purely by performance goals. Likewise, Jagacinski and colleagues (2008) have found important gender differences in perceived non-verbal cognitive ability; men are more confident, while women are more likely to select tasks with a lower level of difficulty.

Both individual and social factors may be important for understanding mathematical achievement. Some authors have asserted that mathematical performance is closely related to intelligence (Lubinsky et al., 2006; Rajkumar & Hema, 2018) while others have argued that achievement in mathematics is more fully explained by factors such as self-efficacy and motivation (Dweck & Leggett, 1988; Dweck, 2006). Dweck (2006) found that students who believed their mathematical ability was fixed (i.e., a fixed mindset) were less likely to persist in challenging mathematics tasks and were more likely to attribute failure to lack of ability. In contrast, students who believed their ability could be developed (i.e., a growth mindset) were more likely to persist when undertaking challenging mathematical tasks and more likely to attribute failure to a lack of effort.

By examining mathematical autobiographies, we can gain insight into how various individual and contextual factors influence achievement goals and behaviors. For example, it seems likely that students who perceive their classrooms to be supportive and mastery-oriented will be more likely to embrace mastery goals and to experience positive academic outcomes. In contract, students who perceive their environment as competitive or performance-oriented may be more likely to adopt performance goals, including performance-avoidance, and to experience negative outcomes such as anxiety and burnout (see, e.g., Kong et al. 2023). By viewing participants' mathematical autobiographies through the lens of achievement goal theory, we can help identity interventions, strategies, and practices that promote positive outcomes and foster a more supportive and engaging learning environment.

Numeracy Across the Curriculum

This paper describes the mathematical autobiographies of faculty participants in a multidisciplinary quantitative reasoning (QR) faculty development program sponsored by The City University of New York (CUNY) and supported by the National Science Foundation (NSF).[1] The narratives presented here reinforce the pedagogical strategies set forth by the National Council of Teachers of Mathematics (NCTM, 2000). Although earlier studies have discussed the mathematical narratives of students and teachers, none have investigated the mathematical autobiographies of college and university faculty in a range of disciplines. Given the importance of mathematical and quantitative reasoning in all subject areas, an understanding of the mathematical backgrounds of faculty who are committed to teaching QR can be especially helpful in the design of effective programs.

The advantages of a multidisciplinary, active learning approach to QR instruction are well established (Bressoud, 2009; Gilman, 2006; Hillyard et al., 2010; Maass et al., 2019; Madison, 2009). Ganter (2006, p. 13) has emphasized that QR "must be everywhere in the curriculum, in all disciplines and all courses." Likewise, Bok (2006, p. 134) has pointed out that "like learning to write well or speaking a foreign language, numeracy is not something mastered in a single course. . . Thus quantitative material needs to permeate the curriculum, not only in the sciences but also in the social sciences and, in appropriate cases, in the humanities."

[1]. Although QR—the contextualized use of numbers and data in ways that involve critical thinking—rests on a solid mathematical foundation, it requires more than mathematical or statistical fluency (Madison, 2004, pp. 4–5; Madison & Dingman, 2010). The key skills that make up QR include reading graphical displays, modeling real-world phenomena, solving practical problems through the use of data, justifying conclusions, and critiquing research designs (AAC&U, 2014; Johnson & Kaplan, 2008). As Shavelson (2008) has noted, QR "is carried out in real-life, authentic situations; its application is in the particular situation, one dependent upon context including socio-politics. The problems are ill defined, estimation is crucial, and an interdisciplinary approach is needed" (p. 34). QR is also known as *quantitative literacy* (QL) or *numeracy*. We have used the three terms interchangeably, although distinctions are sometimes made among them; see https://serc.carleton.edu/NICHE/numeracy_qr.html.

The QR program described here was developed and administered as a set of NSF-funded initiatives: the Numeracy Infusion Course for Higher Education (NICHE) and the Numeracy Infusion for College Educators (NICE) program. Both projects grew out of the QR faculty development program instituted at Lehman College, CUNY, during the 2010–11 academic year, in which faculty met monthly for ten three-hour sessions to learn about strategies for effective QR pedagogy.[2]

In 2011, faculty from Lehman College and LaGuardia Community College received NSF support to develop NICHE, a QR faculty development program that served CUNY faculty across the disciplines. NICHE enrolled three cohorts of faculty in the summers of 2013, 2014, and 2015. In 2017 the NICHE program was expanded and adapted into NICE, which provided greater support for community colleges. The NICE initiative, open to faculty in all subject areas, focused on the needs of Hispanic-Serving Institutions (HSIs) in the Bronx, one of the five boroughs of New York City. The NICE Program enrolled two cohorts of faculty, in 2017 and 2017–18, with an extension into 2019 for those who needed extra time. The NICHE/NICE program participants include faculty at both four-year colleges/universities and two-year colleges. In all three programs, successful completers received stipends ranging from $1,500 to $2,000.

The NICHE and NICE faculty development programs had six objectives:

1. to provide instruction on best practices for teaching QR;
2. to foster the development of instructional and assessment materials that make use of effective strategies for teaching QR;
3. to infuse QR into a wide range of disciplines and CUNY colleges;
4. to increase faculty interest and comfort in teaching QR;
5. to strengthen the faculty's own QR skills, if necessary; and
6. to establish a network of faculty who are committed to improving students' QR skills.

