A Narrative Inquiry Into Students' Proof Journeys and Mathematical Master Narratives

Brittney Ellis, Texas State University
Tenchita Alzaga Elizondo, University of Texas Rio Grande Valley
Lino Guajardo, Central Michigan University

This study uses narrative inquiry to explore undergraduate students' experiences learning mathematical proof and engaging with proof culture. Drawing on interviews and journey plots from five students at Hispanic-serving institutions, we constructed interpretive narratives to examine how their stories reinforced or resisted mathematical master narratives, such as mathematics being done in isolation or requiring innate ability. Students' journeys revealed moments of joy and triumph, as well as loneliness and frustration. While elements of their stories reinforced master narratives—such as feeling isolated—others emphasized the effort required to develop proof skills, countering the narrative that mathematical ability is innate. Our findings highlight how learning environments and instructional practices influence students' engagement with proof and their perceptions of who belongs in mathematics. By analyzing how students navigate proof culture, this work contributes to efforts to make mathematics more inclusive and to better understand the cultural narratives that impact students' mathematical development.

Keywords: Proof Culture, Narrative Inquiry, Student Experiences, Master Narratives

Students' experiences learning mathematical proof—both inside and outside the classroom—offer valuable insights for the mathematics education community, yet remain underexplored in undergraduate research. Existing studies have examined what students in proof-based courses take away from lectures (Krupnick et al., 2018; Lew et al., 2016) and their beliefs about various aspects of proof, including the reading, writing, and understanding of proof (Guajardo & Lew, 2024; Lew & Mejia-Ramos, 2019; Weber & Mejia-Ramos, 2014). While these studies shed light on students' perceptions and learning outcomes related to proof, further research is needed to explore how students' experiences evolve over time as they navigate proof-based courses and engage with proof culture. Their experiences with this culture shape not only their beliefs about proof itself but also their identity and sense of belonging within the proof community.

Recent studies have begun to explore students' experiences through their own mathematical journeys (Melhuish et al., 2024; Wrightsman, 2025). Melhuish et al. (2024), analyzing student reflections on mathematicians' autobiographies, found that students often challenged dominant narratives within the mathematics community—such as the belief that mathematical ability is innate—especially when reflecting on their own paths, including the idea that one can struggle with math and still pursue a mathematics major. Similarly, Wrightsman (2025) used narrative inquiry to examine how students' perceptions of and engagement with norms in inquiry-oriented introduction to proof courses shaped their participation and mathematical identities. She found that while some students adapted to the change in expectations (i.e., collaboration, public reasoning), others struggled as their prior identities related to being "good at math" were unsettled. These studies highlight the importance of understanding how students' beliefs and identities related to mathematical proof and proof culture are shaped by the content, courses, and broader cultural narratives they encounter.

Building on the need to understand students' mathematical journeys, we adopted a narrative inquiry approach to explore students' evolving experiences with learning proof and engaging with proof culture. Broadly, we view proof culture as the commonly shared values, goals, norms and practices within the mathematics community related to proof and proving (e.g., Dawkins &

Weber, 2017). Students' stories about their experiences learning proof over time and engaging with proof culture are powerful because they have the potential to open a window into elements of master narratives that are being reinforced or challenged (e.g., Melhuish et al., 2024). When students' identities and stories diverge from the master narratives, they may feel excluded from the broader mathematical culture (Melhuish et al., 2024). Therefore, identifying how master narratives are reproduced or resisted in students' personal narratives is a necessary step toward making proof culture more inclusive. Without this understanding, we cannot determine which aspects of the master narratives need to change. To address this, our study investigated the following research question: How did students' retelling of their journey through proof-based courses and experiences with proof culture reinforce or counter master narratives in mathematics?

