Studying pedagogical practices in physics through the lens of epistemic (in)justice.

Joineé Taylor[1,2]
Department of Teaching & Learning, Florida International University, Miami, FL 33199

Zahra Hazari[1,2,3], Idaykis Rodriguez[2,3], Geoff Potvin[2,3] and Miguel Rodriguez[4]
[1] *Department of Teaching & Learning, Florida International University, Miami, FL 33199*
[2] *STEM Transformation Institute, Florida International University, Miami, FL 33199*
[3] *Department of Physics, Florida International University, Miami, FL 33199*
[4] *Department of Physics and Astronomy, University of Utah, Salt Lake City, UT 84112*

While some students successfully navigate normative practices associated with physics instruction, physics educators have argued that many students encounter barriers that lead to undesirable learning outcomes. The reasons for such learning outcomes in physics are multifaceted, with increasing attention being placed on shifting traditional pedagogical practices that limit student participation or promote more factual knowledge over knowledge construction processes. In addition, some active learning practices may also be insufficient for students to leverage personal resources (ideational) and environmental resources (material and relational). By inhibiting epistemic agency, practices that limit the leveraging of such resources have been associated with learning barriers which, we argue, engenders a form of injustice we describe as "Epistemic Injustice". In this paper, we use the framework of Epistemic Injustice to analyze small group interactions in an introductory physics classroom. Through a process we call "Epistemic Resource Negotiation", an episode of video-recorded data of student group work in a Modeling Physics course is examined. In our analysis, we focus on instructional practices to identify epistemic resources and how they are negotiated and accessed in ways that inhibit or afford agency. Our work presents an analytical method that may be used to understand how to move toward more equitable pedagogical practices.

2022 PERC Proceedings edited by Frank, Jones, and Ryan; Peer-reviewed, doi.org/10.1119/perc.2022.pr.Taylor
Published by the American Association of Physics Teachers under a Creative Commons Attribution 4.0 license.
Further distribution must maintain the cover page and attribution to the article's authors.

I. INTRODUCTION

As our technologically evolving world experiences what many call the "Third Industrial Revolution", emphasis has been placed on physics learning as a critical component in developing competent 21st-century citizens [1]. This may be attributed to the analytical and technical skills implicitly cultivated through physics learning. However, despite some students' successful navigation of the normative practices associated with physics instruction, physics educators have long argued that many students encounter barriers that lead to undesirable learning outcomes. While numerous factors contribute to such learning outcomes in physics, increased attention has been placed on the need to shift traditional pedagogical practices which limit student participation or promote more factual knowledge (e.g., simple retrieval) over meaningful knowledge construction [2]. Additionally, researchers argue that even in active-learning classrooms if opportunities for students to leverage both personal resources and resources in their environment are limited this may also lead to inhibited epistemic agency and undesirable outcomes [3]. Such limiting practices have been linked to learning barriers which we argue engenders a form of injustice we describe as "epistemic injustice".

Epistemic Injustice is a philosophical framework initiated by Miranda Fricker [4], which catalyzes thought about epistemic conduct and practices. This framework seeks to explain injustices that foster "unfair treatment with respect to knowledge, understanding, and participation in communicative practices" [5,6]. Epistemic injustice can be categorized in three main forms:

1. Injustices suffered by a knower – also called *testimonial injustice*. It is caused when someone's testimony is not given due credit such that the knower is treated unjustly in their capacity as a giver of knowledge [4].
2. Injustices inadvertently perpetrated by a knower – also called *hermeneutical injustices* caused by the epistemic dysfunction and stymieing of understanding due to a lack of interpretive resources [4].
3. Injustices perpetrated by epistemic institutions – this is caused by epistemic practices within the structures of institutions, such as academic curricula and/or academic disciplines, which systematically disregard, distort, and or discredit intellectual material [7].