In teaching faculty how to infuse QR into their courses, the programs used the same kinds of approaches that have proven effective in teaching college students, such as collaborative learning and discovery methods. Each program included a two-day in-person introductory session as well as eight online instructional units delivered through the Blackboard learning management system and supported by the NICHE/NICE website (www.teachqr.org): (1) QR and making numbers meaningful; (2) QR learning outcomes; (3) The brain, cognition and QR; (4) QR and writing; (5) Discovery methods; (6) Representations of data; (7) QR assessment; and (8) QR stereotypes and culture. Each unit, designed for completion in 6–8 hours, included readings, videos, hands-on activities, and interactive discussions. Participants developed instructional materials for their own courses (e.g., learning objectives, QR lessons, and assessment instruments), and each received and provided peer feedback on those materials.

Data and Methods

The data for this paper were taken from an exercise in the NICHE/NICE unit on QR stereotypes and culture. In that unit, faculty undertook a number of readings about stereotype threat and inequality in mathematics (Guiso et al., 2008; Steele, 1999). They reviewed relevant research and discussed the relationships between racial/ethnic/gender stereotypes and mathematical

[2]. CUNY is the nation's largest urban public university, "a transformative engine of social mobility" (CUNY, 2023). Founded in 1847 as the nation's first free public institution of higher education, CUNY now has 25 colleges that serve 275,000 degree-seeking students of all ages.

skills. From 2014 onward, faculty were asked to respond to the following set of prompts (Waring & Wilder, 2013):[3]

> Please briefly describe your own math autobiography. What is your math story? What were your experiences with math in elementary school, high school and college? What are your best and worst memories of math? Next, please reflect on and/or comment on the mathematical autobiographies of your students. Even if you have never undertaken such an exercise, do you have any sense of what your students would say about their attitudes towards and/or experiences with mathematics? And if you have undertaken such an exercise, what have you learned about your students? How do you respond when a student says, "I'm terrible at math"? Regardless of whether or not this has happened to you, describe how you would respond if you are doing QR work and a student said this. How should we, as educators, respond to students' mathematical anxieties? As always, please reflect on and/or respond to your colleagues posting if and when appropriate. As always, please be sure to read the postings of all of your colleagues.

In this paper, we focus on the faculty's responses to the questions about their own personal autobiographies. The Lehman College Institutional Review Board approved the project, and all the faculty agreed to serve as research participants.

From 2013 to 2019, 61 faculty participated in the mathematical autobiography exercise.[4] Forty-two (69%) were women, 15 (24%) were faculty of color, and 47 (77%) were either women or members of underrepresented groups. Thirty-six percent of the faculty were in the social sciences, 31% in traditional STEM fields (natural or physical sciences or math), 21% in the humanities, 7% in business, and 5% in education. The departments/programs most often represented were sociology (16%), mathematics (15%), psychology (10%), English (10%), and biology (8%). Other faculty came from a broad range of disciplines including African American studies, chemistry, history, health sciences, modern languages, and even art and music.

We systematically reviewed the mathematical autobiographies of participating faculty and characterized each of their comments as positive or negative, or *other*. We also made note of the themes and keywords that appeared repeatedly throughout the narratives. Afterward, we evaluated the frequency of these factors and themes within particular groups defined on the basis of gender, race/ethnicity, and discipline. This positional analysis allowed us to identify the role of social status as a moderator of goal effects (Darnon et al., 2012). The mathematical autobiographies were analyzed through a theoretical lens that considered both achievement goal theory (Dweck & Elliott, 1983; Dweck & Leggett, 1988; Harkness et al., 2007; Liu, 2021) and social constructivism (Cobb et al., 1992; Ernest, 1991; Harkness et al., 2007).

Pseudonyms are used here to protect the identities of the study participants. Because the faculty presented their mathematical autobiographies through informal discussions in Blackboard, obvious typos have been corrected.

Findings and Discussion

In these findings, we identify the factors that hinder or promote success in mathematics, exploring how a positional framework can shed light on contrasting achievement orientations. The central themes of the respondents' mathematical autobiographies have been grouped into

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3. Different prompts were used in 2013, but faculty in both 2013 and subsequent years were asked to reflect on their mathematical autobiographies.

4. We also explore participants' mathematical autobiographies in our current NSF-funded Data Analysis Research Experience (DARE) program. That exercise is undertaken more informally, however, to stimulate discussion during our in-person faculty workshops. The narratives described here are from NICHE and NICE.

three categories: (1) negative experiences (e.g., difficulty with mathematics courses or tasks, poor grades or test scores, unqualified or hurtful teachers, gender discrimination, and general dislike or discomfort with mathematics); (2) positive experiences (e.g., strong interest in the subject, natural aptitude, self confidence, excellence in mathematics courses or tasks, and encouragement from parents, teachers, or schools); and (3) reflections on the importance of making mathematics meaningful through contextualized instruction and the use of perspectives and examples that resonate with particular groups of students.

Negative experiences with mathematics

Altogether, 25 faculty—21 of the 42 women (50%) but just 4 of the 19 men (21%)—reported clearly negative experiences related to mathematics. The comments of several respondents could be traced to hurtful or traumatizing teachers. For others, especially in the social sciences and humanities, their negative sentiments reflect either a general dislike of mathematics or poor performance in mathematics courses. It is noteworthy that a dozen faculty—all women—described obvious instances of inequality or discrimination based on gender. Finally, there were a few faculty who never pursued mathematics because they "just didn't like it" or felt that it wasn't their strength. Most of the negative reports mentioned multiple factors that contributed to their difficulties with mathematics.

Mathematics trauma

Many faculty mentioned unkind or incompetent mathematics teachers, and a few even felt traumatized by these experiences. Mindy, an Asian female adjunct faculty member in economics at a four-year college, wrote**,**

> There's probably not a sentiment I could describe to fully embody the hatred I felt toward math [in elementary school]. Looking back, I've come to realize most of it stemmed from the fact I felt *less than* when trying to learn it. . . . Those who were "bad" at math were not allowed to go to recess; instead, we were forced to do drill problems up at the board . . . You would stand up at the board doing problems until you could answer a problem correctly. Only then could you return to your seat. Those who remained up at the board grew more self-conscious and frustrated.

