Grappling with the dominant narrative of physics: Instructors rethink colonial roots together to reshape classrooms

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The colonial roots of science dominate the narrative of physics learning and research. While many acknowledge that the typical physics curriculum does not support students from nondominant groups, it has remained largely unchanged. In an attempt to change this paradigm, a group of instructors voluntarily met to question how one might decolonize a physics classroom. We asked instructors to share whether or not aspects of their identity and pedagogy shifted after participating in the group for two years. In this study, we highlight how identity changed with instructors’ efforts to decolonize their physics curriculum. We also identified instructors describing frustration and exhaustion from systemic constraints in their teaching environment (e.g., student/family pushback, standards, SES). However, within those constraints, each instructor felt empowered to reshape classroom content in an effort to move the community towards more equitable and inclusive physics education.
I. INTRODUCTION

Traditional physics education in the USA has deeply embedded colonial roots that shape what physics content is taught, how we approach teaching and learning, and how we prepare our instructors to teach students. Although efforts have been made to change the cultural practices in physics [1, 2], the education and research community has remained woefully unchanged [3]. In the last twenty years, we see very little improvement in the representation of nondominant groups in physics [4].

All this said, grassroots efforts to move physics instruction towards equity from a small group of secondary and higher education instructors has inspired change in their classrooms. This study examines instructors’ perceptions of their efforts to improve teaching and highlight those changes as an example of productive work in a small learning community. We specifically consider the role of instructor identity in “decolonizing” physics curriculum, which we define as interrogating the Eurocentricity of the physics canon and pedagogy [5]. This study unpacks shifts in instructor identity around equitable instruction through participation in a learning community.

II. ANALYTICAL FRAMEWORK

Instructors’ views on how to act as a physics instructor, what to teach, and how they view their place in society are all associated with their instructor identity [6, 7] and affect what happens in their classroom. Instructor identity has been researched extensively among educational researchers [6]. However, literature specific to the role of instructor identity on equitable physics instruction is scant. Part of the reason for this gap is that both equitable instruction and identity are fluid constructs, making it challenging to connect them explicitly. We define equitable instruction and teaching for equity as teaching in ways that disrupt the prevailing myth of aculturality in physics. This involves establishing meaningful connections between students’ diverse lived experiences and the physics curriculum, with an emphasis on identities and cultures that have traditionally been marginalized or overlooked [8].

To identify and analyze the kinds of shifts the instructors describe, we use C. Mathis’s analytical framework on physics instructor identity towards equitable instruction. We used this framework as a structured lens through which we could discern the kinds of shifts present in the data. The framework includes four instructor conceptions: self, others, knowledge, and pedagogy [8]. Although we recognize how all four conceptions are interconnected and play a role in how instructors conceive and enact equitable physics teaching practices [9], our study specifically considers instructors’ conceptions of self and knowledge.

Conceptions of self describe a physics instructor’s view of themselves and their ability to teach for equity. This includes confidence in their ability to teach effectively, work with administration and colleagues, and support student learning. Conceptions of self can impact perceived instructor competence [10] and instructional quality [11].

Conceptions of knowledge describe physics instructors’ views of canonical (content) knowledge. This includes instructors’ beliefs about the presence of subjectivity in physics. It also includes if and how instructors critique what knowledge “counts” as physics canon (e.g., history and cultural contexts), and their experience with critiquing the content and culture surrounding the physics community.

III. RESEARCH CONTEXT & METHODS

The research context for this study is a professional learning community (PLC) of physics instructors. This voluntary PLC has been meeting online every month for > two years to think about what it would mean to decolonize physics education. They did not previously define what that meant or have a defined plan prior to the start of their work together. The group began with close to 20 instructors attending and over the last year has had eight consistently attending, as well as two additional researchers who observe and participate in conversations.

Each month a different member of the group determines the agenda and leads the 1.5 hrs meeting. The topics discussed ranged from defining and understanding terms (e.g., decolonizing, equity, etc.) to sharing and critiquing lessons, to co-creating new lesson material. Within this context, our research question is: What kinds of shifts come about from this long term, voluntary learning community?

A. Data collection

Our study gathered data from eight instructors across the United States who taught in secondary, two-year college, and university settings. At the end of two years, the instructors were asked several questions about their perceived shifts in their identity and pedagogy. These instructors responded to the initial question, “Can you write or record how your thinking around equitable instruction has changed due to participating in the decolonizing physics group (if at all)?” Five of the eight instructors also participated in a written follow-up reflection asking:

1. What is the goal of the decolonizing physics group?
2. What does it mean to decolonize curricula?
3. How has participation in the decolonizing physics group impacted your views on: yourself, your students, physics content, and your teaching?
4. What will you change going forward after participating in this group?