In this paper, we use the framework of Epistemic Injustice to analyze a set of small group interactions in an introductory physics classroom. Epistemic Injustice, especially hermeneutical injustice, can be mitigated by access to and adequate negotiation of a repository of resources called epistemic resources [4]. The opposite (lack of accessibility and/or excessive negation of resources) is true for the exacerbation of epistemic injustice. Since a myriad of epistemic resources exists, we sought to employ a three-pronged lens to guide our study of such resources. To do this, we draw on the Identity Resources Framework [8], which focuses on racialized and academic identities, and one's connection to practice. However, we refocus the framework's contents on the affordance of epistemic agency, the epistemic agent, and connection to practice. In the framework, Nasir [8] offers three broad resource categories; those that are *material*, *relational*, and *ideational*. In the context of our study, we define them as follows:

1. Material Resources – physical artifacts in a setting that support one's epistemic agency during physics learning. For example, lab equipment or shared whiteboards.
2. Relational Resources – interpersonal connections to others that support one's epistemic agency during physics learning. For example, side-talk with groupmates, and discussions with learning and/or teaching assistants.
3. Ideational Resources – ideas that impact one's epistemic agency during physics learning. Such ideas can be influenced by one's epistemic perspectives or cultural perspectives, including stereotypes.

Epistemic (in)justice can therefore be observed through a process we call Epistemic Resource Negotiation (ERN). We define ERN as the process by which some resource (such as a relational, material, or ideational resource) is introduced, dismissed, and/or exchanged during an epistemic activity (e.g., knowledge construction). Using ERN in the current paper, we examine an episode of video-recorded data of group work in a Modeling Physics context. In our analysis, we focus on the class' (institutionalized and emergent) instructional practices to identify epistemic resources and how they are being negotiated and accessed in ways that inhibit or afford agency. Our work presents an analytical method that may be used to understand how to move toward more equitable pedagogical practices.

II. METHODS

A. Context

In the current paper, we present an excerpt of preliminary findings drawn from a larger, ongoing study aimed at investigating how forms of epistemic (in)justice emerge through engagement in physics courses. This paper, therefore, presents an episode of results from video-recorded observational data. This data was collected during week 4 of the fall 2018 semester, during a 3.25-hour calculus-based introductory physics 1 class at a Hispanic-serving public research university. This particular class implements a reformed curriculum and pedagogy called Modeling Instruction (MI). Thus, the class is structured in a studio format and the curriculum is usually designed around studying a small set of physical models with a focus on the process of building, validating, and deploying these models for a wide range of physical systems. McPadden and Brewe [9] describe that in adopting a modeling approach, students are expected to draw on procedural knowledge such that if they are asked to create a model of an accelerating train, for example, their solution incorporates equations as well as pictures/diagrams, word descriptions, motion maps, and explicit assumptions (amongst other potential representations).

The class observed was taught by one instructor who was accompanied by a teaching assistant (TA) (physics graduate student) and 3–4 learning assistants (LA) (outstanding undergraduate students who previously completed the course and also received pedagogical training according to the Learning Assistant model) [10]. The observational data collected focuses on one group of five students, who had recently learned kinematics and had practiced describing and predicting motion in prior weeks. At this point in the semester, students were transitioning from kinematics to learning about energy and energy conservation, since students learn energy before forces in this course.

B. Analytic Approach

We present an observational analysis of two moments taken from an 8-minute video episode. To select this episode, and critical moments within this episode, we first identified a focal point which was a moment where we tagged a possible epistemic injustice emerging during an interaction. We created boundaries around this point by identifying the set of interactions that led up to and took place after the focal point. Defining boundaries was an iterative process that involved paying close attention to the language used. We then transcribed the episode considering both verbal and non-verbal actions. Finally, to evaluate whether epistemic injustice was truly observed, we analyzed the transcript and video using the process of ERN as a detector. We looked for signs of epistemic injustice by studying how resources were leveraged throughout the ERN process. Signs include inhibition of epistemic authority, rejection/dismissal of testimonies offered during communicative practices, lack of acknowledgment of hermeneutical gaps, etc. However, had this been a moment of epistemic justice emerging, attention would have been placed on the opposite kinds of signs. For example, consider a student's introduction of an ideational resource where her ideation is welcomed by peers who deliberate around her offerings. This negotiation can be indicative of epistemic justice where the student's epistemic agency is supported, and her testimonial is given some level of credence.