Karen, a white female associate professor of psychology at a four-year college, expressed similar sentiments about the importance of teachers' attitudes:

> I took algebra and geometry in high school and performed well; I loved the logic and abstraction of it all. . . When I got to college, I attempted pre-calculus, but the teacher spoke limited English and just stood in front of the class and solved problems on the board. Needless to say, I didn't do well and that was the end of math for me during my undergraduate years.

Similarly, Laleh, a Black female assistant professor of biology at a community college, described an experience in elementary school:

> My teacher declared in front of my class that I was not good at math [even though] I was the only girl in the class to score above a 90 on the exam. My math anxiety has persisted to this day. . . It is amazing how one negative childhood incident in a classroom has shaped my experiences with this subject for a lifetime.

Ineffective teachers

Several faculty mentioned instructors who were well meaning but poorly prepared or otherwise ineffective in their teaching. Jordan, a Black assistant professor of mathematics at a community college, wrote:

> I had gone through elementary school doing fine with math. . . Then, when I hit 7th grade, my teacher used an approach to teaching algebra that made no sense to me

> whatsoever. In order to demonstrate the pattern that existed in a table of x- and y-values, he would draw a sideways caret between numbers and write "+2" or whatever the case was. I was very unused to seeing math concepts represented "visually" like this. . .

Lori, a white assistant professor of art history at a four-year college, described how her teacher modeled incompetence in mathematics:

> 7th grade algebra teacher puts a problem on the board, far more complex than anything we've seen. We work on it for a while as a class, but all our suggestions come to a dead end and we ask the teacher how to solve it. She says "Oh, I don't know. I was hoping that you guys could figure it out." (Note that she probably wasn't kidding—this was a private religious school where the teachers were hired on the strength of their religious faith rather than on any credentials.)

Andrei, a foreign-born white male and full professor of mathematics at a four-year college, likewise described how an inept teacher almost led him away from studying math: "I find elementary school teachers lacking basic knowledge necessary to explain early mathematical concepts to students. . . To be an elementary school teacher in [the United States], you only need to have 6 credits in math."

Several respondents commented that teachers have the potential to make or break students' attitudes toward quantitative work. Even some of the faculty who developed a love of mathematics felt they had been adversely affected by confusing or uninspiring teachers. Albert, a male assistant professor of literature at a four-year college, reported,

> Math was probably the "easiest" subject for me, since I could master the concepts and perform the operations with facility. But I didn't go very far (only AP Calculus A-B—we didn't have enough students for more advanced calc!), and, crucially, I found it grimly boring. There was so little curiosity or wonder or enthusiasm in those classes! I remember Mr. Kwazko, the lumbering basketball-coach-slash-geometry-teacher, who would drill us, week in, week out, on the *very* small handful of rules and operations that you needed to know in order to pass the logic section in the regents exam [a New York State high school exam]. . . Never even a HINT that logic was made for making arguments.

Fear of bad grades.

A fear of bad grades was central to the autobiographies of several respondents, especially those who felt that their academic progress or career outcomes required outstanding performance in all the courses they attempted. These findings highlight the importance of performance avoidance and fear of failure, especially among women. Chloe, a white foreign-born assistant professor of urban studies at a four-year college, described how her strong emphasis on performance goals dissuaded her from choosing STEM subjects:

> The focus on grades (always having to make As in order to get into a good college and get scholarships, etc.) shaped my academic path in the US. This pressure led me to concentrate on performing well over learning and problem solving. . . The fear of not getting into college or being able to pay for college shapes choices and can distract. I have seen some of my best students unwilling to take risks in their work for fear of affecting their grade.

Rachita, an Indian assistant professor of business at a community college, accepted the challenge of doing well in mathematics despite a low grade on an important exam:

> Back in India, we had these scary board exams that were hyped to be very tough and the deciding factor of our lives. My very first 10th board exam was of math. I went blank and couldn't complete the paper. . . When I had to choose classes in 11th grade, I was not allowed to take a math course as a result. I had to beg the school. The school gave me a conditional entry into a math class. The

> condition was I could not attend the math classes, but in the first major test in the first quarter, I had to score a B. I took up the challenge and gave the exam without attending the math classes. Fortunately, my neighbor tutored me. I got 99% and was admitted to the regular class.

Women were especially likely to report that poor grades had threatened their self-esteem and discouraged them from taking math-intensive courses. Hyejoo, an Asian female full-time lecturer/instructor in academic literacy at a community college, wrote,

> I've always struggled with math. Specifically, I think it was when I moved from the US to South Korea in 5th grade. In the US, I remember using calculators and the pace of math being generally slow. . . Then I moved to Korea, and all of a sudden, math was totally out of reach. In all my years in the Korean school system from 5th grade throughout high school, we were never allowed calculators, and things were much too advanced for me.

For Camila, a white full professor of sociology at a four-year college, even the possibility of doing poorly was enough to steer her away from mathematics courses. She wrote, “I [went] to a state university with very large classes, something of a party school. . . It was easy to avoid math and any course that I thought would be difficult.”

Fixed mindset.