Theoretical Framing

The stories that people tell (and retell) about themselves in relation to the world around them are inextricably linked with their identities (Sfard & Prusak, 2005). Students' stories about their journeys learning proof are powerful because these personal narratives have the potential to challenge existing master narratives within mathematics and proof culture (McLean & Seyd, 2015; Melhuish et al., 2024). Master narratives are common cultural stories that influence how people behave and view themselves within a culture, and shape perceptions of who is considered 'good' at being part of the culture (McLean & Seyd, 2015). Unlike personal narratives—stories of individuals' lives—master narratives are "culture-specific stories" that individuals may "internalize or resist, consciously or unconsciously" (p. 323). Master narratives become particularly important in mathematics and proof culture as they often link 'doing mathematics' with 'doing masculinity' (Jaremus et al., 2020; Leyva et al., 2017; Mendick, 2006), while also perpetuating the dominance of whiteness (Battey & Leyva, 2016; Martin, 2019) and Eurocentric viewpoints (Rowlands & Carson, 2002). Notably, Melhuish et al. (2024) identified several mathematical master narratives: Mathematics is done by privileged white men; Mathematics is done by those who are brilliant, but socially inept; Mathematics is done in isolation; Mathematics is dry and not fun; Mathematics ability is innate, and easy for those with high ability; and Mathematics is individualistic and a meritocracy.

Following McLean and Seyd (2015), we adopted a narrative approach to theorize the relationship between individual identity and societal structures. Given their shared adaptability and subjectivity, narratives offer a fitting lens for examining the complex interplay between identity and culture. McLean and Seyd's model connects individuals' personal narratives with master narratives and potential alternative narratives. When individuals conform to master narratives, the dominant social structures are reinforced, whereas resisting them constructs an alternative narrative. Interestingly, McLean and Seyd argued that master narratives can be strengthened in both cases—"directly through unconscious internalization and indirectly through conscious opposition and negotiation" (p. 325). Although internalization is usually an unconscious process, master narratives can be evident in individuals' personal narratives.

Within a narrative inquiry framework, stories are used not to uncover objective truths, but to understand the meanings embedded in lived experiences and how those meanings connect (Coulter & Smith, 2009; McAlpine, 2016; Polkinghorne, 1995). Rather than aiming to "describe the world as it is," narrative inquiry seeks to retell events retrospectively, acknowledging that within constructivist or postmodern paradigms, a singular reality does not exist (Coulter & Smith, 2009, p. 578). Narratives are structured through a temporal and sequential ordering of events (McLean & Seyd, 2015) and typically include elements such as "social context,

complicating events, and an evaluative conclusion" (McAlpine, 2016, p. 33). Narrative inquiry typically takes two forms: *analysis of narratives*, which involves collecting participants' stories through interviews or written reflections (e.g., journaling) and identifying patterns or themes (Coulter & Smith, 2009; McAlpine, 2016) and *narrative analysis*, which begins with data that may not be in storied form and constructs narratives through analytic interpretation (Coulter & Smith, 2009; Polkinghorne, 1995). We leveraged both forms of narrative inquiry to examine students' accounts of learning proof and engaging with proof culture.

Methods

Data Sources and Participants

Data for this study was collected at two southern Hispanic serving research universities in the U.S. We conducted interviews with students who completed a survey and responded "yes" to the interview invitation. All interviews were conducted over Zoom. Students were asked to reflect on their journey through proof-based courses and their experiences with proof culture. We asked them to create a journey plot (McAlpine, 2016) by graphing their experiences using time as the horizontal axis unit and any unit they wanted for the vertical axis (see Figure 1). While we provided some possible units (e.g., level of confidence in writing/reading proofs, sense of belonging in the proof community), we emphasized that they could use *any* unit they wanted to visually represent their experiences with proof culture. Participants used the annotation feature in Zoom to draw their graphs. Two participants created multiple graphs on the same coordinate plane, meaning they chose several different vertical units to describe their varied experiences. We prompted them to walk us through their thought processes while creating their graphs, asking follow-up questions to elicit any specific experiences or memories they had related to pivotal moments. Table 1 contains self-identified background information about the five study participants and the vertical unit(s) they chose to represent with their graphs.