III. RESULTS

The following moments were taken from an 8-minute episode that took place the day after students conducted a lab activity titled, "Investigating a Bouncing Ball". These moments were selected because they illustrate how success/failure to leverage resources can inhibit or afford epistemic agency and might result in either epistemic justice or injustice. For this activity, students were examining the motion of a bouncing ball. They first needed to make predictions of graphs for position vs. time, velocity vs. time, and acceleration vs. time, and then use motion detectors to create these graphs.

The episode focuses on a group of five students composed of two women, Ophelia and Ela, and three men, Luke, Jose, and Paulo. However, the episode presented is centered around Paulo who is the most vocal among the group. His hypothesis and ideas were being challenged by the group's experimental findings. It is the discrepancies in his thinking that lead to the moments presented below.

Moment 1: I don't get why this is wrong…

Paulo: I have a question
Breane: Yeah
Paulo: So with this experiment, what I predicted was wrong for the acceleration. I thought it would just be a constant negative acceleration because you have gravity always acting on the ball but the acceleration went negative, positive, negative, so like I don't get why this is wrong, for the acceleration. The velocity is wrong as well but like I don't get like, if you have the ball bouncing like downward isn't gravity always, isn't that the only acceleration acting on the ball?
Breane: Mhmm *(shakes head to indicate yes)*

Paulo: So why is it negative, then positive, then negative, and then positive?
Breane: Well, let's see. So, it's speeding up in the negative direction. Yeah, why does that happen?
Paulo: So, like the first drop, right, acceleration will be negative because your point of origin is zero [in audible]
Breane: Yeah, it will be when it's going down it's going…
Paulo: Negative, which is what I got here, and then once it's going up won't acceleration still be negative because it's going away but it's slowing down.
Breane: Mhmm *(indicating yes)*
Paulo: I don't know I don't know why it's like that
Breane: Very interesting (*said slowly with a finger on chin*) maybe that's supposed to happen
(Breane begins walking away slowly. Paulo slowly smiles while looking in her direction.)
Breane: Think about it.
Paulo: Okay

Once Breane accepted his request for a *relational resource*, Paulo introduces *ideations* about what he suspects is occurring when a ball bounces. In this moment, he can be seen trying to make connections between what he understands about acceleration due to gravity being a vector that acts downward, and the idea that an object moving upward is being slowed down which he argues is both indicative of negative acceleration.

At the end of moment 1, Breane tells Paulo to think about why there is a change in direction for the acceleration in their experimental results. She walks away from his group, leaving him for about 1 minute to ponder. Once she returns, she asks Paulo, "Have you thought of anything yet? In the 3.5 seconds when I walked away?" Paulo, in a series of responses, expresses that he is still struggling to understand why the acceleration is not constant which brings us to the start of this second moment.

Moment 2: I know…but why?

Breane: Alright so what happens, so it's a bouncy ball right what happens when it hits the floor? Does it slow down on the way up?
Ela: Yeah
Breane: No, like the moment it hits the
Paulo: No
Breane: What happens? When it…
Paulo: [It's] at the same speed and then it slows down
Breane: Does it?
Paulo: Well, it loses some energy —
Ela: Well —
Paulo: to the floor right. [Paulo and Ela talk at the same time]
Ela: Yeah
Breane: Yeah, it loses some energy, right? *(Breane walks over to one side of the table and picks up a material resource which is the tennis ball)* But usually when we do these things, we just kind of model it one way right. Or it's something it's like moving at a constant acceleration both ways but when I bounce the ball right *(Breane demonstrates by dropping the tennis ball)*, it's...when it hits the floor something happens as it's coming back up.
Paulo: I know that you mean that it's slowing down when it comes back up?
Breane: Um, not exactly but it's that fact like, I don't wanna say the word
Ela: It stops for a second
Breane: Okay, I'm not saying like sneak peek look at the next page usually it could tell you what you are trying to learn here. So, like the titles, I go by the titles right. So, like something happens
Paulo: So, I know, I know that it loses energy once it hits the floor
Breane: Yeah right. So that causes something.
Paulo: Slows down
Breane: So that causes a change in what is going on here
Paulo: But why isn't acceleration? Why wouldn't acceleration just constantly be positive if [??] is always pulling away from the sensor.