Many of the mathematical autobiographies describe a sense of powerlessness over the ability to do well in math—the idea that mathematical ability is not likely to be influenced by careful instruction or study. Indeed, a *fixed mindset* has been identified as a key factor that undermines performance goals (Dweck & Leggett, 1988; Dweck, 2006; Hauk, 2005), and it was especially common among the women in this group. Lydia, a white associate professor of history at a community college, described how her difficulties with mathematics generated a strong sense of frustration: “By 7th grade I was aware that I was in a ‘lower’ math group. Kids who picked it up faster were in other groups. So I knew I wasn’t very good at it. I remember a growing and solidifying sense of frustration with math, the sense of walls closing in.” Likewise, Nancy, a white adjunct faculty member in sociology at a four-year college, always felt that she lacked natural ability in mathematics and avoided if for that reason:

> I do remember certain students who were "good at math." They just had a natural knack for it, and thought mathematically. Problems and formulas that were very challenging for me to understand were easily mastered by these other students. So I gradually developed a sense that "math wasn't my thing" and I pursued advanced study in other areas.

Quantitative subjects other than math.

Some respondents had trouble with abstract mathematics but reported a greater affinity for applied quantitative work. Alejandro, a Latino male foreign-born assistant professor of sociology at a community college, mentioned his dislike of “traditional math” but his more positive feelings toward statistics. In contrast, two respondents specifically mentioned difficulties with statistics. (This may reflect the number of faculty who took statistics, which is often a required course in the social sciences.) Victoria, a Latina female assistant professor of sociology at a community college, had a more nuanced view of statistics that incorporated concerns other than poor performance:

> When I was little, I wanted to work for NASA and be an astronaut. Somewhere along the way, I got pushed/pulled into other areas, and I think my gender is part of that. . . I think my anxieties come from both fears that I won't be seen as "smart" if I can't follow along with a quant peer's work (though they never worry about not understanding my qual work), or pressure of showing off math skills in other areas of my life (e.g., splitting the bill in my head among friends at dinner). Also, through my education and scholarship, I see how numbers/stats are often used to maintain inequalities and oppression. The idea that "if we just had more accurate data" or "if we only were all QR literate" plays into that framework that elevates numbers as "The Answer," of stats-as-end-all-be-all, and that becomes difficult, for me, when we're talking about people's lives.

Finally, statistics is not the only quantitative field that some faculty found more accessible than mathematics. Evelyn, an assistant professor in the office technology unit of a community college, reported a negative view of mathematics but an affinity for accounting.

Ethnic discrimination.

The importance of positionality and social status (Darnon et al., 2012) could be seen in several narratives. Irene, a white associate professor in the social sciences at a community college, described a negative experience with discriminatory mathematics teachers:

> In co-ed elementary school in East Harlem, the Sisters of Charity were excellent educators [but] high school in the Bronx was very different. There I was taught by Dominican nuns who were mainly of Irish descent and some had obvious disdain of students with my ethnic [Italian] background.

Lesedi, a foreign-born Black instructor in a department of history and social sciences, traced some of her difficulties to linguistic and ethnic differences. She wrote:

> My love affair with math ended in high school. Growing up in the then Rhodesia in a racially segregated society, the vernacular was the main language of communication and all teachers were Black. In high school, English was the language of instruction and the faculty [were] multiracial. In junior high school (Year 1 and 2) my math teacher was a White lady! I know many people cannot relate to this but the first year was a nightmare. Trying to understand all the new concepts with my limited language skills had far reaching consequences for my future relations with Math.

While other research has pointed to the importance of race in shaping mathematical autobiographies and experiences (Steele, 1999; Williams, 2017), this issue was less salient among the NICHE and NICE participants, perhaps because the majority of those from underrepresented groups were foreign-born and would therefore not have been minority group members in their native countries.

Gender discrimination.

The mathematics autobiographies evaluated for this project suggest that discrimination in mathematics instruction is more closely linked to gender than to ethnicity, race, or national origin. For example, Lesedi (introduced above) emphasized the role of gender: “I was in a co-ed class with a male teacher who believed girls were bad at math and when we asked for assistance, he would tell us to ask one of the boys after class! He had a syllabus to go through. ‘Fortunately,’ after the year 4 exams I didn’t have to take a math class ever again!”

Many respondents were raised in environments where teachers favored boys over girls, or men over women, and assumed that the former were more capable of handling mathematical subjects. Grace, a white instructor in English at a four-year college, described her experiences with a sexist and incompetent teacher: “9th grade algebra regents was taught by a teacher who routinely said, "girls can't do math" (this was 1980). He was a terrible teacher in so many other ways. There was little hope for anyone, but his attitude made the girls feel that it was our gender, not him, that was holding us back.” Likewise, Chloe (introduced earlier) wrote,

> Uninspiring teachers taught the natural sciences, such as biology, as well as math. . . And, like [Grace], I had a teacher in trigonometry who would when a girl answered a question correctly go to a boy to confirm the answer but not vice versa. . . So, my senior year in high school, I decided not to take math. (I have no idea why a school system would leave this decision up to a teenager!)

These gendered messages about mathematical abilities were sometimes reinforced not only in the schools, but in students’ homes. Erica, a white assistant professor in the humanities at a four-year college, described the messages she received from her family:

> My standardized test scores as a child and teen showed me consistently at the 99th percentile for verbal skills and somewhere between the 92nd and 94th for math. I interpreted this to mean that I wasn't naturally good at math, and this excused my disconnection and boredom in math classes. Also, as one of ten children in a Catholic family, I inherited the understanding that my education wasn't as important for my future as my brothers' was. (My mother, who had an MBA, dropped out of law school to marry my father and never worked again—except the unpaid drudgery of being a mother of 10!!!). . . My first year at college was in 1979–80 at Notre Dame, where the ratio of men to women was 3:1 because it had only recently gone co-ed. The result was that the women who were admitted had to match one of the highest admission standards in the country that year. . . I realized that I was smarter than most of the boys, and for the first time I really began to like my math classes.

