Teaching Toward Equity: The Role of Student Conceptions in Physics Instruction

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Many students are affected by inequities in physics education, partly due to instructional norms that prioritize abstract, decontextualized knowledge over students' lived experiences. While equity-intended reforms have called for more inclusive practices, there is limited research about how physics teachers' conceptions of their students shape their approach to equitable instruction. This study investigated how twenty-five secondary and postsecondary physics teachers conceptualize their students' abilities, needs, and how these perceptions influence their pedagogical choices. Drawing on the Physics Teacher Identity Framework [5], we focus on the "conceptions of others" dimension to examine how teachers position students within the classroom. Semi-structured interviews were conducted and thematically analyzed to identify patterns in how teachers interpret students' engagement, motivations, and challenges. Findings reveal that teachers frequently acknowledge the impact of structural barriers, struggles with executive functioning, and emotional factors on student learning. Teachers with more nuanced, student-centered conceptions emphasized differentiated support, relevance to students' goals, and hands-on, phenomenon-based instruction. These views contrast with deficit-oriented perspectives that reduce student difficulties to a lack of effort or ability. Our analysis suggests that physics teachers' conceptions of students are critical to their approach towards enacting equitable practices. Teachers who hold asset-aligned perspectives and view students as capable and complex learners are more likely to adopt inclusive strategies that center emotional support, scaffolding, and culturally relevant pedagogy. This study highlights the significance of addressing teacher beliefs in professional learning and physics education reform initiatives. Implications for developing equity-focused instructional approaches and teacher preparation programs are discussed.

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I. INTRODUCTION

Physics education has historically faced inequities, with marginalized students encountering barriers to access, engagement, and success [1]. Some of these barriers include the cultural irrelevance of the curriculum, negative stereotypes and low expectations, tracking, and underrepresentation [2]. Despite growing efforts toward equity and inclusion, such as professional development for teachers and access and representation initiatives, physics classrooms often prioritize abstract, decontextualized knowledge over students' experiences. These instructional norms are shaped by institutional systems, curriculum structures, and, importantly, teachers' conceptions of students' abilities, backgrounds, and ways of knowing [24].

Teachers' conceptions of students significantly influence classroom environments, pedagogy, and opportunities for engagement [3]. While research has examined how teacher identity influences instruction [4,5], less is known about how physics teachers conceptualize their students in relation to "equitable instruction". We define equitable instruction as teachers' ability to create an environment where *all* students feel a sense of belonging, are engaged and challenged, and have agency in their learning. Questions that have yet to be explored are: How do physics teachers perceive students' cultural and intellectual resources? What assumptions underlie physics teachers' expectations for students' participation and learning? How do these views influence physics teachers' instruction, assessment, and equity-focused practices?

This study employed thematic analysis to analyze physics teachers' interview transcripts on their positioning of students, aiming to understand its impact on equitable instruction.

II. LITERATURE REVIEW

Physics education has long prioritized abstract problem-solving, decontextualized knowledge, and rigid disciplinary norms [6]. This contributes to excluding culturally diverse physics students, who often encounter deficit-based narratives about their abilities and belonging [7,8]. While research has emphasized the need for more culturally responsive instruction in physics education [9, 10], less attention has been given to how teachers' conceptions of students influence their approach toward teaching.

A. Teachers' Conceptions of Students and Their Impact on Instruction

Teachers' cultural conceptions about students' abilities and ways of knowing shape classroom dynamics [11]. Their implicit and explicit assumptions influence how teachers facilitate classroom discussions, engage with students, and assess them [12]. In physics, where narrow definitions of intelligence can dominate the classroom [13, 14], these conceptions can either reinforce exclusion or create broader opportunities for engagement.

Research shows teachers often have higher expectations for students who fit stereotyped norms of academic success or match teacher demographics [14,15]. In physics, where the majority of instructors are white men [15], this can mean that students who are similarly represented are deemed by teachers as being naturally suited to the discipline. In contrast, women and students of color must prove their competence. These perceptions and expectations shape access to rigorous content, mentorship, and participation norms [16].

B. Cultural and Epistemic Positioning in Physics Classrooms

Growing research in science and physics education suggests that students bring diverse cultural and epistemic resources into their learning that are often overlooked [9, 17]. Studies on funds of knowledge [18, 25] and community cultural wealth [19] show that students from non-dominant backgrounds possess rich knowledge that can contribute to their learning. However, teachers often frame these resources as irrelevant or non-scientific, reinforcing exclusionary barriers [26].

Research has shown how students' sense of belonging and identity in physics is shaped by how teachers position them within the classroom [7]. When teachers value students' lived experiences as learning assets, students are more likely to see themselves as capable learners [18]. In physics, teachers and students from nondominant backgrounds (i.e., women, students of color) experience the need to reject their non-conforming cultural identities to fit into the physics space [21].

C. Shifting Teachers' Conceptions Toward Equity

Research indicates that professional learning centered on critical reflection and student narratives can help teachers reframe their perceptions of students. Lasting change requires sustained engagement with students' cultural and intellectual resources, not just one-time interventions [22].