Table 1. Demographics and Background of Interview Participants

Name	Race/Ethnicity	Gender	Proof Courses	Vertical Unit(s)
Aiden	White Hispanic	Man	Intro to Proof, Modern Geometry	Support from professors, outside support, relationship with professors, "proofing ability"
Arthur	Hispanic	Man	Discrete Math, Algorithms (at elite university); Intro to Proof, Modern Algebra, Real Analysis	Understanding of proof, difficulty with proof
Ethan	Hispanic	Man (Cisgender)	Intro to Proof, Topology, Real Analysis, Modern Algebra I	Confidence reading/writing proof, understanding of proof, sense of belonging
Liam	White	Non-binary	Intro to Proof, Real Analysis I and II, Modern Algebra	Comfortability in reading and writing proof

Rollin	White Hispanic	Man	Intro to Proof, Modern Geometry, Modern Algebra, Real Analysis Boundary Value Problems	Understanding of what a proof is and how to read/write proofs

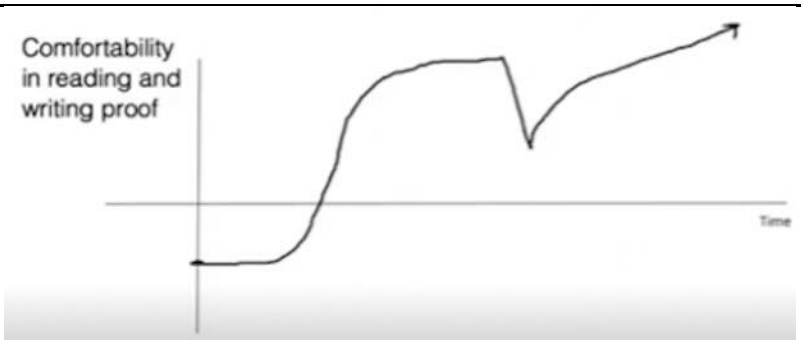

Figure 1. Liam's Journey Plot with vertical unit "Comfortability in reading and writing proof."

Data Analysis

We followed McCormack's (2000a, 2000b) guidance for transforming interview data into interpretive narrative accounts. First, we watched each interview and recorded active listening notes to re-engage with the storyteller after time had passed (McCormack, 2000a). As part of the note-taking process, we reflected on our positions as researchers in relation to the participants. Due to the subjective nature of this work, it was important for us to think about how our own subjectivity and positioning might influence the analysis process. For each interview, two authors independently drafted initial narratives. Although participants created journey plots with respect to time, their descriptions of the events within the plot were not always linear. Since narratives unfold over time and have a sequential structure, we focused on piecing together the participants' stories based on temporal aspects and sequences of events as we drafted initial narratives. Then, we synthesized the two narratives for each participant, paying attention to features one narrative captured that the other didn't, as well as the tone, flow, tense and structure. On average, each synthesized narrative was about four paragraphs long.

To strengthen credibility, we sent the synthesized narratives to each participant, asking if our interpretation was accurate and whether they would add or change anything. Two of the five participants responded affirmatively without suggesting changes. We then compared and contrasted the syntheses to identify shared or stand-alone experiences. For example, comparing Arthur and Liam's stories revealed a common experience of having an "aha" moment while independently studying proofs after hitting a low point with feeling comfortable understanding proof. Then, we used the master narratives identified by Melhuish et al. (2024) to indicate elements of the participants' stories that countered or endorsed the master narratives.

Results

The participants' stories reflected different challenges, involving individual reflection, reorientation towards proof, and striving to find community and support. Several journeys were marked by extreme highs and lows (Liam, Arthur) while others showcased a positive upward trend over time (Rollin, Ethan). We first present summarized versions of each participant's narrative, then highlight how certain aspects of their stories either reinforced or countered the following master narratives: *mathematics is done in isolation*, *mathematics is individualistic and*

a meritocracy, *mathematics ability is innate and easy for those with high ability*, and *mathematics is dry and not fun.*

Students' Summarized Personal Narratives

Aiden's Story: "It's us and the professor. If the professor can't help us, no one can." Aiden's journey into proof-based math courses was represented by an experience of loneliness and yearning for support. He was "surprised and very joyful" to discover the rigor in proof classes, expecting his "niche little hobbies" would help him succeed. But when asked to "translate Hilbert's axioms into symbols," he struggled to find help—tutors and other professors couldn't assist, leaving only the course instructor. The intro to proof class consisted mostly of lectures, and students "struggled" equally, offering little peer support. He realized proof is a "very lonely subject compared to other math subjects," and over time, support "dropped" due to its rigor. Still, he appreciated engaging with the professor's "hobby." Despite the loneliness, his love for math and proof reached a high point, and he believes his ability to engage with proof has improved.