On a positive note, Lilly (introduced earlier) reported that she had been inspired to change how she approached her daughter’s education as a result of her newfound awareness of the role of gender bias in mathematics education: “Now that I have a daughter myself, and after reading about the gender biases for math, I can't wait to encourage her to work on her math skills!”

Difficulties in mathematics courses.

For several of the faculty, particularly the women, difficulties with courses such as calculus marked a turning point in their mathematical autobiographies. Vivian, a white assistant professor of psychology at a four-year college, described how these difficulties drove her away from mathematics courses:

> I really lost my interest in math when I took calculus in my first semester at college. Due to a combination of factors (boring and difficult to understand professor, lack of interest, and anxiety about math), I ended up earning a D grade in the class. As a mostly A student, I was very embarrassed by that grade and avoided "hard" math classes from then on out.

Katherine, a white full professor of English at a community college, described how negative experiences in college calculus and chemistry led her to gravitate away from mathematics:

> I attended an elite private college (I chose it because my guidance counselor told me I wouldn't get in), and that's where I learned to doubt my math abilities. My first semester I took college calculus and chemistry, and those two courses made me change my major and move away from math and science. I think the courses were designed to be gateways for pre-med students, and were meant to "weed out" students. I was "weeded out."

Elizabeth, a white female assistant professor of political science at a four-year college, had a similar experience with calculus: “I hit AP Calc in my senior of high school and had a horrible teacher. . . I remember sort of glimpsing at the beauty that was possible in math . . . but not being able to get past the memorization/proof part to get there. I think this teacher truly didn't care, he was old, almost retired, and not interested in helping someone out.”

These findings suggest that instructors who are ineffective or indifferent to teaching are more likely to create a classroom environment that is geared toward performance achievement goals. In such an environment, students—especially females—who don’t perform well may be more likely to lose interest in the subject.

Although two male mathematics faculty recalled negative experience with mathematics in elementary school, they both reported overcoming these challenges and eventually embracing the field. Eniola, a Black male associate professor of mathematics at a four-year college, reflected,

> My first encounter with math, I remembered just dropping my pen, being seriously confused with what the symbols were all about. However, the grade I was in at the time, was fail in one subject fail in all. I was sure going to fail math and that meant I will fail all other subjects too, so I looked

> for any math book I could lay my hands on and taught myself from the ground up. I found math fascinating and never looked back . . . until I got all my advanced degrees in math.

Positive experiences with mathematics

Although many faculty reported negative experiences with mathematics, a significant minority felt otherwise. Altogether, 25 respondents—19 of the 42 women (45%) and 6 of the 19 men (32%)—wrote mathematics autobiographies that were wholly or primarily positive. Fifteen reported that their experiences were wholly positive, 4 reported positive experiences marred by incompetent instruction, and 6 reported positive experiences that nonetheless required them to overcome obstacles along the way. These favorable experiences were sometimes grounded in a genuine affinity for mathematics and an emphasis on mastery goals (Dweck & Elliott, 1983; Dweck & Leggett, 1988). In other cases, positive sentiments were nurtured by supportive parents or teachers, good grades in mathematics classes, self-confidence, or a perceived natural aptitude. For Jessica, a white female associate professor of mathematics at a community college, several factors came into play:

> I remember throughout elementary school having lots of fun thinking about mathematical things. In 6th grade my teacher had me doing extension work that was in addition to what other students were doing. I thought that was great—did not mind doing the extra work because I liked it. In college I decided to major in math partly because I knew I needed a course each semester that was not going to require me to read multiple books. I used the math homework as a break from my reading and work for my other courses. . . My mother always encouraged me and even said that she wished that she had majored in math.

Mathematics as a tool for understanding the world.

Several faculty described how they saw mathematics as a welcome challenge or as a tool for understanding the world. Moreover, some attributed their interest in quantitative work to constructivist, active-learning approaches to teaching (Cobb et al., 1992; Ernest, 1991, Harkness et al., 2007). Tara, an Indian assistant professor of physics and earth sciences at a community college, wrote: "I was always interested in learning more since my love for physics was always made easier by using mathematical tools. I was also tutoring some lower grade students to earn extra bucks during college studies. So math and physics have always been best friends to understand or simplify the complexities that exist in nature." Likewise, Tarique, a foreign-born associate professor of mathematics at a community college, described how he loved the challenging puzzles that mathematics presented:

> From my childhood, whenever I would go to a book fair, I always looked for a puzzle book in mathematics and could not wait until I solved all the problems. I am not sure why I always liked math—I guess when I spend a lot of time solving a problem and am finally able to solve it, the joy that I receive is not comparable to anything else. I knew when I was a fifth grader that I want to be a mathematician. There is no other option for me.

Rachel, a white assistant professor of biology at a four-year college, reported that she had always loved math: "I don't ever recall having someone tell me that I could not do it or that girls were bad at math until I was a senior in high school. My mother tells me that I pronounced at the age of 6 that I would be good in math and science and terrible at languages, and so it has been ever since."

Manfred, introduced earlier, described how his interest in mathematics was nurtured at an early age when he was given a computer by his father. He was later inspired by a calculus professor who opened his eyes to the power of mathematics:

> When I was probably 7 or 8 years old, my father came home with a Texas Instruments computer. It was thousands of times slower than my cell phone today, and the only program permanently stored on the hard drive was a very early version of Word Perfect. . . I would type huge programs

> in so I could play a game, and slowly, I learned what different commands did and started writing my own little programs to amuse myself. They weren't very sophisticated, but it's from that experience that I developed an understanding of variables and how to think abstractly. . . In my first semester at college, I took Calculus II. . . I also took an ancient Greek philosophy course that was terrible; the philosophy professor seemed like he was stoned in class, and the discussions were banal. Meanwhile, my Calculus professor was quoting poetry in class and using Calculus to prove really crazy, unimaginable things. I switched my major to math (and economics) and suddenly I was a "math person."

