Tracking Inequity: An Actionable Approach to Addressing Inequities in Physics Classrooms

Recent studies reveal people from marginalized groups (e.g., People of Color, women) continue to earn physics degrees at alarmingly low rates.[1,2,3] This is not surprising, though, given reports of the continued perception of physics as a masculine space[4,5] and the discrimination faced by People of Color and women within the field.[6,7,8] To realize the vision of an equitable physics education, fully open to marginalized groups, teachers need ways of seeing equity as something that is concrete and actionable on an everyday basis. In our work with teachers, they have found value in intentionally reflecting on their teaching and their students explicitly in terms of race, gender, and other social markers. We find they are then better positioned to build equitable physics classrooms. Without a focus on specific social markers, it can be easy to run into common obstacles like color-evasiveness, which obstructs the pursuit of equity in classrooms.[9]

In this article, we present a three-step process involving a classroom observation tool called EQUIP (https://www.equip.ninja/), which teachers can use to identify and attenuate patterns of inequity. We begin by describing EQUIP and how its design supports physics teachers to think about equity in terms of social marker patterns in typical teaching and learning situations. Then, we illustrate how our partner teachers used EQUIP in action research, as they sought to build equitable spaces for collaborative learning in computation-based high school physics.

EQUIP: Equity QUantified In Participation

EQUIP is a free open source web app which provides teachers with quantitative data on equity patterns during classroom interactions.[10] There are various ways to conceptualize "equity." EQUIP is designed to focus on equity in terms of students' participation, both their actual participation and their opportunities to participate in the learning process. Participation in scientific discourse is crucial to learning[11,12] and is important for both the contributor and other participants. Per the Diversity Statement of the American Institute of Physics, "diverse perspectives lead to better solutions to problems, better decision-making, and better outcomes." EQUIP breaks down participation opportunities by both social marker and individual students and can be categorized by both their quantity (i.e., number of contributions during an interaction) and quality (e.g., fact/recall, explanation).[11] This allows the teacher to analyze how these opportunities get distributed in a classroom. For example, teachers can see if a particular student is dominating a discussion or if emergent multilingual students are not getting opportunities to contribute toward rich scientific explanations (Figures 1a and 1b).

[Insert Figures 1a and 1b here]

EQUIP is customizable. This means that teachers can configure EQUIP to analyze equity patterns unique to their classrooms and school contexts. This is done in two ways. First, social markers (e.g., gender, race, SES) are customizable. Because no two student rosters are exactly the same, teachers can input the social markers relevant to their students. For instance, some classrooms may have less economic diversity, but greater linguistic diversity. Also, some classrooms may have greater gender diversity, in which case teachers may want to incorporate additional gender categories for students beyond the typical gender binary.

Second, EQUIP is customizable in terms of "discourse dimensions," which are those qualitative aspects of classroom discourse that teachers think matter for their students' learning. Teachers commonly track the kinds of questions they ask different students and the quality of students' responses. However, they might also be interested in more subtle things, such as students' level of enthusiasm or the presence of microaggressions. Again, teachers decide which discourse dimensions to track and configure EQUIP accordingly.

Typically, teachers use EQUIP to code video recordings of classroom interactions (e.g., whole group discussion, small group discussions) or have a coach or friendly colleague use EQUIP in real-time while watching them teach. EQUIP itself does not record or store classroom audio or video recordings. For each student contribution during a discussion, the observer codes their participation in the EQUIP web app. Over time, participation data accrues, which can then be analyzed through EQUIP's multiple data visualization platforms. We encourage teachers to remember that these quantitative data are best used in conjunction with qualitative data on equity and inequity, such as minoritized students' subjective experiences in classrooms. In other words, it is also important that students *feel* that they have fair opportunities to participate.