Breane begins by soliciting ideations from Paulo. At this point, two other students, Ela, and Luke, direct their attention toward Breane. Ela engages in the ideational exchange by offering a response to Breane when she says, "loses energy to the floor." Breane acknowledges but dismisses the response. The LA whose attention is focused on Paulo mostly responds to Paulo in the ideational exchange. Further Ela and Paulo seemingly ignore each other as relational resources during the exchange. Their attention is mostly directed toward the epistemic authority, Breane, and sometimes they are heard talking over each other. As the students were trying to make connections between the concepts in an effort of understanding what happens when a ball bounces, Breane impedes this process. Struggling to avoid "giving away the answer", Breane offers the students a kind of cheat code. She says, "Okay, I'm not saying sneak peek look at the next page usually it could tell you what you are trying to learn here." However, we see that Paulo acknowledges but dismisses both the LA's ideation and material resource offerings. He indicates that he is aware of the phenomenon that the titles call attention to and restates his original question alluding to the fact that it was not being answered.

IV. DISCUSSION AND CONCLUSION

In this paper, we explore a small group interaction to examine how instructional practices might inhibit or afford epistemic agency through the ways in which epistemic resources are accessed and negotiated. We focused on how this process is facilitated by an epistemic authority, who in this case is a trained LA. Thus far, we observed two ways epistemic injustice can emerge in a physics classroom.

Firstly, we found that in instances where hermeneutical gaps go unnoticed or unacknowledged, hermeneutical epistemic injustice emerges. We saw this with Paulo who struggled to recognize the relationship between acceleration and velocity, concepts that the LA never mentions. Breane was not very attentive to the concerns raised by Paulo which was his confusion about moments of positive acceleration. Hermeneutical gaps can create marginalization in the knowledge construction process which limits a student's epistemic agency. Fricker [4] argues that as virtuous hearers, i.e., equitable instructors, alertness and sensitivity are critical so as to mitigate such marginalizations. Failure to notice hermenutical gaps can result in what Elzinga [11] describes as failed attempts to use accessible tools that are unsuitable to the task and result in poor performance and frustration. We saw this as Paulo remained confused although Breane attempted to offer various unsuitable epistemic resources. In the moments presented, Paulo was audibly struggling to recognize the connections between his current conceptual ideas and the interactions occurring experimentally. Recognizing this could have helped the LA better leverage the resources to scaffold the student's construction of knowledge. However, she did not fully leverage the opportunity to understand the hermeneutic gap which was the relationship between acceleration and velocity. Paulo's limited introduction of (and sometimes repetitive) ideations was indicative of his minimal access to the necessary epistemic resources that would provide clarity. For example, Breane could have called on conceptual resources such as word descriptions or mathematical models in addition to the graphs to help the student explore concepts that influence acceleration. Additionally, Paulo was a part of a group and thus had access to other group members who could have been leveraged as relational resources. Breane could have facilitated Paulo's engagement with other group members. Instead, we saw that Breane often dismissed students' ideations as she placed more focus on sticking to the course material and getting the students to the next conceptual point in the course, which was energy.

Secondly, we saw that the LA uses epistemic authority to stymie the students' epistemic agency as they were trying to construct an understanding of what happens when the ball hits the floor. Breane impedes students' ideational exchanges offering them a "cheat sheet" kind of resource (which can also be seen as the least agential) by directing attention to a traditional epistemic "invoking authority" frame in the physics classroom [12], the workbook. Traditionally textbooks/workbooks have been revered as sources of legitimate knowledge and thus, often consulted as authoritative guides [13]. Hence, the workbook was offered as an authoritative material resource; but in this moment, Breane's introduction of this resource undermines the students' epistemic capabilities and directs epistemic power toward the text thereby creating an instance of epistemic injustice.