B. Data analysis

We conducted an open-coding analysis [12] where the first and fifth author sought to identify ways in which the
instructors’ conceptions shifted. The themes were defined and developed based on instructors’ use of descriptive words such as “I realized,” “I learned,” or “I have become.” The first round of coding identified moments where instructors described shifts that aligned with the analytical conceptions. The second author then independently coded the data looking for instructor-identified conception shifts. Next, the three researchers performed an iterative cycle of aligning the statements with the four conceptions. When disagreements appeared, all differences were resolved through discussion. In Section IV, we share themes that were present in at least five instructors’ reflections. We validated the data using extensive member-checking. The eight participating instructors were given the following pseudonyms: Ruby, Layla, Khary, Gwen, Sharon, Bill, Pearl, and Yolanda.

IV. FINDINGS

We found instructors shifted in their conceptions of knowledge and their conceptions of self. While we also found shifts in conceptions of others and pedagogy, these themes were not found in the majority of instructors. The second theme (shared below in IV.B), while not aligned with a particular conception, was added to inform the reader of a more holistic view of the reflections.

A. Instructors’ conceptions of physics knowledge shift

Our first theme highlights a change in instructor’s conceptions of knowledge. All eight instructors share that they changed their classroom content as a result of their work with this group. They each describe content in their instruction that they can or already use to directly challenge the Eurocentric physics narrative. They also found agency in critiquing the historical and contemporary context of their instruction with their students, including different viewpoints of physics into their curricula.

For example, several instructors reflected that they used to view physics from an ideal and theoretical lens and now apply a more grounded, context-rich lens. Bill shares,

“It was eye-opening to think about how the physics concepts I am used to teaching, which are so sanitized of any sort of real-life implication, really ought to be presented with the messy, complicated context of our modern world.”

Bill’s imagery of the “sanitized” physics vs. the “messy, complicated context” of physics highlights a movement towards increased real-life connections. Layla compliments Bill’s idea with questions she now uses in lesson planning:

I had never really questioned why we teach certain content beyond the extent of switching up the order, maybe placing more emphasis on momentum (as is done in Matter and Interactions). But I am now realizing how much I had thought as a teacher: “everyone does it this way” or “we’ve always done it this way” and I’m questioning it... I am now in the habit of asking myself as I plan each unit: why is this science important, how is it used today, how can I encourage my students to find connections.

Bill and Layla both describe a shift from teaching on auto-pilot and how they have started to think deeper about why they are teaching, what they’re teaching, and how. Getting a bit more specific to the classroom, Ruby shares some examples of how that has played out:

“I used to try to downplay history because I didn’t want to remind people that all of the famous physicists are white men, but now, I talk about that being problematic. I explicitly mention that one man got credit for many people’s work - often at the expense of others’ lives. For example, I discuss how Newton was heavily invested in the slave trade or that Ibn Sahl came before Snell and Snell still gets the credit.”

Ruby acknowledges that it is important to represent the power dynamics involved in recognizing contributions of certain individuals to science. She also talks about people who have acquired fame for their work in science but were also involved with activities that were harmful to others.

Still other instructors discuss how they have learned about more historical context about certain topics. For example, both Sharon and Pearl use batteries as an example of content they have shifted. Sharon states,

“I’ve learned new content (like the Baghdad battery or the modern history of colonial oppression in batteries), and I’ve been pushed to think deeper about overarching frameworks.”

Pearl shares that she now teaches these ideas explicitly,

“Thanks to this group, I have tried incorporating pieces of lessons like the conflict mineral in the electric battery industry, and the structure of how I elicited student ideas about inertia.”

Pearl highlights shifts in her own teaching that directly affects the students in both content (battery-focused ethical issues) and practice (eliciting student ideas).

Yolanda also mentions batteries as an example of content change, but also shares the kinds of tools that the group has given her during their discussions.

I had always been uncomfortable teaching about projectiles, nuclear reactions/Weapons, and many other topics that so glaringly had to do with war and killing but I didn’t know what to do with that. This group has offered me tools, frameworks, protocols, language, and confidence to speak openly with my students about the ways in which physics colonizes and to offer ways in which physics can be used for GOOD. Some of my favorite lessons have come from work done in this group (ie: batteries, climate change, renewable energy, recognition vs contribution in physics).

