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Opposing Dimensions in Mathematicians' Counter Narratives Written for Undergraduate Students

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In mathematics, counter narratives can be used to fight the dominant narrative of who is good at mathematics and who can succeed in mathematics. Eight mathematicians were recruited to co-author a larger NSF project (RAMP). In part, they were asked to create author stories for an undergraduate audience. In this article, we use narrative analysis to present five polarities identified in the author stories. We present various quotations from the mathematicians' author stories to highlight their experiences with home and school life, view of what mathematics is, experiences in growth in mathematics, with collaboration, and their feelings of community in mathematics. The telling of these experiences contributes towards rehumanizing mathematics and rewriting the narrative of who is good at and who can succeed in mathematics.

Keywords: Counter narratives, narrative analysis, mathematicians

Stories provide a particularly powerful way to make sense of our lives and provide structure to society. Stories may be personal narratives, the narratives we tell ourselves about our lived experiences, as well as dominant (master) narratives that are culturally shared. In the United States, there are prevalent deficit narratives in relation to students of color (e.g., Adiredja, 2019; Berry III et al., 2011) and women (e.g., Leyva, 2017) and their ability to do mathematics. As elaborated by Berry III et al.,

Master narratives embody and dictate expectations about how things work and how stories are framed. Often, master narratives present contrasts between groups of people by advantaging dominant groups and disadvantaging members of marginal groups such as women and people of color (p. 11).

An important means of challenging dominant (or master) narratives are *counter stories* or *counter narratives* (e.g., Solórzano, D. G. & Yosso, 2002) which run counter to status quo and dominant narratives. Many scholars have presented such narratives as a way to disrupt prominent stories of who is good at math and who can succeed at math (e.g., Berry III et al., 2011; Harris et al. 2011; Langer-Osuna et al., 2016; Leyva, 2016; McGee, 2009). These narratives are often crafted by researchers or those marginalized and brought into spaces to perturb and make change.

Narratives themselves are constructed with a certain audience in mind. Kaasila (2007b) explains, “when we are telling a narrative (or narratives), we often take our audience into

consideration and adapt what we say and how we say it accordingly” (p. 206). In this project, we examine a set of narratives that were crafted explicitly for students to read in undergraduate proof courses. Eight mathematicians whose stories challenge the dominant narratives of who can succeed in mathematics, provided two-page biographies for students.

In this proposal, we share an analysis of these narratives, identifying rhetoric and plots these mathematicians shared. For the scope of this paper, we present findings from the portion of our analysis focused on “key rhetoric” (Kaasila, 2007a) indicating opposing polarities internal to the author’s stories. This analysis is led by the following research question:

What opposing dimensions are salient in mathematicians’ career counter narratives as told for a student audience?

Narrative and Mathematical Identity

A narrative approach to identity emphasizes that identity is created by the stories we tell about our lives. Narratives are stories that include events that are “attach[ed] to a character” (Kaasila, 2007b, p. 206) and are organized into plots. Identity is then a “subjective, constructed, and evolving story of how one came to be the person one currently is” (McLean & Syed, p. 320). Furthermore, the author of a narrative imparts coherence to the story. Kaasila (2007a) identifies, “[k]ey rhetoric [a]s a coherence system through which different life events are connected and their relation is explained by dividing the narrated world into different dimensions of reality” (p. 377). Kaasila (2007b) further asserts that key rhetoric often points to expectations, whether met or subverted, adapting Tennen’s (1979) notion that expectations determine how narratives are shared. That is, the author of a narrative may be framing their story as adhering to or subverting their own or societal expectations.

Relatedly, many scholars argue for distinctions between master (or dominant) narratives and alternative (or counter) narratives. McLean and Syed (2016) elaborated that, “Master narratives are culturally shared stories that tell us about a given culture and provide guidance for how to be a ‘good’ member of a culture; they are a part of the structure of society.” These narratives may be unproblematic if one’s life easily fits into the dominant narratives. However, one’s personal narrative may involve adopting an alternative narrative that differs or resists the dominant narrative. We take on McLean and Syed’s stance implying there is *negotiation* between self and society and *internalization* of dominant narratives. We would anticipate that subversion of expectations may be reflected in personal narratives when alternative narratives are provided of who is good at math and what it means to do mathematics.

