Interrogating Proof Norms: “It’s kind of like telling me, ‘Oh, act like a robot.’”

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We draw on poststructuralism to interrogate assumptions of what counts as “normal” in proof. Guided by post-qualitative inquiry, we share moments from an unstructured interview with an undergraduate student, Sherine, alongside research literature to question two dominant proof norms: depersonalization and the absence of the problem-solving process. Our interrogations reveal how proof norms potentially reinforce messages that exclude relationality, storytelling, and emotional connection from the proof process, as well as newcomers to proof who benefit from seeing the nonlinear process of problem-solving. We argue for broadening what gets recognized as legitimate proof, where proofs can be both formal and personal, polished and messy, logical and human.

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We invite you to read two proofs for the divisibility property: for all integers m and n, if $a \mid b$ and $a \mid c$, then $a \mid (mb + nc)$ (Figure 1). You, like others we have shared these with, might notice that the proof on the left feels like a “normal” proof[1] whereas the proof on the right feels unusual[2]. You might catch glimpses of my (the proof author - Saúl’s) personality and uncertainties. I hope you feel a sense of connection between us- me and you (the reader).

By assumption, there exist integers k_1 and k_2 such that $b = k_1 a$ and $c = k_2 a$. For any integers m and n we have $mb + nc = m(k_1 a) + n(k_2 a)$, by assumption, $= (mk_1 + nk_2)a$. Thus, $mb + nc$ is divisible by a.	My goal is to show that a divides $mb + nc$. To me, this means that I can write $mb + nc = ka$ where k is an integer. I’m really not sure how I will get there but I’ll start with what I know. Since I know that a divides b, then I know that there must be an integer r so that I can write $b = ra$. Since I also know that a divides c, then I also know that there must be an integer s so that I can write $c = sa$. Hmm. It might sound a bit repetitive, but I like to keep track of where I have been to help me with where I’m going. Next, I will consider m and n to be integers. Since $b = ra$ and $c = sa$, I can substitute them in $mb + nc$ and write $mb + nc = m(ra) + n(sa) = mra + nsa$ Haha. N. S. A. Acronyms make me laugh for some reason. Anyway, I can see that I can factor out a from $mra + nsa$ so I can also write $mb + nc = (mr + ns)a$. It’s not looking how I want yet but maybe I need to review my goal. My goal is to write $mb + nc = ka$ with k being an integer and that is not what I see. Wait! m, r, n, and s are all integers so $mr + ns$ is also an integer! I’m going to define k to be $mr + ns$ and say $k \coloneqq mr + ns$. Nice, nice, nice! I think I’m getting to where I want to be! Since $mr + ns$ is an integer, then k is also an integer because it is equal to $mr + ns$. Now I can write $mb + nc = ka$! I’ve reached my goal! This means that a divides $mb + nc$! #That’sShowbiz!

Figure 1. A “normal” proof, and a personalized proof

Entering this project, we (Saúl and Kristen) began feeling uncomfortable labeling the proof on the left “normal”. Our experiences working with students and reading mathematics education literature suggested that what is typically considered “normal” in proof may not resonate with all learners, and that some students might find value in proofs that depart from these expectations.

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[1] You can find this proof in Houston’s (2009) textbook: *How to think like a mathematician: A companion to undergraduate mathematics*.

[2] I (Saúl), did in fact breach proof norms (Dawkins & Weber, 2017)!

For instance, Brown (2018) shared an example of a student who personalized a justification for the role of axioms in proof using culturally familiar language like "ese" and "holmes." Vroom and Alzaga Elizondo (2024) found that students appreciated existence proofs that included the author's problem-solving process, suggesting that such transparency offered a more relatable view of proving. Weber and Melhuish's (2022) observations further underscored our concerns: "The way to be 'good' at mathematics is, at least in part, to emulate the language, argumentation, and culture of mathematicians" and "deference to the discipline of mathematics (as conceived largely by a select few Western, white men) is likely to reinforce existing power differentials inherent in the system" (p. 307). In what ways, then, does this "normal" proof reinforce those dynamics? In this work, we draw on poststructuralism to interrogate taken-for-granted assumptions about what counts as a "normal" proof and whose ways of knowing it centers.

Poststructuralism: An Interrogation Lens

Rather than treating proof as universal and neutral, we understand it as embedded in particular institutional and cultural norms that govern who and what counts as mathematically legitimate. From a poststructuralist perspective, "truth" in mathematics is not fixed or discovered in isolation from people; instead, it is discursively created through language, practices, and social expectations for mathematical activity (Foucault, 1980).