Arthur's Story: "Cleared the fog a bit, wiped the mirror...it [was] a moment of clarity." Arthur's journey was marked by a battle between understanding and difficulty, and it was a readjustment of understanding what proof was that ultimately supported a positive outcome. Before college, he felt fairly confident with proof, but at a prestigious university, instructors expected him to know the basics without support, making him feel like a "single cog" and "the weakest link." After transferring to a local university, he struggled to balance life, work, and school, using math and proof as an escape. Working independently—sometimes at 3:00am—he had a "real moment of clarity," recalibrating his view of proofs to focus on how they relate to other exercises. The fog lifted, like he had "finally taken off his glasses to clean them." His experience shows that learning proof isn't nurtured by prestige, but by support, clarity, and connection, and through readjusting his perspective, he rebuilt his relationship with proof by finding the right environment to feel supported.

Ethan's Story: "I'm learning…getting there, I just don't believe I'm quite at that level yet." Ethan's journey through proof-based courses was one of growth and self-awareness as he strived to find his place within the proof community. Initially unsure of his skills in reading and writing proof, his confidence grew through courses like Modern Geometry and especially Topology, whose abstract nature "really forces you to hone your skills." Abstract Algebra further improved his understanding, though he still felt like he hadn't written proofs "nearly long enough" to take himself seriously among experts. Until he could answer questions on Math Stack Exchange, he couldn't confidently see himself as part of the proof community. He was "learning and getting there," even if not quite at that level yet. In contrast, his classroom community felt more supportive—he and his classmates were "in the same boat," helping each other through topics. Ethan's journey shows that mastering proof is not just about skill but about finding belonging, and while being part of the broader proof community still feels distant, he's found support and connection among peers.

Liam's Story: "Proof can be whatever it needs to be." Liam's story is one of turbulence, related to their experiences with "comfortability reading and writing proof." Starting college math in Calculus 3, they felt "thrown in" to advanced concepts like limits and epsilons, making proof feel like a "big beast" to conquer. An introduction to proof course with a norm-breaking instructor changed everything—accessible proofs increased their comfortability, and they began to love proofs, unlike their friend in a more "rigid" program. However, independently studying category theory challenged them again with its rigor and conciseness, forcing them to reckon

with their understanding. Things shifted when they eventually realized that each subfield has its own proof conventions. After a year of analysis, they needed to "get [themselves] out of this little box" and reframed proof as "whatever it needs to be…it's just a way to explain our reasoning for why this thing is true." This turning point allowed them to flourish, raising their comfortability with proof as they continued their studies in mathematics.

Rollin's Story: It is one thing to "read a recipe" and another to create a delicious cookie. Over the course of his education, Rollin encountered proof in various forms and contexts, gradually developing his proof knowledge and writing skills. In high school, he learned that a proof was a series of logical steps leading to "a correct answer," but this basic understanding couldn't handle the advanced proofs in research papers. At university, he learned to "make" proofs—logical steps and axioms—but realized that "writing" proofs required creativity and deeper knowledge, like the difference between "reading a recipe" and creating a delicious cookie. His skills grew through coursework and an opportunity he had to participate in a Research Experience for Undergraduates (REU), where he authored a proof of an optimal solution to Conway's game. Though he viewed the proof as "simple," it marked a turning point, showing he could "comfortably make them for research," even if he's "not quite there yet." Rollin's journey evolved from rigid steps to crafting original arguments, with research as the "ultimate goal" of proof writing.

Elements that Reinforced or Countered Master Narratives

Mathematics is done in isolation. Parts of Aiden's story both reinforced and countered the mathematics is done in isolation master narrative. On one hand, his experiences with math before proof classes countered this narrative because he actively sought help, not wanting to do math in isolation. On the other hand, when he started taking proof classes, his realization that only the professor can help reinforced this narrative because the situation forced him to learn proof mostly alone (only with the professor's help). Ultimately, his experiences in proof courses reinforced this narrative's strength. Arthur's experience in proof courses at the elite university—feeling like a "single cog" and "the weakest link"—also reinforced this narrative. Ethan's experience, however, countered this narrative because he felt like he and his classmates were all in "the same boat" and they helped each other when they could.