Mathematics identity becomes salient when one tells stories of their mathematics experiences including “stories about one’s relationship to mathematics, its learning and teaching. This means that a person’s mathematical identity is also context bound and always under construction” (Kaasila, 2007b, p. 206). Martin (2007) suggests that mathematics identity is the “dispositions and deeply held beliefs that individuals develop about their ability to participate and perform effectively in mathematical contexts and to use mathematics to change the conditions of their lives” (p. 15). From a narrative perspective, this means considering how one’s stories and experiences with mathematics are constructed within their institutions, communities, and in relationship to sociohistorical dominant narratives (Larnell, 2016). That is, mathematics identity is reflected in the stories told of how one arrived at their current dispositions and beliefs, and how expectations were subverted or maintained in this process.

Methods

Eight mathematicians joined the larger RAMP project team to develop curriculum materials for introduction to proof. The mathematicians were selected based on their reputation in the field and via snowball sampling (Parker et al., 2019). That is, mathematicians recommended colleagues and friends who are active in the field and dedicated to supporting a more diverse and inclusive mathematics community. Amongst the group of eight mathematicians, two identify as Black/African American men, one identifies as a Black woman, one as a Black and Chinese woman, one as a Latinx woman, one as a Latino man, and one as a woman and Native Pacific Islander.

The eight participating mathematicians were asked to exhibit mathematical results (without restriction on the origin of statements) through proof writing based on their own intended goodwill and mathematical expertise. The authors refined their work through team-led proof sculpting--a process to reduce the noise of mathematical exclusivity in favor of amplifying reception by vetting choices of transmission based on a form of accessible reasoning. This type of collective engagement recasts expertise. The resulting pieces run counter to the style prevalent in research mathematics: Concluding the veracity of a mathematical statement does not have to cost the reader (nor the author) their humanity as an act to pay homage to mathematical elitism. These costs and refutations were mentioned amongst other themes in author stories that were requested to accompany the proofs. A set of guiding (but not required) questions were provided to help shape the author stories which had an overarching aim of sharing how the mathematicians arrived at their current career. These included prompts about their life before becoming a mathematician, finding meaning and joy in math, struggles and overcoming struggles, and what it means to do mathematics. Each narrative was roughly two pages and designed to be part of the curriculum provided for students.

We took an “analysis of narratives” approach (Polkinghorne, 1995) analyzing the narratives for themes that hold across them. We focused on mathematical identity markers, mathematical socialization markers, key rhetoric reflecting polarities, and plot features. The plot features and key rhetoric were adapted from Kaasila (2007a) where plots were considered in terms of *outcomes*, *key events*, and *important people*, and key rhetoric to identify how incoherent or differing dimensions of life stories are connected. All instances of contrasting language such as “but”, “however”, or explicit language such as “contradiction” or “surprise” were identified in order to identify and analyze the “polarities” described in the mathematician stories. To focus on mathematical identity, we adapted Larnell’s (2016) coding scheme marking instances that reflected, “importance of mathematics”, “motivation”, “strategies”, “opportunities”, “constraints”, and “capacity to perform.” For socialization, we used Larnell’s categories: “institutional”, “sociohistorical”, “community-home.” We note that it is in the sociohistorical category we are most likely to observe dominant narratives endorsed or contradicted in the mathematician stories. Each story was read and analyzed independently by two members of the team. In the next section, we report on some of the polarities that were salient in relation to mathematical identity and socialization as indicated by key rhetoric in the narratives.

Results

For the scope of these results, we share a series of polarities identified and some quotes that illustrate the ways they were discussed in the narrative collection.

Polarity: Home and School Life

An early polarity observed through the narratives was a divide between home and school. This polarity difference was not always experienced the same, but the contrast between the two

environments was salient. One mathematician shared that mathematics was an escape, elaborating, “In a whirlwind of instability, I could always rely on math to be a subject where I could solve problems and feel good about the world.”

However, more commonly, school was described as constraining with one mathematician explaining:

As a child and teenager, I was diligent and shy at school, while being loud, goofy, and creative at home. Most of my weekends were spent gathering with our large extended family, celebrating our Indian heritage. I remember these times fondly. I felt, and still feel, at home with my cousins, in sharp contrast to how out of place I felt at school.