Identifying mathematical proof discourses is no small task; discourses are so deeply embedded in practice that they often go unnamed. We appreciate Dawkins and Weber's (2017) work, which surfaced some taken-for-granted expectations through an extensive literature review where they identified different *norms*, or accepted expectations for practice, and *values,* or shared goals or orientations, in the context of proof. One such value, which we will continue to interrogate, is *independence from the author* – or that "mathematics knowledge and justification should be independent of (non-mathematical) contexts, including time and author" (p. 129). Two norms that uphold this value are the *depersonalization* norm – "mathematical proof is written without reference to author or reader's agency" (p. 129) and the *absence of problem-solving* norm – "a proof is an autonomous object, not a description of a problem-solving process" (p. 130). This means that a "normal" proof, for instance, avoids the pronoun "I", and authors' personas are concealed along with how they came to understand the argument.

Gee's (1989) framework on *primary* and *secondary discourses* helped us conceptualize how students might experience these norms. Primary discourses are developed in everyday settings through interactions with family, friends, and cultural communities, while secondary discourses are those required to engage in institutional spaces. Mathematical proof discourses (e.g., the norms and values of proof) are secondary discourses. Participating in proof may feel natural or comfortable for students whose primary discourses align with these academic expectations. But it might feel unnatural for others whose primary discourses do not align as much. This discomfort reflects a mismatch between proof discourse and the discursive practices students bring with them. This is *not* a deficit in the students, but a narrowness in the dominant norms.

Researchers studying the teaching and learning of undergraduate proof have largely engaged with the "predict" or "understand" paradigms of inquiry (Stinson & Walshaw, 2017), which are supportive to study the effects of teaching interventions or try to explain phenomena that are part of the teaching and learning of proof. For instance, such paradigms have been useful in investigating how students understand proof (e.g., Guajardo & Lew, 2024; Vroom & Alzaga Elizondo, 2024; Zazkis & Rouhani, 2024). We argue that there is more to learn from a "deconstruction" paradigm, such as the use of poststructuralism, which encourages scholars to continuously examine what is taken for granted and reveal what is unsaid when people settle into norms (Lather, 2006; Stinson & Walshaw, 2017). While mathematics education researchers have drawn on poststructuralist theory in other contexts (e.g., Dubbs & Herbel-Eisenmann, 2021; Johnson et al., 2022; Stinson, 2008, 2013), this lens has not been widely applied to the study of proof in undergraduate mathematics. We believe that poststructuralism offers a powerful way to interrogate what is deemed as "normal" proofs, providing motivation to disrupt dominant discourses.

Our Positionalities

I (Saúl) was born and raised on the Texas border, surrounded by people who looked a lot like me. I've gone through different iterations of how I identify myself, not really knowing what to settle with (Hispanic, White, Latino?). As I write this, I identify as Latino/e. Despite taking mathematics courses at a Hispanic-Serving Institution, I struggled to see myself as a doer of mathematics until my enculturation into mathematics. While I enjoy research, I don't feel that I can *do* research. Like mathematics, it has always felt presented as a matter of fact. A long-term goal for my writing is to explicitly show the vulnerability of my work, along with how I, with the support of those around me, can do research. As Kristen and I attempt to make mathematics more inclusive, I also hope to do this for research.

I (Kristen) am a white woman who grew up in a deeply gendered space in the Appalachian Mountains. Much of my research has focused on students' *access* to mathematical norms (e.g., Vroom, 2022; Vroom & Ellis, 2024), but through ongoing collaborations, including with Saúl, I've started to think more critically; How can I support "changing the game" rather than just "playing the game" (Gutierrez, 2009, p. 6)? This shift, and especially our interrogation lens, is uncomfortable for me as someone who avoids rocking the boat. At the same time, it's important for me to help open up academic spaces, especially mathematics, to make room for more ways of being.