Our Context: Integrating Computation into High School Physics

To illustrate how teachers can use EQUIP to improve their practice, we describe a project involving high school physics teachers from Michigan. Our team supported partner teachers to develop and implement new computation-based physics activities. This was inspired in part by the NGSS, which recognize "computational thinking" as a key scientific practice. Building lessons on topics ranging from spring oscillation to projectile motion, teachers incorporated opportunities for students to create visual models of physical phenomena using GlowScript, a programming environment for creating simulations. Equity was a key focus of our joint work, since research shows that access to computation in the U.S. remains inequitable.[14,15]. Collectively, we agreed that the project would only succeed if students from minoritized groups also gained access to the computational activities, as opposed to only students from historically dominant groups in science.

Nine physics teachers participated in the project during the 2018-2019 school year. All nine teachers identified as White; six identified as men and three as women. Since the computation-based activities were organized around group work, we video recorded two small groups (i.e., 2-4 students) per classroom, selected based on parental consent and those that included students from minoritized social marker groups, particularly girls and students of color. Teachers then used EQUIP to analyze the participation patterns.

Teachers used an action research model throughout the project. After video data were collected and analyzed in EQUIP, teachers would meet with the research team to debrief and reflect on their data. This also became a space for teachers to work in community with their colleagues to think about how to change their teaching to make their classrooms more equitable, specifically in terms of providing more opportunities for minoritized students to participate. Teachers conducted this action research cycle several times during the school year.

In the remainder of this article, we present our partner teachers' work with EQUIP in the form of three basic steps for any physics teacher to follow: 1) customizing EQUIP to your classroom; 2) interpreting EQUIP data and setting equity goals; and 3) making an action plan. We also discuss some of the questions and issues that came up with teachers, as well as some tips for doing this kind of equity work.

Step 1: Customizing EQUIP to Your Classroom

To support teachers in thinking about which social markers to track, our team asked: *What kinds of hierarchies exist in your building/district and in your classroom*? We wanted teachers to consider inequity in terms of social markers that were locally relevant. Each teacher decided to track several social markers. As Figure 3 shows, race and gender were most common. However, teachers also tracked less traditional markers. For example, one teacher worried that students with more programming experience would be seen as more competent, thereby securing more participation opportunities during the computational activities. Another teacher, teaching at a Catholic school, noticed a religious hierarchy at his school, that non-Catholic students were falsely considered less competent than Catholic students. This prompted the teacher to track "religious affiliation."

[Insert Figure 2]

With respect to discourse dimensions, most teachers found "content of student talk" (computation/coding; physics; off-topic) and "type of student talk" (question; explanation; other) helpful and informative. Initially, some teachers tracked other discourse dimensions like "attitude" (positive; negative; neutral) and "participation type" (active; passive). However, they quickly realized that these were hard to distinguish and subsequently code based on video, and consequently did not provide meaningful or actionable data. Another early mistake—perhaps out of overzealousness—was tracking *too many* discourse dimensions at the same time. Teachers found that this made EQUIP observations complicated and time-consuming with little additional gain.

Tips

- Link the social markers you track to specific inequities happening at your school
- Identify fewer, less ambiguous discourse dimensions—especially when first using EQUIP

Step 2: Interpreting EQUIP Data and Setting Equity Goals

EQUIP provides quantitative information on classroom interactions, but the numbers are subject to our interpretations. Therefore, it is important to think carefully about how and why we interpret in/equity patterns the way we do.

To illustrate, consider sample data from a small group of four students: Jalen (Black), Kristy (White), Lequoia (Native), and Monet (Black). Figure 4 shows EQUIP data from two different observations of this group, specifically how explanation-level talk was distributed by race. In both observations, participation is unequal, as Jalen clearly dominated both group sessions. How could these patterns be interpreted?

[Insert Figure 3]

For some of our partner teachers, these kinds of patterns were problematic. They sought *equality* of participation as a goal: 25% for each student, regardless of students' social markers. However, other teachers found such patterns equitable, since the student dominating was a Black young man—a historically marginalized group in science education. From this point of view, quantitative inequality is not considered problematic, but rather can be interpreted as equitable in this case.