Similarly, another mathematician contrasted school as causing an “academic conflict” that became problematic as the rigidity of the “high school schedule” contracted with their earlier experiences both with the philosophy of Montessori and also the “freedom of viewing/connecting dots outside of the classroom.” That is, the school setting was presented as a constraint (in various ways) in their mathematics story.

Finally, we note another contrast that emerged in some of the stories: the math opportunities outside of school versus inside whether those be competitions, or camps, or in the case of one mathematician’s games,

Whether it was finding the logic to solve a puzzle or simply counting dominoes to record the score of a game, I really enjoyed it all. In school, the story was a little different. I

always performed well in math classes but found them repetitive and not very interesting. It seemed frequently outside experiences of math were salient to supporting interest.

Polarity: Mathematics as Creativity and Computation/Speed

A related polarity can be found in mathematicians’ descriptions of what mathematics is. As seen in that last quote, school mathematics was often linked to its “repetitive” and closed nature. It was common for stories to contrast earlier understandings of what mathematics is, such as one mathematician noting, “I thought all the interesting questions had been answered and that being a professor meant knowing all the answers.” To follow up this statement with “Spoiler alert: none of that previous sentence is true.” There were often key events that led to this shift such as research opportunities.

Another relevant storyline is the way that the dominant narrative around mathematics, that what it means to be good at mathematics, is somehow tied to having absolute knowledge or speed. For example, one mathematician shared an experience learning a new topic that interested one of their students:

I would imagine a few years back, I would be nervous about understanding a topic with which I was unfamiliar. I realized this was tied to my ego. I didn’t want to look like I didn’t know something about mathematics. This is a contradiction, it seems. If the mathematics I love is about ideas, then why is my ego involved? Why should I care about who did the problem fastest?

This quote describes two contrasts: the contrast between where the mathematician is now versus “a few years back” and the contrast between “speed” and “ego” versus “love” of mathematics.

Finally, we note one other way this polarity came out. One mathematician explained, “I try to convey that everyone (not only white men) can do math, that math is more than computation and arithmetic, and that math can be fun.” Here the contrast is explained in the context of making efforts to change a dominant narrative. It would be remiss not to note that nearly every author story did not conclude with them doing their mathematics work, but ways that they have integrated changing narratives for others into their lives.

Polarity: Mathematical Breakthroughs and Struggles.

Another polarity is part of what Larnell (2016) calls the strategies of mathematics. Related to ideas that math should be fast, with answers known immediately and quickly recited, is the inherent tension of breakthroughs and struggles. Across the stories, the mathematicians contrasted these elements with statements like: “To me, mathematics is messy and that is the beauty of it, because it allows me to be messy without judgment,” “I became more comfortable with the fact that mathematics is very hard and that challenges are ok,” and,

The most glorious moments are always the breakthroughs of a new idea, or an epiphany.

It’s an indescribable moment that I hope we all get a chance to feel. One moment, the struggle is real, frustrating and long. I can feel like I am getting nowhere. There are times where it feels like I have wasted time. But when the moment of clarity arrives, it’s worth it.

If we consider key rhetoric as bringing coherence to stories, we can see the ways that messiness, challenge, and struggle are all coherent parts of the beauty and joy of doing mathematics. While the polarities are in contrast, they are not in tension in the work of the mathematicians in their reflections on the present day.

Polarity: Isolation and Collaboration/People

Another dominant narrative frequently subverted in the stories was the idea that mathematics is not a human endeavor and that mathematical activity is meant to be done in isolation. This isolation was often highlighted as a part of their mathematical journey that contrasted with the joy they later felt. For example, mathematicians explained the challenges of feeling alone in school or the challenges related to research in their careers with one mathematician noting, “I found it very difficult to keep my research going since, at the time, I did not have collaborators.”

Many of the mathematicians contrasted this isolation with feelings of joy in connecting with others through mathematics. For example, the mathematician above described a key event where they had given a talk and invited collaboration which led to:

In the years that followed, we got together and had the best time cranking out some super neat results on posets and order dimension. It still brings tears of joy to my eyes when I think about those days in the basement of the math department at [blinded] with these phenomenal women because it was the first time I truly felt like an honest-to-goodness mathematician, working on some very cool math with some very cool people.