How We Interrogated the Norms

I (Saúl) engaged in an unstructured interview with an undergraduate student, Sherine. Sherine described herself as an Arab/Middle Eastern cisgender female person and used she/her pronouns. At the time of the interview (Fall 2024), she had recently completed an online Introduction to Proofs course over the summer. From the outset, I shared my purpose for the interview: to interrogate dominant norms in mathematical proof by learning from Sherine's experiences. In the first part of the interview, Sherine read a section from Dawkins and Weber (2017) titled "Value 2: mathematical knowledge and justification should be independent of (non-mathematical) contexts, including time and author." This approach was inspired by Stinson (2008, 2013), as we aimed to "[ascribe] more agency to the individuals in recreating or shifting meanings of the discourse" (Gutiérrez, 2013, p. 44). The second part involved her reading the full proofs shown in Figure 1. In both parts, I opened with the same prompt: *What do you think, wonder, and feel as you read or now that you have finished reading?* The interview was intentionally unstructured; we did not prepare follow-up questions in advance so I (Saúl) could be fully present with Sherine and let the data emerge organically rather than be shaped by prior categories. The interview lasted approximately 1.5 hours and was audio- and video-recorded.

Our interrogation process was non-linear and messy. We read and re-read, talked with Sherine, shared ideas with other researchers, re-listened to our conversations, and repeatedly revised through discussion and writing. This messy process was guided by post-qualitative inquiry (St. Pierre, 2024) and writing as a method of inquiry (Richardson & St. Pierre, 2005; St. Pierre, 2015). These invited us to release rigid structures in data collection and analysis, embracing the uncertainty and creativity that arise when we allow something new to take shape (St. Pierre, 2015). We reemphasize that our goal was to interrogate the norms themselves, a theoretical endeavor, not to describe the entirety of our conversation with Sherine. Her conversation helped us, Saúl and Kristen, feel and notice our reactions to these norms. To do so, we often returned to the recording, at first to become familiar with the conversation, and then to notice connections and moments that pulled at us. We then paid attention to what seemed troubling about the norms. Alongside this, we regularly met to discuss, read, write, and reflect, allowing our engagement with the literature to shape our understanding and what we wrote. Our writing is personal, shaped by who we are, our interpretations, and our affective responses to the discourses.

We also want to emphasize that we view Sherine, as well as ourselves, as both shaping and reproducing mathematical proof discourses. In fact, Sherine indicated that she has reproduced some of the norms we are interrogating due to her teacher inexplicably reproducing them, even saying, "It never occurred to me if it makes sense." In our writing, we highlight moments where Sherine questions dominant discourses and also critique moments where she appears to reproduce them. We intend for you to read them *not* as a critique of *her*, but as a critique of the *discourse*. We also acknowledge that all of us act in ways that are sometimes inconsistent; we do not interpret her seemingly conflicting comments as evidence of confusion or deficiency. Rather, we use a "yes, and" approach to discourse: contradiction is not failure; it is part of being human within systems that are full of tension.

Interrogating Proof Norms

In what follows, we interrogate the two norms upholding the independence from the author value. We do so by drawing on the conversation with Sherine using research insights to argue how these norms can be exclusionary. We invite you to join our interrogation; ask yourself, how is this dominant way of doing proof messed up, and for whom?

Interrogating the Depersonalization Norm

Let us start with a quote cited by Dawkins and Weber (2017) in their discussion of this norm, where Davis and Hersh (1981) satirically describe "the ideal mathematician" as:

> [following] an unbreakable convention: to conceal any sign that the author or the reader is a human being. It gives the impression that, from the stated definitions, the desired result follows infallibly by a purely mechanical procedure. (p. 36)

Sherine questioned this "unbreakable convention," explaining:

> We know that they are human, so why would we conceal that fact? It's kind of like telling me, 'Oh, act like a robot.' [...] And it should be more like human, because you want people to be like, 'Whoa, oh my god, a person did that,' not think it's some robot. It is a huge achievement if it was really good, you know? [...] Humans are amazing, let them use their brains. So, like the idea that we're robots…I'm sorry, but we're better than robots, and robots aren't necessarily perfect.

Here, we see that the depersonalization norm sends troubling messages to students like Sherine to act in an unnatural way, "act like a robot," to suppress their humanness and ingenuity. Sherine expressed that proofs should be "more like human" to showcase the creativity of the person who authored the proof. We agree. Proofs should be allowed to reflect the identity of the author so that students can experience proof as a personal and creative practice.

When discussing an instance of a "more human" proof through the use of "I", Sherine explained, "Some people feel like they need to avoid using 'I,' so they would use the royal 'we'.