The fact that the two girls of color (Lequoia and Monet) participated the least is also noteworthy. Some teachers might interpret this as evidence of individual traits (i.e., shyness or "just a quiet kid") or take a deficit view that they were not as capable as Kristy and Jalen. However, we tried to bring awareness to the influence teachers have on student interactions, through pedagogical structures and classroom norms[16], even during small group work when students are generally seen as navigating social interactions more independently. Debriefs with teachers also opened conversations about how racism, sexism, and other oppressive forces might help to interpret the data.

Tips

- When setting equity goals, account for students' social markers and distinguish "equity" from "equality."

- Avoid over-individualized interpretations of EQUIP data; instead, consider the impact of pedagogical structures/norms and social marker-related biases and oppressive forces (e.g., racism, sexism).

Step 3: Making an Action Plan

After interpreting and reflecting on their EQUIP data and classroom video, our partner teachers engaged in collective discussion with each other and with our team about how to address inequities. This involved making an action plan with concrete changes for teachers' classrooms and how they structured group work. Before that, though, teachers need to recognize that they have power to influence group work interactions, not just whole-class discussions.

Teachers came up with a number of ways that might attenuate inequity in group work. For example, they discussed assigning specific roles to group members, or physically positioning some students closer to the laptop where they could be less easily ignored by peers. Teachers also grappled with the number of students to put in a group and the number of laptops to give a group, although the availability of technological resources poses its own equity dilemmas.

We do not offer these ideas about group work as "best practices." There are no panaceas to inequity. What matters is the collective process of generating pedagogical moves and iteratively testing them over time. Teachers kept a running Google doc where they documented and revised their action plans over multiple iterations of action research.

Tips

- Embrace your power as a teacher to shape equity patterns in your classroom.
- Commit to executing your action plan and revising it over time.

Conclusion

Inequity must be an urgent, everyday concern in physics education. All physics teachers can make equity work concrete and actionable by actively monitoring equity patterns in their classrooms. Tools like EQUIP can play a role in this work. We acknowledge that all students should have opportunities to participate in rigorous physics learning, but we caution educators to always reflect on who is prioritized and who is erased when we are not actively attending to students from marginalized groups. When we understand our students and our teaching explicitly in terms of social markers, we stand a better chance of building equitable classrooms for minoritized students.

Acknowledgement

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Figure 1a. Sample EQUIP graph: heatmap showing individual student participation.

Figure 1b. Sample EQUIP graph: type of teacher question distributed by language proficiency categories.