Mathematics is individualistic and a meritocracy. Aspects of the student stories reinforced and countered the master narrative mathematics is individualistic and a meritocracy. Liam's and Arthur's experiences reinforced it because they both arrived at a "moment of clarity" through individual reflection and effort, and felt personal satisfaction making it through a low point with continued persistence and hard work. Contrastingly, Ethan's experiences reflected valuing peer support and how people in the broader community helped each other on Math Stack Exchange, countering the narrative that one works for one's own personal gain (individualism).

Mathematics ability is innate, and mathematics is easy for those with high ability. The language Ethan and Rollin used throughout their stories reflected building proof knowledge and skills along the way, implying mathematics ability is not innate—countering this master narrative. For example, Rollin recognized that he was "not quite there yet" and Ethan was "learning and getting there," both articulating that even though they had learned a lot and their confidence with proof had grown, there was still more to learn. In comparison, Arthur and Liam both experienced struggling with proof at the beginning of their journeys because of the classroom environments they were in. While they did not directly endorse this narrative, the commonalities between their experiences—feeling like they were expected to have prior knowledge and grasp new concepts quickly—reinforced the master narrative to some extent.

Mathematics is dry and not fun. None of the participants' stories directly reinforced the master narrative mathematics is dry and not fun. Aiden's experience of entering proof courses and noticing how his "niche little hobbies" (which were logic related) were connected to proofs made him feel "surprised and very joyful," countering this master narrative. Even though he eventually found learning proof to be a lonely experience, he continued to enjoy proofs through the experience of interacting with his professors' hobbies (which were presumably exciting and fun to them). Logan similarly experienced joy and love for math when they took the intro to proof course with the professor who made proofs more accessible, and their enjoyment continued even after they hit a low point when studying category theory.

Discussion

In this paper, we shared five students' journeys through proof-based mathematics, each offering a distinct perspective shaped by personal experiences with proof culture. These narratives included moments of joy and accomplishment, as well as periods of isolation and struggle. While each story was unique, common elements emerged that connected students' experiences to mathematical master narratives previously identified in the literature (i.e., Melhuish et al., 2024). As discussed earlier, mathematical master narratives are stories tied to mathematical culture that shape perceptions of who belongs in mathematics and what it means to do mathematics. By examining how these narratives surfaced in students' accounts, we gained insight into how proof culture is experienced on a personal level. While elements of students' stories reinforced master narratives—such as Aiden's experience of isolation—others, like Ethan and Rollin, emphasized the sustained effort required to develop proof skills, which countered the master narrative that mathematical ability is innate.

A key takeaway from our results is the influence that learning environments have in shaping students' experiences with proof and their sense of support. Both Arthur's and Liam's stories contrast welcoming environments with isolating experiences at more "prestigious" universities. Arthur began his journey at an elite university where he felt unsupported and like the "weakest link" due to a lack of prior knowledge. After transferring, he found an environment that allowed him to take time for himself and succeed in proof. Similarly, Liam described a "norm-breaking" instructor who made proofs accessible and brought joy to learning proof—an experience that stood in stark contrast to their friend's more "traditional" and rigid program, which led to a strong dislike of proofs. Their redemption stories also revealed the "good side" of meritocracy (Weber & Melhuish, 2020), in which striving for improvement was motivating without being rooted in competition or comparison (i.e., the "bad side").

Taken together, these student narratives offer a meaningful lens into how proof culture is experienced and interpreted by students. Understanding which master narratives are endorsed or resisted in students' personal accounts of learning proof and engaging with proof culture provides a starting point for shifting these narratives. While master narratives are deeply embedded and unlikely to disappear entirely, elements within them can evolve to become more inclusive—especially when we recognize which narratives are most salient and how students are already challenging them through their lived experiences.

Acknowledgments

We would like to thank our research participants for their time sharing their stories with us and responding to follow up requests to confirm or challenge our interpretations.

References

Battey, D., & Leyva, L. A. (2016). A framework for understanding whiteness in mathematics education. *Journal of Urban Mathematics Education*, *9*(2), 49–80.