[…] 'We' is perceived better than 'I'." While Sherine acknowledged she has adopted this convention in her proof writing, she also explained, "if the proof is sound and looks good, then who cares if they used 'I'?". While scientific writing aims to view its subject matter as autonomous, authors are expected to avoid passive voice in writing. Burton and Morgan (2000) offer insight into why "we" might be perceived as better explaining that the royal "we" avoids passive voice while meeting the goal of making the subject matter independent of the author:

> The unwritten assumption here is that, in most cases, the author's persona is not relevant. This assumption is consistent with the commonsensical belief that the subject matter is neutral and that the use of such impersonal language reflects this neutrality. (p. 437)

We want to highlight two points. First, the subject matter is *not* neutral (Bishop, 1990) and perpetuating that "truth" through the proof text reinforces that damaging narrative. Secondly, as Weber and Melhuish (2022) pointed out, avoiding personality to be more objective is not universal. This discourse is rooted in Western and masculine institutional traditions (Bishop, 1990; Hottinger, 2016; Leyva et al., 2021) and promotes generalization and colorblind practices (McNeill, 2025; McNeill et al., 2022).

While Sherine expressed a desire for proofs to be more transparent about the human author, she also gravitated towards the "normal" proof on the left in Figure 1, explaining,

> It's cleaner. It does not have like extra words. Like, if I'm reading a proof, let's be real, all mathematicians are kind of lazy. Like, nobody wants to read that whole script, right? We just want: proof, know what's going on, and that's it.[...] I wouldn't say [the personalized components of the proof] adds anything. I don't like it. It's just kind of there for no reason. Like, it's not really helping me with understanding. Like, it's not helping me with the proof and it's not helping me with understanding. So, like, it's not really useful.

What do *you* think? Does the personalized part add something? We believe it does. It adds a relational dimension between me (Saúl, the author) and you, the reader. I am being transparent about my persona, my humanness, and in doing so, I invite you to connect with me, to see yourself in the text, rather than encountering something sterile and robotic. And yet, the idea that my persona is irrelevant in proof writing is reproduced in the norms of mathematics; "good" provers (mathematicians) view relational elements as extraneous and undesirable: "Let's be real, all mathematicians are kind of lazy. Like, nobody wants to read that whole script, right? We just want: proof, know what's going on, and that's it."

The depersonalization norm conflicts with the epistemologies of students, particularly non-masculine and non-Western students, whose primary discourses value relationality and emotional connection (Bishop, 1990; Keith, 1988). Storytelling and other narrative-based ways of communicating have long played a central role in how many non-dominant communities teach, learn, and construct identity (Genz, 2011; Lauer & Aswani, 2009). These practices are not only valid forms of expressing knowledge, they are also more intimate. They stand in contrast to the depersonalized proof norm that prioritizes disembodied logic, objectivity, and detachment.

Our point is that the depersonalization norm implicitly sends messages that non-Western, non-masculine people cannot count as practicing mathematical proof unless they strip them of their history and culture. Proof can be exclusionary for those whose primary discourses involve personal and emotional connection, since it may invalidate how they engage with mathematical proof. How else do you see the depersonalization norm as messed up, and for whom?

Interrogating the Absence of the Problem-Solving Process Norm

Like the depersonalization norm, we see that the absence of the problem-solving process norm hides the humanity of the proof-author, and additionally, the proof-reader. Here, what gets hidden is not the *who* of the author, but the *how* they may have thought through the problem, struggled, and found a way through. When Sherine reflected on Dawkins and Weber's (2017) subsection about the absence of the problem-solving process, Sherine explained:

> I feel like describing the [problem-solving] process might be only for people who just started dealing with proofs instead of people who know how proof works.

Sherine's comment suggests that process, or the nonlinear, human work of figuring something out, is seen as something for newcomers. Then, after reading the personalized proof, she shared:

> It [the proof with the problem-solving process] makes sense, it's an explanation, but that's not what a proof *is*. Proofs do not explain stuff. Proofs show you why is something… Like proofs *prove* something.

Here, Sherine reproduces the view that proofs should not include the problem-solving process. To her, a defining characteristic of proof is that it only shows the validity of the claim, rather than it also explains why it's valid. Sherine did not dismiss the value of process. She saw it as helpful, just not something that belonged in a proof. She explained, "You should write the proof alone, and then maybe if you want to describe the process, that would be something not included in the proof" - a kind of footnote for beginners. We see that putting the process in the margins outside the "real" proof is narrowing for a couple of reasons. First, as with the depersonalization norm, this norm erases a relational dimension of mathematical work. Proofs are not simply abstract objects; they are human-made texts written for human readers. When the process is hidden, there is little sense that someone was here, thinking through this, maybe even thinking of you and your sensemaking as they wrote.