Others described the joy in collaboration or made similar comments about the integration of people and mathematics. One mathematician noted, “I came to realize that I find the most meaning in mathematics through human connection and interaction” or another reflected, “So what brought me back to this world of academic and research mathematics? People.”

We note that the role of people went further than just people to do mathematics with, but also included the many role models, family members, and community in the lives of the authors. As one mathematician noted, “Who are the people who support us unconditionally? Surrounding yourself with these people can create a life more expansive and fulfilling than you can possibly imagine.”

Polarity: Outlier and Belonging

Finally, we note one last polarity related to the human element: belonging or being an outlier. This polarity is intimately tied to representation and the people around you. The mathematics discipline is notoriously white and male. When taking classes, mathematicians mentioned ideas

like, “this love for combinatorics did not remedy how alone and isolated I often felt not knowing other people like me in mathematics,” “I am often the odd one out racially and/or culturally wherever I go,” and,

On the other hand, I often felt out of place in many of my classes at [blinded university] as a woman of color. I remember constant signaling from my peers and other professors that I didn’t belong in math. I found refuge from these experiences through my hobbies and social life, and especially through my participation in a competitive collegiate dance.

One mathematician reflected that they still feel a degree of imposter syndrome despite their CV:

You might never guess that is how I feel when you look at my CV and all of the math I have done and learned along my mathematical journey. Yet, that feeling lingers. Now that I am older, I understand that some of that feeling is often triggered because I did not see myself reflected in those who I considered mathematicians: my teachers and professors. The fact remains that being Latinx and a woman means I am often one of the few in a room who is not part of the dominant group in mathematics: male and white.

This feeling of “not seeing” oneself amongst others in mathematics was quite salient. Key events in the authors’ stories would allude to seeing themselves represented or collaborating with others that are not part of the dominant group.

For example, one mathematician noted the impact of seeing a Black, male professor explaining a critical moment,

A tall large Black man entered the room. He took his suit jacket off and said: “I am [name blinded]. This is analysis.” He began to detail the course and what it was about. It was at this moment where I whispered to myself: “That is who I want to be.”

Across the stories, mathematicians talked of building community and not just in the sense of collaboration above but building community amongst others like themselves. With one mathematician explaining,

I worked to find a community of mathematicians where I do feel like I belong. The mathematicians I am closest to are not only my colleagues, but also my friends. We connect on shared values and views and work together to promote equity and justice in the mathematical community.

Further, as discussed above, this work was also done to open doors for others coming up, students, young scholars, and as one mathematician noted about the stereotype of who does math, “By dispelling this stereotype, we create a more inclusive culture for mathematics.

Discussion

An overarching goal of stories and narratives is to center the humanity of both the individuals and their communities. Humanizing mathematics has been a part of the endeavor to improve education of mathematics in service of justice and inclusion (e.g., Berry III, 2021; Tan et al., 2022; Yeh & Otis, 2019). If we want students to see themselves as doers of mathematics, it is necessary that we problematize popular narratives of mathematics in terms of both who is capable of doing mathematics and what mathematics is. Some of this work has been championed taking a humanistic approach to mathematics. In summarizing Hersch’s contributions, Pais (2018) explained, “the purpose is not (only) to study mathematics in itself, but as an activity, developed by humans in a variety of different settings” (pp. 235-236). This approach stands in stark contrast to the materials often provided in proof-based classes. Davis and Hersh (1981) elaborate that proofs often obfuscate the humans involved with an “ideal” mathematician writing to “conceal any sign the author or the reader is a human being. It gives the impression that, from

the stated definitions, the desired results follow infallibly by the purely mechanical procedure” (p. 36).

If we consider the narratives provided, we can identify many ways that mathematics, as engaged in by mathematicians, is a fully human experience. People and communities shaped the stories told. These narratives eschew not only dominant narratives that only certain types of people should and can succeed at mathematics, but also what mathematical success entails. The stories elaborated on how school mathematics geared towards speed and computation is not necessarily the mathematics of joy and discovery that supported and inspired the authors’ journeys. The mathematicians were agents in the stories, and the proofs they produce are not authorless. As we consider ways to humanize mathematics for students, author stories can provide a powerful means to challenge the status quo. While it is unlikely that the norms of how proofs are written will shift any time soon, we can certainly take strides in pulling back the curtain and sharing not just the final product, but the process and the people involved.

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