Not only does Yolanda describe several examples of content change, she also expands on how the current context in which physics is used can be extremely problematic. At the same time, she has found comfort in
learning about how to articulate the “ways in which physics can be used for GOOD.”

B. Instructors feel bound by the academic system

Instructors at all levels share constraints across multiple contexts that do not support them in decolonizing physics in their educational environment. While they share this theme, we do not see instructors in this group enacting prior research highlighting “race evasiveness” [13] or “system-blaming powerlessness” [14]. During their work, they reflect that there are both individual and systemic issues outside of their sphere of influence that affect their ability to change their courses: the classroom setting, physical location, standards, colleagues, and student families. For example, Bill writes about the kind of classroom as restricting his teaching:

I have benefited a lot from the discussions in this group, even as I have struggled to bring ideas back to my lecture-based, large-enrollment college physics classes and labs… I’ve become quite a bit pessimistic about the possibility of meaningful physics instruction in large colleges… I am mostly treading water and trying to help the students get through the system as well as they can.

Here, Bill describes the lecture-based teaching approaches as restricting the kinds of changes that can be made. Their description of getting students “through the system” and “treading water” seems to imply that some aspects of the power lies in the system/water and not with the instructor.

This idea of a lack of empowerment also presented itself in terms of depending on the specific state standards of the instructor as Gwen described here:

I did not realize how bound the teachers in this group feel… With teachers in [my state], I am frustrated by how often, ‘the standard says…’ comes up. (Evidently [certain USA states omitted for anonymity] are the most bound to standards.) Do we need to change the standards? How do we do that?

Layla shares a similar idea that it is the type of course (and presumably the corresponding standards) that constrain her:

“Unfortunately, I teach AP courses so I can’t switch things up as much as I’d like.” Khary mentions that even within her school, individuals affect her agency in her teaching:

It’s been somewhat challenging to do this work well for me; there’s a bit of idealism in it which I experience as the anxiety of waiting for a student/family to push back on why this is happening in my class, particularly when no other colleagues are doing the same thing. I don’t want to be on the frontlines any longer because it’s psychically draining for me.

While the majority of the instructors shared more systemic academic traits, Khary’s reflection highlights that even within the school, the voices of students, their families, and colleagues can affect instructors’ sense of agency to significantly change their practice. At first glance, this might appear as a more individualized and anecdotal example, but this kind of pushback from students has been identified in other contexts [15].

C. Instructors’ conceptions of knowledge shift regarding the idea of “decolonizing physics”

Each instructor explicitly writes that they cannot yet, and do not yet know how to, decolonize physics. While the group may have started out trying to decolonize, all these instructors articulate that the efforts of the group have shifted to smaller scale endeavors: they are not trying to completely overhaul the curriculum yet, but rather make it more equitable. Seven of the eight instructors in the group described a recognition that “decolonizing physics,” as the group had set out to do, was not yet achievable for themselves. They acknowledged that they needed to do more research and learn more about the topic so they could effectively teach it to their students. For example, Ruby wrote, “[Decolonizing curricula] is maybe not possible to do!” Bill wrote that the group’s efforts are not focused on decolonizing physics, but rather for truth and equity within the curriculum.

I am not sure that this [decolonizing physics] is something that the group is doing. Decolonize is a heavy word, and there’s a high bar. We are maybe trying to improve our instruction to be more truthful and equitable."

In a follow up conversation during our member-checking process, Bill elaborated that the group was not decolonizing in the sense of “substantial reparations for the descendants of chattel slaves” or “land transferred back to First Nations”. This is another example of a shift in conceptions of knowledge in terms of equitable instruction.

D. Instructors’ conceptions of self shift: they realize how much they can still learn and stay motivated

Instructors’ conceptions of self shifted towards an awareness of limitations, while also increasing their willingness to continue expanding their knowledge. In their reflections, every single instructor described how they are still in the process of learning about how to better teach physics. Khary shares, “I’ve learned how little I actually knew about how knowledge is constructed within a STEM discipline, and how much I took for granted that everything I learned was objective.” Just like Khary shared in the previous quote, other instructors identified that the scope of decolonizing physics was much larger than they initially anticipated it to be. For example, Pearl states that she is “still emerging” in her skills about “knowing how to facilitate class conversations digging into this kind of content.” Layla also shares something similar and goes on to describe how that shows up as a new way of interacting with her students:

While I can’t claim to be very knowledgeable yet, I at least am at the point in the Dunning-Kruger effect where I know that I don’t know and I feel comfortable with
that. I am happy to share with my students “Look, I don’t know this. Let’s explore together.” That’s been a big shift for me.