Second, the absence of the problem-solving process undermines support for newcomers and reinforces exclusionary norms about who belongs in mathematical spaces. Without an open discussion of how proofs are thought out and written, a curtain is maintained that separates those presumed to have an innate mathematical ability (people whose primary discourses are closely related to the secondary discourse for mathematical proof) and those who are not presumed to have it (people whose primary discourses are not closely related to this secondary discourse). Maintaining a norm that omits the process reinforces a kind of gatekeeping. Leyva et al. (2021) shared that instructional practices such as indicating to students that if they are not understanding course material soon enough, they should consider dropping the course, have been perceived by students as messages that they are not good enough to participate in any mathematical practice including those pursuing degrees such as Business since mathematics courses can be requisites for those majors. When proof-writing excludes process, a similar message may be conveyed: that unless you already understand how to read these polished arguments, you don't belong. This is particularly harmful for students whose primary discourses are not closely related to the secondary discourse necessary for mathematical proof.

In this way, the absence of the problem-solving process norm not only withholds intellectual support; it communicates a broader ideological stance about who is presumed to be a "real" mathematician and who must continually prove their right to participate. How else do you see the absence of the problem-solving process norm as messed up, and for whom?

An Argument to Interrogate Proof Norms

In this paper, we've argued that the depersonalization and absence of the problem-solving process norms are not neutral or purely mathematical. These norms are socially constructed and, as we've shown, can function in exclusionary ways. By defining what counts as proof in such narrow terms, these norms obscure both the humanity of the author and reader. Secondary discourses are easier to acquire by those whose primary discourses are already similar to the secondary discourses (Gee, 1989). Therefore, these norms also privilege those whose prior experiences, discourses, and identities align with dominant mathematical values, values historically shaped by Western, masculine traditions, while invalidating relational, human, and process-oriented ways of engaging with proof.

Drawing on poststructuralism, we troubled what's been taken for granted. As Lather (1991), drawing on Caputo (1987), writes, the goal of this kind of deconstruction isn't to settle things once and for all, but "to keep things in process, to disrupt, to keep the system in play, to set up procedures to continuously demystify the realities we create, to fight the tendency for our categories to congeal" (p. 13). Through this lens, we questioned the binary between objective and personal proofs, pushing back on the idea that including the author's personality, thinking, or struggle somehow devalues a proof.

To be clear, we're not arguing that depersonalized proofs have no place. There are contexts where those norms may serve useful purposes (we suspect mathematics research journals). But that type of proof is only one representation, among many, that we should value and allow students to encounter. While we believe the implicit messaging alone justifies expanding these norms, there is also evidence that mathematicians themselves often adopt personalized styles and voice (Contreras et al., 2025). At the same time, some instructors may feel particularly compelled to emphasize precision and formality to their students - "sometimes to the point of being more pedantic than they might be with experienced mathematicians" (Rupnow & Randazzo, 2023, p. 305). We encourage broadening what gets recognized as legitimate proof, and inviting students into forms that are more relational, expressive, and reflective of the thinking behind the final product.

As an anecdote, when we wrote personalized proofs as we prepared for this project (and, frankly, this personalized conference paper), something opened up for us. It felt freeing. It felt vulnerable. It felt different from what math and academia usually allow. We think this is a promising direction for future research: What happens when students are invited to personalize proofs? How does it feel to write in ways that reflect your own thinking and voice? And just as importantly, how does it feel to read this kind of proof, or this kind of academic paper?

More broadly, we see this work as part of a growing movement in our field to reexamine and resist "normalities," such as those of you who are questioning "normal" curricula and teaching practices (e.g., Leyva et al., 2022; Osibodu, 2024). We invite you to join us in exploring poststructuralism, not only as a way to critique, but also to imagine differently. For some, deconstruction may offer a motivating approach that safeguards against dogmatism and reminds us that even cherished mathematical (educational) categories are not innocent. As Lather (1991) puts it, deconstruction continually demystifies the realities we create. It keeps the system in play. Let's keep the system in play, where proofs can be both formal and personal, polished and messy, logical and human. Where there's room for more kinds of knowing, more ways of belonging, and more stories of how we figured things out.

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