Jian, a foreign-born Asian assistant professor of biology at a community college, took six mathematics classes in college and did well in them. That’s when he recognized the importance of mathematics for brain development. He stated, “Community colleges often focus on career, but I think education should focus on learning knowledge, thinking, and shaping people’s mind. People often say mathematics is useless. But I would say, it’s not about whether it is useful. It is about training our brain, and shaping our brain. Our brain is plastic. Through these trainings, we actually change it.”

The importance of a nurturing environment.

Several faculty mentioned supportive teachers and schools when describing their positive experiences with math. Justin, a white male associate professor of political science at a four-year college, felt strongly that a nurturing educational environment had allowed him to build on his natural aptitude for math. Likewise, Chisimdi, a Black assistant professor of biology at a community college, attributed her mathematical aptitude to supportive teachers and family:

> I loved algebra in the 7th grade. . . I thought solving for x was the coolest thing ever. The expectations from my parents were to do well in any endeavor so I guess I internalized this to mean that failure was not an option. From my teachers, I received support and praise. Now that I reflect on this, I wonder if having immigrant teachers from similar backgrounds to my own played a significant role in how I view my math and science capabilities.

Linda, introduced earlier, credited her mathematical skills not to innate ability, but to an encouraging, math-centered environment:

> My father was a CPA and . . . my mother was taught "mental arithmetic" in her upper west side public school just after WWI and could still add figures faster in her head than I could when she was 100. My most important math lesson was when I was in first grade and it was time for an allowance. My father gave me a choice, $1 a week or 1 penny the first week, 2 the second week, 4 the third, etc. I chose the buck a week. and he said he was relieved because he could not have afforded the other. . . He then explained exponential progression.

Success breeds success.

Perhaps not surprisingly, many faculty attributed their favorable attitudes to their success in mathematics courses. Amanda, a lecturer in psychology at a four-year college, reported that her positive experiences in mathematics classes led her to doubt the gender stereotypes she had heard about:

> Personally, math was always a strong subject for me. I excelled in math throughout primary school and was at the top of my class in high school and [in] the few math college courses I took. I heard the gender stereotypes about math, but I never believed them, because the strongest math students in my classes were usually female as well. In high school, we had "enriched" math courses and 90% of the students in the class were female.

Emma, a white assistant professor of education at a four-year college, reported that she had gained a clear conceptual understanding of mathematical concepts only when she decided to pursue a career in mathematics education:

> I excelled at [math] until calculus even though I didn't consider myself to be a “math person.” As I continued to study mathematics and more specifically, mathematics education, I came to learn that my understandings of mathematics were quite fragile and fragmented. I was a good student and

> capable of rule following and procedures but had little to no conceptual understanding of even the most basic concepts. It wasn't until I began teaching 3rd grade that I started to learn more about my own mathematical thinking- alongside my students!

Mathematics and other interests.

A few participating faculty had favorable experiences with mathematics but were ultimately led in other directions. Ian, a white instructor of reading, writing, and literature at a community college, reflected on the support of his mother, a progressive mathematics teacher:

> My mom taught math at the middle school and high school levels throughout my growing up. Looking back, I can see that she was an engaged teacher who took a mostly contextualized, constructivist approach. She addressed the topics of manipulating fractions and calculating percentages through a stock market game (this was back when stock quotes were listed in fractions in the newspaper). Each got fake money to allocate across different stocks and we calculated the value of our investments every week and made changes until the end of the contest. . . Similarly, we practiced calculating areas and proportions by designing houses.

His account is consistent with research showing that students understand mathematics best through active learning projects that build new knowledge based on previous knowledge and experience (NCTM, 2000). Ian liked mathematics and did well in his mathematics courses, but he ultimately fell in love with poetry. Likewise, Lucia—a part-time faculty member in American Studies at a four-year college—always excelled in mathematics but eventually gravitated toward philosophy, "lured by the logical puzzles and games" presented in her philosophy courses. In contrast, Cindy, a white assistant professor of allied health at a community college, reported that her interest in philosophy had led her back to math. She noted, "I completed all my math requirements by my sophomore year of high school and didn't have to do any more. . . [But] I started getting into it again when I began reading philosophy. Apparently the maths are the key to the universe."

Success despite poor instruction.

Several respondents reported a positive outlook toward mathematics despite their frustration with inept instructors. Mia, a foreign-born Indian female assistant professor of mathematics at a four-year college, reported "I am good at math. My best memories are the emphasis on algorithms and rigor. My worst memories are of second-rate professors whose only goal seems to be to show they are smarter than their students, so they took simple concepts and made it as hard as possible." Likewise, Alexis, a white female associate professor of biology at a community college, wrote,

> I am one of those lucky females who never had bad experiences with math when I was younger. . . I was put in gifted classes, praised in front of the classes, allowed to participate in enrichment programs in the summers. . . My worst experience(s) would probably not be considered that bad—but in college, I was unhappy with the instruction. The professors were actually grad students, usually foreign-speaking and hard to understand, and they chose textbooks that were awful . . . badly written, emphasizing equations, but ignoring the visual aspects of the math.