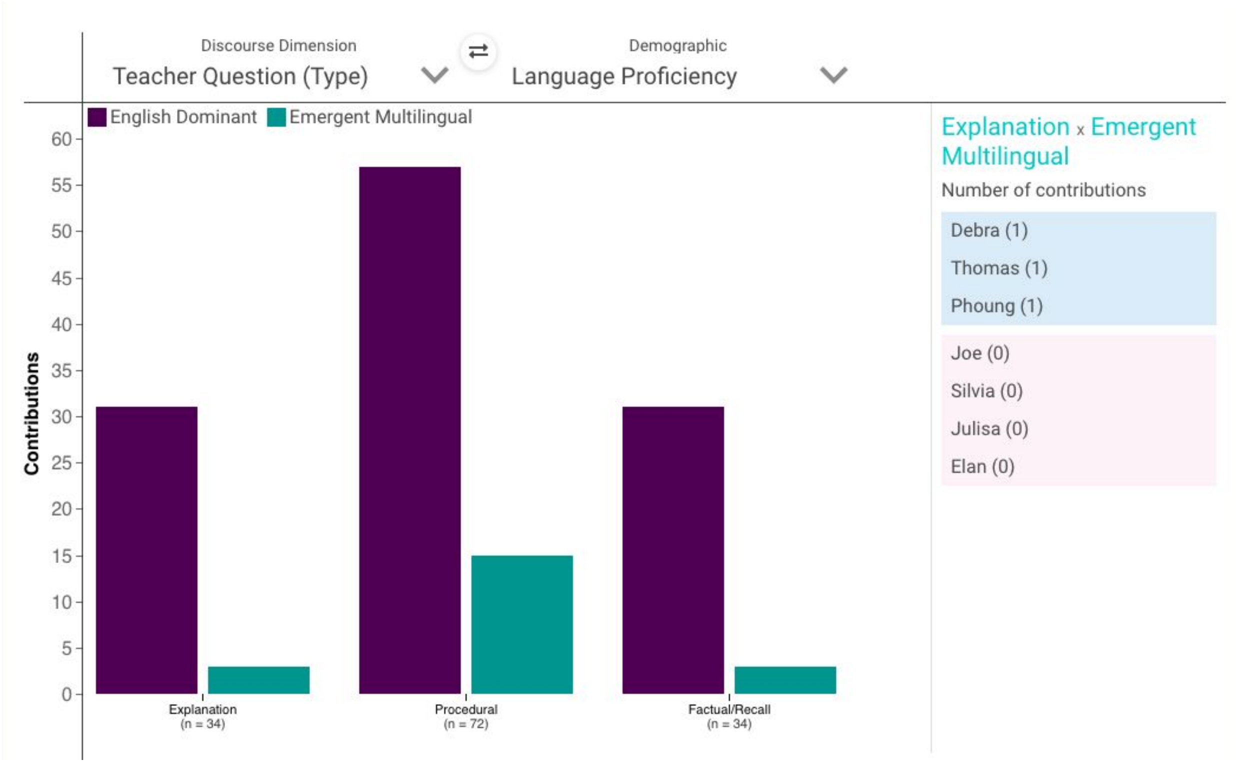

Figure 2. Social markers tracked by high school physics teachers.

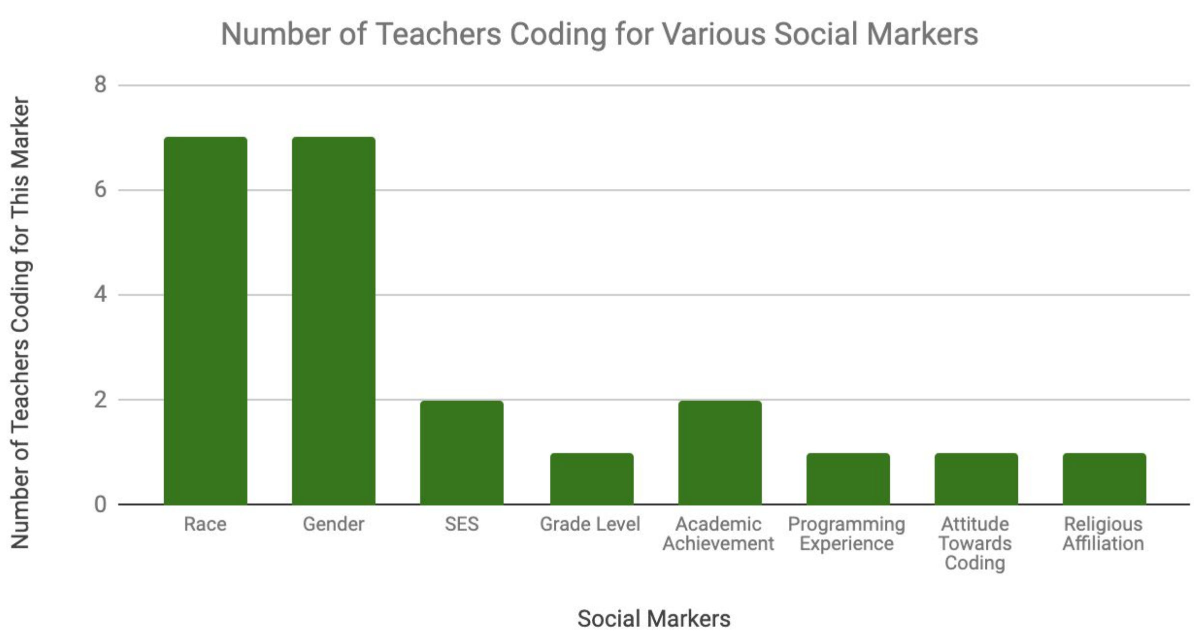

Figure 3. Sample EQUIP group work analytics.