Layla describes her learning using the Dunning-Kruger effect, where experts in a particular field are more likely to identify gaps in their knowledge than novices who may not yet recognize those gaps. Layla shares that she does not yet feel “very knowledgeable,” but she is allowing herself to be more vulnerable with her students. She now models that it is okay to not know everything, exemplifying a learning mentality to effectively better serve her students. Gwen’s reflection showcases an understanding that she must put in deliberate effort to first unlearn problematic ideas to then move towards a more equitable framing of physics.

While in this group, I realized that the implicit message of race and whiteness associated with authority in physics had also been ingrained in me, and that, like anything, it will take explicit unveiling, reflection, interrogation, to uncover and disturb the assumption that physics belongs somehow to white people and especially white men.

Gwen articulates that while she engaged with the group, she discovered that she had unknowingly internalized the eurocentric narrative of physics. Understanding that this message is “ingrained” in her, she expressed a need for deliberate efforts to “uncover and disturb the assumptions.”

Even while they all recognize that their work is unfinished after two years, instructors also write that they still value the meetings and are not deterred from the work — even if they may never fully create a fully “decolonized curriculum”, as shared in Section III.B. It is also noteworthy that all of the instructors came to this place even though they came into this project with rather different views on what it would mean for physics instruction to provide more equitable outcomes. For example, Ruby shares, “I think of this as more of an ongoing, lifelong endeavor….There is still so much to learn - so perhaps it is not a shifted view so much as increasing the depth and commitment to those views.” Other instructors write explicitly about how the group is a reason for this change. For example, Gwen shares, “I’m happy that I’m still receiving big a-has during [these meetings].” Pearl expands on the feeling of ongoing effort, even as she reflects a sense that she feels she is just beginning the work,

I can tell I’m just at the start of decolonizing the bulk of my physics curriculum, but thanks to this group I feel like I can see a fuzzy road map for how to do it. Our conversations make me feel empowered and also give me a sense of urgency towards making changes happen in my own classroom.

Pearl writes that though she is “just at the start,” she sees a “fuzzy road map” for how to decolonize her curriculum, feeling “empowered” to make “changes happen” in her classroom. Along these lines, Yolanda also writes of empowerment: “This group gives me hope and every meeting leaves me feeling energized and empowered.”

V. DISCUSSION & CONCLUSION

Our analysis of instructors’ written reflections identified four major themes. First, this group co-revised and expanded their content in a way that made them see the curriculum as more equitable, thus refining their conceptions of physics knowledge - and how that applies pedagogically. The content shift (e.g., climate change, battery origins, Newton’s problematic actions) are a concrete, albeit relatively safe, example of how instructors have changed aspects of the curriculum, without having to deal with the negative consequences of school community pushback and the overarching structure of colonization.

Instructors also described feeling bound by their educational systems as they attempt to decolonize physics. The system, in this case, does not change structurally (e.g., the lecture hall, the inequitable representation, private schools vs. public, the inequity outside the classroom itself). Through their work in this group, these instructors developed an understanding that they cannot change the system as a whole (yet!), but they can move the needle towards equity. We saw their reflections as demonstrating several aspects of transformative professional learning [16] and see this study as an initial step towards articulating one example of how physics instructors might productively engage in moving towards more equitable instruction.

Our fourth theme speaks to instructors’ feelings of productivity and hope. We are encouraged by their desire to continue their efforts. Undaunted, instructors found ways around these circumstances through gradually making changes to curriculum as shared in Section IV.A. Through the conceptions of self framework, we see that instructors have strengthened their sense of empowerment to do this work. Even though these instructors came in with different viewpoints, their interactions and support for each other’s learning has created more motivation and action.

A major implication of this study is that this PLC shifted the canon by revisiting, problematizing, and/or telling a truer story of history. For equity work in physics education research, this study highlights an example of what physics instructors can do given the opportunity. We recommend looking to instructors for expertise in developing more equitable curricula and partnering with them to identify additional tools to connect with students and share different perspectives. This partnership will ultimately create stronger curricula and healthier, more diverse, and more inclusive classrooms.

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[1] The Underrepresentation Curriculum: 

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