Coulter, C. A., & Smith, M. L. (2009). The construction zone: Literary elements in narrative research. *Educational Researcher*, *38*(8), 577-590.

Dawkins, P. C., & Weber, K. (2017). Values and norms of proof for mathematicians and students. *Educational Studies in Mathematics*, *95*(2), 123–142.

Guajardo, L. & Lew, K. (2024). "My" meaning for understanding this proof: Comparing student perspectives to a mathematician-centered model of comprehension. In Kosko, K. W., Caniglia, J., Courtney, S., Zolfaghari, M., & Morris, G. A., (Eds.), *Proceedings of the forty-sixth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. (pp. 866–870). Kent State University.

Jaremus, F., Gore, J., Prieto-Rodriguez, E., & Fray, L. (2020). Girls are still being 'counted out': Teacher expectations of high-level mathematics students. *Educational Studies in Mathematics*, *105*(2), 219–236.

Krupnik, V., Fukawa-Connelly, T., & Weber, K. (2018). Students' epistemological frames and their interpretation of lectures in advanced mathematics. *Journal of Mathematical Behavior*, *49*(1), 174–183.

Lew, K., Fukawaka-Connelly, T.P., Mejia-Ramos, J.P., & Weber, K. (2016). Lectures in advanced mathematics: Why students might not understand what the mathematics professor is trying to convey. *Journal for Research in Mathematics Education*, *47*(2), 162–198.

Lew, K. & Mejia-Ramos, J.P. (2019). Linguistic conventions of mathematical proof writing at the undergraduate level: Mathematicians' and students' perspectives. *Journal for Research in Mathematics Education*, *50*(2), 121–155.

Leyva, L. A. (2017). Unpacking the male superiority myth and masculinization of mathematics at the intersections: A review of research on gender in mathematics education. *Journal for Research in Mathematics Education*, *48*(4), 397–433.

Martin, D.B. (2019) Equity, inclusion, and antiblackness in mathematics education. *Race Ethnicity and Education*, *22*(4), 459–478.

McAlpine, L. (2016). Why might you use narrative methodology? A story about narrative. *Eesti Haridusteaduste Ajakiri. Estonian Journal of Education*, *4*(1), 32–57.

McCormack, C. (2000a). From interview transcript to interpretive story: Part 1—Viewing the transcript through multiple lenses. *Field Methods*, *12*(4), 282–297.

McCormack, C. (2000b). From interview transcript to interpretive story: Part 2—Developing an interpretive story. *Field Methods*, *12*(4), 298–315.

McLean, K. C., & Syed, M. (2016). Personal, master, and alternative narratives: An integrative framework for understanding identity development in context. *Human Development*, *58*(6), 318–349.

Melhuish, K.M., Guajardo, L., Lew, K., Dawkins, P. C., & Roh, K.H. (2024). An elaboration of master narratives in mathematics and how undergraduates relate to counternarratives. In Kosko, K. W., Caniglia, J., Courtney, S., Zolfaghari, M., & Morris, G. A., (Eds.), *Proceedings of the forty-sixth annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 309–316). Kent State University.

Mendick, H. (2006). *Masculinities in mathematics*. Open University Press.

Polkinghorne, D. E. (1995). Narrative configuration in qualitative analysis. *International Journal of Qualitative Studies in Education*, *8*(1), 5–23.
Rowlands, S., & Carson, R. (2002). Where would formal, academic mathematics stand in a curriculum informed by ethnomathematics? A critical review of ethnomathematics. *Educational Studies in Mathematics*, *50*, 79–102.
Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher*, *34*(4), 14–22.
Weber, K., & Mejia-Ramos, J. P. (2014). Mathematics majors' beliefs about proof reading. *International Journal of Mathematical Education in Science and Technology*, *45*(1), 89–103.
Weber, K., & Melhuish, K. M. (2022). Can we engage students in authentic mathematical activity while embracing critical pedagogy? A commentary on the tensions between disciplinary activity and critical education. *Canadian Journal of Science, Mathematics and Technology Education*, *22*(2), 305–314.
Wrightsman, E. (2025). Student Narratives of Inquiry-Based Introduction to Proof Courses. (Doctoral dissertation, Texas State University).