

## Decolonizing physics curricula: A case study about a kinematics lesson

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Physics curricula has been reflective of eurocentric ideals through maintaining a white, male-dominated narrative that discourages diverse cultural practices; we see very little work describing and/or supporting physics educators in decolonizing their curricula on a larger scale. In response, a voluntary professional learning community (PLC) of physics educators has been working together to decolonize their curricula and implement improved lessons. We share one collective attempt to reimagine a lesson from a monthly online meeting, highlighting the existence of grassroots effort. We compare and contrast this work to previous case studies that exist more broadly in STEM, and provide examples of processes that participants developed to decolonize their curricula in the context of a kinematics lesson about stoplights. This example provides a possible pathway for educators to implement these methods in their classrooms and encourage educators to support the movement toward decolonization.

## I. INTRODUCTION

The need to challenge traditional narratives, and foster a more inclusive and diverse approach to both teaching and learning has become a priority for educators in the recent past [1-3]. Contemporary educational research demonstrates an emergent trend toward studies focused on decolonizing curricula [4]. We define ‘decolonization’ in education as challenging eurocentric biases, exclusionary practices, and historical marginalization of non-Western perspectives, while conversely seeking to create a more inclusive, diverse, and culture-based teaching approach that reflects the knowledge of non-dominant cultures. We recognize that this definition of decolonization does not address settler-colonialism and its ongoing, material impacts. It must be qualified as a subset of incomplete educational actions *towards* decolonization within the constraints of the system, instead of the necessary overhaul of all curricula and the centering of marginalized voices.

In the literature, there are several ways educators have suggested to decolonize curricula [5-7] and many approaches attempted in other contexts [8-10]. Decolonizing *physics* curricula involves applying the principles of decolonization specifically to the teaching and learning of physics. Many teachers are beginning to navigate these practices, as very little research has been published that investigates this in the context of physics [10]. For the sake of brevity, we will apply three specific approaches to our physics context, described below.

Educators often make an explicit effort to include **diverse perspectives** when attempting to decolonize their curricula [11-13]: Recognizing and valuing alternative viewpoints, knowledge systems, and cultural variations. This tactic might involve incorporating contributions from non-Western researchers and thinkers in the curriculum and acknowledging their role in advancing the field.

A second approach includes **the integration of social justice issues** [2,14]: Incorporating discussions critiquing current social inequalities and their implications in learning, research, and applications. Morales-Doyle (2017) includes examining the ethical considerations of scientific advancements and their impact on different communities. For example, a recent trend in physics education promotes integrating climate change and its social impacts in physics curricula in the context of energy [15].

A third is **promoting student advocacy in society** [15]: Incorporating the support and amplification of the voices, needs, and rights of students. This involves student empowerment and community engagement. For example, in a chemistry class, students were encouraged to apply their learning to advise community members about methods to improve the local soil and water composition [15].

Our analytical framework of “decolonization” uses the Justice-centered science pedagogy theoretical framework

[14] and Culture-based Pedagogy [2,11] to articulate the ways in which teachers explore the societal contexts that apply to physics. Our research seeks to understand more practically what decolonization means in a classroom.

## II. PLC RESEARCH CONTEXT

This paper examines the collective efforts of a Professional Learning Community (PLC) of physics educators as they navigate the complexities of decolonizing curricula. They do this by aiming to integrate three contexts - historical, societal, and personal - and pedagogical perspectives in every lesson they review. By critically engaging with existing physics content, pedagogical approaches, and assessment methods, they aim to redefine the canon of physics education and embrace diverse cultural knowledge, epistemologies, and contributions.

The journey of this PLC is not without challenges. They face resistance from institutional norms and encounter tensions with characteristics of whiteness in their interactions [16]. However, this PLC hopes to inspire broader change within the physics educational landscape by embracing a decolonized approach to teaching. In this paper, we share examples of the ‘societal context’ lens applied to a lesson during a PLC meeting. Societal context refers to the interconnected web of cultural, economic, technological, social, and political dynamics prevalent in a society at a particular time. It encompasses the collective facets that characterize and influence how people within that society think and relate.

## III. RESEARCH DESIGN

We seek to demonstrate how a collective attempt to reimagine a kinematics ‘Yellow Light’ lesson highlights the existence of productive, grassroots efforts to decolonize physics curricula.