The emergence of these instances of injustice demonstrates that even active learning classrooms, which are designed to foster epistemic agency, can be sites of epistemic injustice. For example, in this study, the modeling instruction classroom is designed as a collaborative learning environment that encourages cooperative group engagement, while instructors actively manage discourse during activities [14]. However, microscale analyses reveal that these active-learning opportunities call for varying levels of support along the way by the instructor such as appropriately leveraging resources, especially those that are relational resources in the case of cooperative group work.

V. LIMITATIONS

The findings presented in this paper are a section of results from a larger study in progress, investigating how forms of epistemic (in)justice can emerge during physics learning. We recognize that interactions are mainly constrained to one student, as he was the most engaged verbally. We also recognize that the instructor in the episode is a learning assistant who might have limited instructional experience and that instructional strategies can vary from person to person. Further, we note that this is not an exhaustive analysis of the various forms of epistemic injustice that can occur. Nevertheless, the focus is placed on the method for analyzing and detecting epistemic (in)justice since the goal of this paper is to introduce an analytical method for studying shifts toward more equitable pedagogical practices.

VI. ACKNOWLEDGMENTS

The authors thank the Spring 2022 EDG 7667C instructor and students at FIU and the FIU PER group, for contributions to ideas in this paper

[1] National Research Council, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (National Academies Press, Washington, DC, 2012).
[2] D. E. Meltzer, and V. K. Otero, A brief history of physics education in the United States. American Journal of Physics, **83**(5), 447–458. https://doi.org/10.1119/1.4902397
[3] E. Miller, E. Manz, R. Russ, D. Stroupe, and L. Berland, Addressing the epistemic elephant in the room: Epistemic agency and the next generation science standards. *Journal of Research in Science Teaching*, **55(**7), 1053-1075. (2018)
[4] M. Fricker, *Epistemic Injustice: Power and the Ethics of Knowing*, (Oxford University Press, 2007).
[5] F. S. Tanswell, and C. J. Rittberg, "Epistemic injustice in mathematics education". *ZDM Mathematics Education*, **52**(6), 1199–1210 (2020).
[6] I. J. Kidd, J. Medina, and G. Pohlhaus, "Introduction to the Routledge handbook of epistemic injustice" In *The Routledge handbook of epistemic injustice*, (Routledge, 2017) p. 1.
[7] G. Pohlhaus., Varieties of epistemic injustice, In *The Routledge handbook of epistemic injustice* (Routledge, 2017) pp. 13–26.
[8] N. I. Nasir, "Racialized identities: race and achievement among african american youth", (Stanford University Press, 2011).
[9] McPadden and E. Brewe, "Impact of the second semester University Modeling Instruction course on students' representation choices. Physical Review Physics Education Research, **13** (2), 020129
[10] H, Kornreich-Leshem, R. Benabentos, Z. Hazari, G. Potvin, and L. Kramer, The cognitive and affective roles of learning assistants in science, technology, engineering, and mathematics college classrooms: An exploration of classroom experiences and students' metacognitive awareness and disciplinary identity. Science Education, 106(3), 545-572. (2022).
[11] B. Elzinga, "Hermeneutical injustice and liberatory education". *The Southern Journal of Philosophy*, **56** (1), 59–82, (2018). p. 10
[12] T. J. Bing, and E. F. Redish, Analyzing problem solving using math in physics: Epistemological framing via warrants. Physical Review Special Topics-Physics Education Research, **5** (2), 020108 (2009).
[13] Apple, M. W. The text and cultural politics. The Journal of Educational Thought (JET)/Revue de la Pensée Educative, 17-33. (1990).
[14] E. Brewe, V. Sawtelle, L. H. Kramer, G. E. O'Brien, I. Rodriguez, & P. Pamelá, Toward equity through participation in Modeling Instruction in introductory university physics. Physical Review Special Topics-Physics Education Research, **6** (1), 010106. (2010)