The importance of making mathematics relevant

Nearly a dozen faculty, including several from both the "negative" and "positive" groups, remarked that mathematics instruction is most effective when it is contextualized—when students can appreciate its relevance to their lives. This finding reinforces previous research on the importance of using real-world problems and fostering motivation through the use of constructivist pedagogies that make students active participants in the learning process (Cobb et al. 1992; Ernest, 1991; Harkness et al., 2007). An instructional approach that emphasizes *making mathematics relevant* also suggests an emphasis on mastery goals, since it requires an understanding that transcends any one course and that can be applied in multiple contexts.

Alice, a foreign-born Asian female and associate professor of economics at a four-year college, "never really liked math until I came to appreciate its relevance and value in my life which was in the last 20 years or so. . . It was not until I started going for my Ph.D. in economics and seeing the connection between math and economic theories in my 'Mathematical economics' classes that I really came to appreciate the value of it." Naomi, a white associate professor of sociology at a four-year college, had a negative experience with calculus as an undergraduate, but she enjoyed statistics courses in graduate school because they "contextualized the numbers and brought them to life." Sophia, introduced earlier, indicated that her outlook shifted from negative to positive in graduate school "when the math courses [she] was taking were about statistical analysis of data and were something [she] cared about."

Oumaru, a Black adjunct faculty member in the social sciences at a four-year college, noted that "math would have been less abstract for me, and I would have enjoyed learning math" if his professors had taught math using discovery methods. Lori, introduced earlier, had a similar view: "A couple of years ago, I read, and hugely [enjoyed], David Foster Wallace's 'Infinity.' Lesson learned: math isn't all about memorizing formula and acting like a human calculator—it can be conceptual and abstract in a way that would have clicked with me a whole lot more than the way in which I, and most people, are taught it."

Even a few of the mathematics faculty lamented that mathematics instruction is often stripped of any real-world context. Jessica, introduced earlier, criticized the way mathematics is typically taught: "Today we need to think about how technology should change what we emphasize in math class. Why spend lots of time learning to execute algorithms which can more efficiently be done by technology? I believe that emphasizing algorithms, when technology can easily do that work, makes math seems even less relevant to students."

From experience to practice

The mathematical autobiography exercise sparked strong interest among the NICHE and NICE participants, generated lively discussions, raised awareness of the diversity of experiences of the program participants, and led faculty to consider how to promote constructivist approaches and other positive pedagogies. The exercise also led participants to reflect on the broader theme of inequality, heightening their awareness of critical issues such as stereotype threat. Although we cannot readily disentangle the effects of any single activity, the majority of faculty indicated, at the conclusion of the program, that they had altered their pedagogy in favor of these perspectives and methods (Wilder, 2020). A faculty member in the social sciences distilled the sentiments of many respondents: "I have grown to love the constructivist approaches. I relish the joy I see in students when they are doing what they love."

In their reflections, many of the faculty who recounted negative experiences at the hands of insensitive teachers described how they had made a commitment to ensure that their students did not have similar experiences. For many, this meant approaching students with a high degree of sensitivity and acknowledging their mathematical anxieties. For example, Mindy (described earlier) stated, "Maybe we need to ask students to confront their own anxiety, to say with pride that yes, this course requires math and QR, and as students you are capable." Lori, described earlier, mentioned the need to calm students' anxieties "by giving them the tools to solve what had seemed to be insurmountable problems, but also to communicate that some anxiety might be justified—that math can, indeed, be hard—but that meeting its [challenges] can lead to wonderful things."

Many participants acknowledged the importance of confronting students' mathematical anxieties head on. As Kathy stated,

> I have a clearer sense now after reading the supporting articles and reading others' math autobiographies that the anxiety is real—and can/must be ameliorated. Thinking about math anxiety in terms of stereotype threat will be useful in working with students, as will talking with them about the value of math in life. . . I am also struck to the core by Esther's comment that QR for CUNY students is a social justice issue. I never thought about math this way, and this idea will impact my pedagogy in a profound way.

Similarly, Laleh (described earlier) stated, "The good that has come out of [my negative experiences with mathematics] is that I am very mindful of my language with my students, especially when I have to motivate them to improve. Unlike the teachers of my day, I understand that public humiliation is not a positive motivator." Not surprisingly, an overemphasis on performance (i.e., grades) was recognized by several faculty as a hindrance to perseverance in mathematics. Chloe (introduced earlier) reflected, "This pattern of gauging one's ability based on a test score starts so young and carries through the later years (habituation). . . [I like] the notion that we should set high standards and communicate that we believe everyone will be able to meet those standards."

Finally, many faculty who reported positive experiences with mathematics expressed a desire to serve as role models for their students. An Asian male professor of physics at a community college reported, "It is really gratifying that eventually I understood relativity. My experience has also become a confidence booster: I am still telling myself that if I can understand relativity, there is nothing that's too difficult for me. This is the moral I've been sharing with students."

Observations and reflections

The mathematical autobiographies discussed here suggest five generalizations that may be helpful to keep in mind when planning mathematics/QR instruction and when interacting with students.

1. Both structural variables (e.g., teachers, external support) and individual characteristics such as agency (e.g., growth mindset, motivation) are important in explaining success, or lack of success, in mathematics teaching and learning.
2. In environments where there is weak structural support (such as disinterested instructors), performance goals tend to predominate, and agency is of paramount importance.
3. In environments where there is effective structural support (e.g., engaged teachers who promote progressive pedagogies), mastery goals tend to predominate; both faculty and students are likely to emphasize the applications of mathematical knowledge in real-world contexts.
4. Students' progress toward achievement goals—and the relative importance of mastery goals and performance goals—is conditioned by their social identities, and especially by gender.
5. Structural variables and individual variables (such as agency) interact. It is therefore important to recognize the diversity of students' experiences and to maintain a commitment to overcoming the barriers that can hinder achievement in mathematics, including poor instruction and gender bias.