Ten participants who attended a conference designed to help physics participants incorporate social justice pedagogy decided to start an online, voluntary group to discuss various ways to decolonize physics curricula. At these monthly meetings, participants examined curricula, designed lessons, and critiqued pedagogy and knowledge in physics teaching practices. Researchers joined the group and began to video-record the meetings via Zoom. Each video was ~1 hour and 30 min. The participants were given pseudonyms: Ruby, Layla, Khary, Yolanda, Johanna, Maggie, Julie and Emily. All participants were either physics educators in high school, two-year college, or university spaces, are located in the United States, and come from diverse cultural, ethnic, and racial backgrounds.

Layla presented a draft lesson to the group that was then workshopped during the meeting to improve the lesson, using their rubric of historical, societal, personal, and pedagogical perspective integration. The lesson was adapted from Eisenkraft [17], where students evaluate the

driver safety of a nearby intersection. By incorporating their measured length of yellow light time, the width of the intersection, and the speed limit with kinematic equations, students determine 'stop' and 'go' zones and look for a gap.

We performed a phenomenological discourse analysis on video excerpts that were identified through the authors' initial observations. A transcript of the meeting regarding the lesson was created and analyzed using Vosaic, an online video analysis software. The transcript was analyzed using an open coding analysis where authors used emergent theming to identify participants' ideas for the implementation of societal contexts [18]. Coding was completed over three rounds. The first round identified four contexts predetermined to be important by the participants: societal, historical, personal, and pedagogical. Secondly, we defined common themes within the participants' suggestions to use as subcodes and narrowed the scope to focus solely on data found by examining societal contexts. These findings were shared with all group members. Through this process of member-checking, small adjustments were made to the themes [19]. Finally, we did not see a particular framework in the literature that aligned with our data. We chose to pull three aspects, described in Section I, from different frameworks for our analysis.

#### IV. FINDINGS

From the data, we found that participants reflected the following three indicators whilst implementing societal contexts into the Yellow Light lesson: A) diverse perspectives, B) social justice, and C) advocacy in society.

##### A. Diverse Perspectives

In their discussion, participants introduced lesson modifications to increase focus on diverse perspectives to diminish the power of a dominant narrative, and provide students with exposure to a gamut of infrastructural designs across the USA. They suggested that individuals in the same city, across various regions in the USA, and in other countries, may have different experiences with road designs. Participants identified transportation modality, physical ability, socioeconomic status (SES), locality, and race as factors that impact these experiences but are not acknowledged in eurocentric education. In what follows, we share examples of each of these ideas.

Transportation modality (cars, buses, subways, bikes, peds, etc.) was among the first topics discussed when focusing on variations in experiences between pedestrians and car drivers while navigating particular infrastructures. Below, Khary contrasts experiences of different intersections and commuter travel methods.

**Khary:** *Maybe there could be an exercise around the utility of rotaries versus lights at intersections, where traffic doesn't necessarily stop, but it slows to make those turns. I don't know how pedestrians navigate rotaries. They seem terrifying because nobody is stopping.*

Khary suggests students contrast the movement through rotaries (i.e., roundabouts) and four-way intersections. These traffic features can be specific to a particular location, and yet still make the assumption of one modality - motorized vehicles. Khary then expands the focus to pedestrians and highlights safety for walkers between two different redirective road infrastructures.

Maggie opened a discussion about how different regional, geographic and cultural values may lead to varying results when designing and implementing road infrastructure and how they prioritize a range of diverse travelers. She highlights a distinctive road feature, the left U-turn, offering another intersection alternative for students to compare between states. In the following example, Ruby describes how Singapore, a non-Western, yet neoliberal country with a history of colonial rule, provides a perspective of how the structure and design of road use can affect the health of their consumers:

**Ruby:** *Singapore is really interesting as an alternative way of designing. The pedestrians and bikes and scooters... have the right of way. They've prioritized it in a way that's really powerful, so it might be interesting to contrast that with your city, and have a comparison like 'Here's another alternative way of living and health; what are the health statistics of the people in your city versus the health statistics [of Singapore] because everyone's walking.'*

Ruby describes how focusing on a model supporting pedestrian, bike, and scooter use correlates to better health. She previously highlighted that Singapore creates a disincentive for car transportation through the high taxation of vehicular ownership. Ruby articulates how different cities' financial structure and cultural values influence transportation infrastructure.

Instructors suggest broadening diverse perspectives by including views from people with varying physical abilities. Regarding the planning of traffic light patterns, participants describe how those with physical disabilities are disadvantaged by the loss of their perspective:

**Yolanda:** *Even for pedestrians and yellow lights, it's typically timed for people that don't have any physical disabilities. I think bringing awareness to students that... there's a ton of planning that goes into [intersections]. And the erasure of someone's experience [can cause] harm.*

Yolanda highlights that traffic lights are designed for the able-bodied subset of the population. She also emphasizes the importance of how excluding the experience of disabled people leads to inequalities.

Finally, Johanna describes how a critical lens regarding structural choices in city planning can highlight racism and reduce access to pedestrian walkways, neglecting the diverse perspectives of local pedestrians:

**Johanna:** *I live in the poorest part of [a Midwestern state]; traditionally, low-income, black, [and] not a lot of white people. But they put a highway through our neighborhood in the twenties or thirties, I think. And they*

*took out the... pedestrian area. And we have this giant highway now, that's basically 8 lanes across.*

Johanna discusses how her city built a highway through a black neighborhood. She acknowledges the historic social disparities regarding infrastructure design, which frequently cause harm to black communities both historically and today [20]. She continues, stating that the installation of this highway has disadvantaged her local community, having created unsafe conditions for pedestrians. This contrasts Ruby's example describing the prioritization of pedestrian travel in the city planning in Singapore.

### B. Social Justice

Instructors discussed integrating social justice issues in various ways, including Johanna's previous description of the disparity in safety prioritization between pedestrians and car users, particularly in low-income neighborhoods that are correlated with higher concentrations of nondominant racial communities [20]. Participants primarily highlight SES variance and its impact.

For example, Julie discusses potential questions that students could ask about their cities regarding traffic statistics in comparison to the SES in their area of focus:

**Julie:** *There are places where the wealth of the neighborhood influences the decisions made around pedestrian access...[such as] how highways are often put in poor neighborhoods. How does that affect speed, traffic volume, accidents, and speed limits? And also questioning installing traffic calming measures, and which neighborhoods get those in place and which don't? I'm wondering if students could do research using GPS or using Google Maps?*

Julie acknowledges the patterns between road infrastructure and the general wealth of neighborhoods; pedestrian transportation accessibility and safety are lower and large road obstructions are higher in low-income neighborhoods. Similarly, Layla suggests that the lesson could increase student awareness of the need for easily walkable infrastructure.

**Layla:** *There's a huge disparity in the communities that can afford cars. They're supported in the city and they can get around. Then we have communities in [a Southern city] that cannot afford cars, and it's not a walking-friendly city, and they cannot get to their grocery stores. I would love to bring students awareness to those communities, and how they're not supported by the [infrastructural] decisions.*

Layla describes a lack of walkable urbanism in her city. This disproportionately impacts the lower SES population that may not be able to afford a personal vehicle, and thus cannot access their community in a safe or convenient manner when compared to their higher SES counterparts.

### C. Advocacy in Society

Instructors incorporated societal contexts into the lesson discussion by acknowledging the importance of advocacy

in society, which highlights how knowledge of the previous two sections can support student's empowerment and community engagement through physics. This allows for the encouragement and usage of student voice through instructional approaches that are based on students' interests, passions, and ambitions regarding the safety of their communities - connecting to social justice [14].

Thinking about engaging students, Emily conjectures that they could advocate for their own safety ordinances using scientific practices and statistical information:

**Emily:** *I noticed that my state has a data visualization tool for crashes because there's so many crashes in my city, and we don't have a bike helmet law. I was looking at the data visualization tool and noticed 'wow, there's a couple super problematic places in my city that they should really look at.' [I was] wondering if [having] targeted projects [where] students see if the yellow light timing is maybe something that would fix some of these problems? I like the potential of this project to introduce my students to how public [and] policy change happens.*

In this set of proposed activities, Emily discusses how students would be given the opportunity to investigate car crashes in their own communities using a public data visualization tool to identify high risk intersections. She suggests that students could study the yellow light timing in those locations to identify patterns. Then, students can use their knowledge of kinematics and their local context to elicit societal change. Here, Emily has created a space for students to use their voice to advocate change from their own local government and improve community safety.

Ruby continues to brainstorm ways of getting students to connect with their community, and bring local community members into the classroom, stating, "Are there local [city planners] who would be willing or excited to come into a classroom and... connect it directly to what's going on in your city at that time?" Ruby proposes that students may benefit from engaging with city planners who could share the importance of their work, potentially increasing student interest in the physics used in infrastructural decisions. Ruby continues, describing recent safety changes in her cycling commute:

**Ruby:** *In [a Northwestern city], they've started to turn on the walk sign before they turn on the green light, and that's made a huge difference for me and my cycling commute because I feel a lot safer; but I wonder how long that time is? There's a cool problem... thinking about how far into the intersection is the person and the bike by the time the car gets to start - which is a safety thing, right?*

Ruby suggests a problem that could be given to students to figure out what amount of time between the pedestrian crosswalk initiation and the traffic light turning to green equates to a safer outcome. This type of problem could allow students to become curious about their own local commutes, and how to make them safer.