Conclusion

Students' early mathematical experiences influence their success in later math-intensive tasks and courses. The mathematical autobiographies discussed here demonstrate the importance of both individual and social factors, including experience with constructivist learning, in shaping individuals' attitudes toward mathematics. They also support the assertion that an orientation toward performance goals rather than mastery goals (Dweck & Elliott, 1983; Dweck & Leggett, 1988; Harkness et al., 2007; Liu, 2021) does not necessarily impede the development of favorable attitudes regarding quantitative work. For at least some individuals, early success or failure in competitive environments (such as mathematics courses) sets the stage for later developments and influences whether they see themselves as mathematically gifted or mathematically inept. These narratives also reinforce the importance of social status ("positional level of analysis") as an important moderator of achievement (Darnon et al., 2012).

While many faculty participants in the NICHE and NICE programs emphasized individual aptitude as a key factor in their attitudes toward mathematics, others stressed the importance of external support (or lack of support) as a critical element in their mathematical interest and motivation. Those who reported positive attitudes often mentioned a fascination with the subject, excellence in their early mathematical pursuits, encouraging teachers and parents, and a strong sense of self-confidence—a belief in their natural aptitude. Of the faculty who had mixed experiences with math, many found it enjoyable only when they saw its utility and recognized that it was a useful tool for understanding the world. These results support the notion that successful instruction requires constructivist and inquiry-based models of teaching—progressive pedagogy that "[connects] content to real-life situations" (Cuban, 2001, p. 89). In situations where there was strong structural support, faculty tended to emphasize mastery goals; many wanted to achieve mathematical proficiency so that they could apply mathematical concepts and methods in real-world contexts.

The participants who reported negative experiences with mathematics told stories of unqualified and even hurtful teachers, difficulties understanding mathematical concepts in school, poor grades, a general dislike of math, and—in many cases—gender discrimination that was expressed both openly and in more subtle ways. These negative experiences often spoke to a sense of powerlessness. Respondents described situations where they felt they lacked control, such as when teachers questioned their abilities or labeled them as low achievers. Overall, these narratives demonstrate the importance of positional and social factors, especially gender, as mediators of the relationship between motivation and achievement. Moreover, they suggest interaction effects related to both individual and social factors. In particular, many of the women who had doubts about their abilities found that their insecurities were exacerbated by teachers who discriminated against them. This, in turn, sometimes led to performance avoidance among those who feared they would be judged negatively if they attempted higher-level mathematical tasks (Dweck & Elliott, 1983; Dweck & Leggett, 1988).

The faculty who participated in the CUNY QR programs represent a broad range of institutions and subject areas. While previous research on mathematical autobiographies has focused on students enrolled in mathematics classes or studying to be teachers, mathematical and quantitative narratives are relevant to all disciplines. In this case, the diverse backgrounds and teaching experiences of the faculty were also accompanied by certain commonalities. Most were junior or mid-career faculty whose K–12 and college experiences took place from the 1970s through the 1990s. Some of the problems they described, such as blatant sex discrimination, may take different forms today. Nonetheless, it is still common for girls to be told that "just because they are girls, they can't be any good at math" (Bennett, 2013, p. 6).

Notably, some of the themes that emerged in previous research on students' mathematical autobiographies, such as cheating and academic dishonesty (Hauk, 2005), were conspicuously absent from these narratives. Faculty may be a select group with different experiences than most students, or they may simply be reluctant to discuss certain topics in an open forum. Although it is true that faculty committed to QR instruction may be systematically different from the general population in other ways as well, it is important to recognize the great variety of experiences and attitudes represented within the sample. Clearly, there is no single "faculty experience" with regard to mathematical autobiographies.

Educators who reflect on their own mathematical autobiographies, and on those of other faculty and students, are likely to better appreciate the diversity of experiences that students bring to their quantitative courses. They are also likely to more fully understand the factors that promote favorable attitudes toward mathematics as well as the teaching strategies that are often especially effective with hesitant learners (e.g., progressive pedagogies, construction methods, and inquiry-based learning). This exercise highlights the importance of sensitivity to students' mathematics-related anxieties, but it also shows how attitudes can change in response to new experiences—how even deeply held negative views ("I'm not a mathematics person") can be overcome by individuals who learn to appreciate the relevance or the beauty of mathematical inquiry.

Mathematical autobiographies can also be useful outside the faculty development context. They can help instructors learn more about students' motives and attitudes, signal an interest in students' success, or serve as a starting point for broader conversations about mathematics teaching and learning. The prompts can be as simple as "Tell me your mathematical autobiography" or they can include detailed questions that probe into topics such as gender roles, students' use of mathematics outside the school environment, or changes in their attitudes over the course of their educational careers. The information gleaned from these activities must be put to good use, however. When instructors listen to the voices of their students, they are in a better position to plan activities and assignments that are responsive to their students' needs. Faculty should embrace progressive pedagogies that have been shown to be effective in promoting STEM education (e.g., Cuban 2001), work to ensure that women and underrepresented students are provided with the support they need, and understand the importance of both performance goals and mastery goals. Mastery goals may be especially relevant as students come to appreciate the usefulness of mathematics in a variety of academic and non-academic contexts.

The narratives presented here suggest that mathematical autobiographies are likely to be useful in both faculty development programs and university courses. However, further research is needed to explore the extent to which they promote pedagogical innovation, favorable attitudes toward mathematics, and mathematical or quantitative aptitude among faculty and students. Exercises such as this must be implemented before they can be assessed, and both implementation and assessment can lead to improvements that inform mathematics teaching and learning.

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