Thinking about her own community, Johanna offers her experience of a push for increased safety regarding

stoplight timing. She discusses how studies have been conducted revolving around the safety, timing, and prioritization of varied people in her neighborhood. Participants share differing perspectives based on their communities, showcasing how asking questions to students could lead to different responses based on where they live.

## V. DISCUSSION AND IMPLICATIONS

We identified three indicators of participants' discussion that focused on decolonization within the societal context: diverse perspectives, social justice, and advocacy in society.

Each of these pedagogical modifications toward decolonizing are not mutually exclusive. We acknowledge that our process of categorization enacts an oversimplification of the rich complexity of the instructors' work. For example, ideas about adding diverse perspectives can often overlap with social justice topics. Participants touched on the difference in perception that people can have depending on their mode of transportation. Lack of access to a vehicle in most regions of the USA may be seen as a symbol of low SES based on preconceived societal biases. Therefore, by considering the needs and experiences of those who do not use a personal vehicle, instructors can integrate both diverse perspectives and social justice into the lesson. In particular, participants raised the point that different road infrastructures may prioritize different people. Thinking about these nondominant perspectives is decolonizing in nature because different cultures can have distinct priorities of transportation modalities.

Participants aimed to decolonize this lesson by having students explore diverse perspectives. They suggested contrasting the differences between Western and non-Western societies with respect to intersections, SES, and travel modality. Ruby discusses Singapore's road infrastructure, highlighting how their culture values walkability and financially discourages car possession. Road infrastructure tends to be built with the transportation values of the accompanying society, particularly those of higher SES, taken highly into consideration.

Additionally, instructors discuss the ways in which traffic infrastructure can support dominant groups. For example, Yolanda emphasizes how intersections are often curated for the able-bodied majority. She posits that students could investigate how traffic planning strategies (e.g., the crosswalk time allotted) could impact those with disabilities, of which minorities are more likely to have [21]. Johanna's example of freeways built through predominantly black neighborhoods also embodies how racism can infiltrate planning and affect walkability, commute time, and safety. Using these examples, instructors can bring student awareness to infrastructural decisions and matters of social justice that affect people differently depending on their unique factors [2]. Layla furthers this point by emphasizing her desire to help inform students on how/why these design decisions are made.

Finally, decolonizing involves advocacy in society, a prevalent theme throughout the discussion. Instructors emphasized the importance of student involvement within their own communities while using their physics knowledge. Emily discusses students doing a project that analyzes the yellow light timing involved in local car crashes, personalizing students' learning and assessment. It also allows for student engagement in the progression of change and safety in areas they care about. Ruby responds by adding that involving local city planners in the classroom could help further inform students of the safety of their city and what can be done to improve it. She also suggests that students could model the safety of the delays in yellow light timing and research how they could be improved for a diverse array of individuals, places, and modes of transportation. This is decolonizing in nature by fostering collaboration between peoples which encourages the decentering of dominant narratives.

## VI. CONCLUSION

While there are some communities working on decolonizing curricula, minimal large scale structures are in place to support physics educators in decolonizing their curricula. In this study, we used a decolonizing analytical framework to examine how a collaborative attempt to reimagine a kinematics lesson highlights the existence of grassroots efforts to decolonize physics curricula. Our analysis demonstrated ways in which participants integrated societal contexts by including diverse perspectives, integrating social justice, and promoting student advocacy in society. Participants demonstrated innovative strategies and transformative practices to refocus curricula development, uncover embedded biases, and progress towards celebrating diverse voices and knowledge systems.

Educators can use a similar lens as this PLC to disrupt the dominant Eurocentric physics curriculum by incorporating societal contexts in their lessons, acknowledging that a given physics class may not incorporate all suggestions. Further research can investigate 1) how an individual instructor uses these ideas in their own context to push their lesson beyond the traditional physics content, and 2) how participants discuss and revise lessons using all three contexts: historical, societal, and personal connections. This research is only highlighting the methods of one PLC, and future work needs to investigate the practices of other groups with similar goals. We hope this work begins to pave the way for a more equitable and enriching science education going forward.

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