This study builds on the work by examining how physics teachers' conceptions of students shape their instructional decisions. Through analyzing teacher interviews, we explore physics teachers' perceptions of students in the classroom and how these conceptions influence their approach toward equitable instruction in the physics classroom.

III. RESEARCH QUESTION

Our study examines 25 physics teachers' conceptions of others (students) across secondary and post-secondary institutions. Our research question is: *What are physics*

teachers' conceptions of their students and their influence on equitable teaching approaches?

IV. THEORETICAL FRAMEWORK

To explore physics teachers' conceptions of their students' identity in relation to equitable instruction, we employ a new framework called the *Physics Teacher Identity Framework* [5], which consists of four key components:

1. *Conceptions of Self* – How teachers perceive their own identity, beliefs, and role in the classroom.
2. *Conceptions of Others* – How teachers perceive their students, including their abilities, backgrounds, and learning needs.
3. *Conceptions of Knowledge* – How teachers view the subject matter they teach and its accessibility to students.
4. *Conceptions of Pedagogy* – How teachers understand and implement instructional strategies to facilitate learning.

Playing a distinct yet interconnected role, each conception influences a teacher's identity and approach to equitable instruction. This study focuses on physics teachers' conceptions of others, namely their students.

V. METHODS

Twenty-five physics teachers were selected from a pool of 250 to participate in our study, based on diversity among various factors, including years of teaching experience, race, gender, and geographic location. Each participant participated in a semi-structured interview guided by a protocol designed to explore their conceptions of self, others, knowledge, and pedagogy. For this study, we focus specifically on teachers' responses related to their conceptions of others.

All interviews were audio- and video-recorded and transcribed. Interview durations ranged from approximately 20 to 60 minutes, depending on the length and depth of the participants' responses.

Researchers used Dedoose qualitative analysis software to deductively code all interview transcripts using the Physics Teacher Identity Framework [5]. We then excerpted all "Conceptions of Others" codes, inductively coding them to identify broad thematic categories. We created a code book with themes, definitions, and examples of codes, which was used to iteratively code and refine specific themes and subthemes. Coding was carried out collaboratively by multiple researchers (the authors), who met regularly to ensure consistency and resolve discrepancies through discussion.

VI. FINDINGS

We highlight the major themes that emerged across the coded interviews. Each theme below describes the conception teachers hold of their students, along with correlating equitable teaching practices. We share excerpts of interviews to better illustrate nuances in each theme. All teachers' names are pseudonyms. Five major themes emerged from our analysis: 1) students' experiences with challenges outside of school result in teacher flexibility and empathy; 2) students' fear and anxiety around physics leads to teacher empathy and fostering resilience; 3) students' diverse learning needs, interests, and cultures, leads to teacher differentiation and cultural relevance; 4) students' diverse goals for learning leads to a focus on relevance and foundational learning; and 5) students being positioned as capable, curious, and knowledge creators leads to teachers using inquiry based, student-centered teaching and making space for students' epistemic agency.

A. Challenges Lead to Flexibility and Empathy

Teachers often conceptualized students as whole humans with outside challenges and obstacles, such as socioeconomic status, family illness and death, drugs, and other challenges, creating inequitable learning outcomes in the classroom. This conception of students led to teachers having empathy for students and being flexible with assignments and grading. For example, physics teachers Raya and Noelle note that many of their students face external challenges that interfere with their academic work:

> **Raya:** "There were definitely some students who are struggling with outside factors… I think there was a kid who's struggling with drug addiction, for example, and it's just unfortunate, not a lot I can do about that. There were a couple of students who I think were also dealing with family issues. They had some people who had deaths in the family to cope with, and also things like relationship issues with their own peer relationships, that I think really affected their ability to concentrate and to turn in work."
>
> **Noelle:** "There's something going on that's preventing [some students] from doing what they should be doing, and maybe it's not my business to find out. But I know that there's something. [...] Very often it's not just that they lack discipline or lack value in the educational process."

These quotes exemplify a theme in the data that recognizes how students' challenges at home influence their success in the classroom, and that misbehavior or disengagement may not be the root of perceived behaviors. Other teachers discuss dire challenges -- parents taking their own lives, family members being killed, Covid, and other outside challenges. This conception of students results in teachers being empathetic and flexible, particularly around assignments and grading. Raya's conceptions of students imply that her instructional approach gives students more flexibility in assignment deadlines, and Noelle later discusses allowing students to retake assessments.

B. Fear and Anxiety Lead to Empathy and Fostering Resilience

Teachers frequently discussed the importance of developing student resilience and a growth mindset. Many teachers noted the stereotype that physics is difficult and recognized that their students found physics intimidating, which led to anxiety and affected their performance. Underlying these conceptions of students is a recognition that not all students feel a sense of belonging in a physics classroom. For example, physics teacher Thia shares about student anxiety and fatigue.

> **Thia**: "What I find with physics, and especially AP physics, is I'm dealing with a lot of [student] anxiety, my first couple of weeks in physics, is trying to just calm everybody down. 'It's okay. Yes, it's hard. We're going to get through it. I'm going to help you.' [...] I have some students who've already taken five AP tests in the course of two weeks. So this testing puts fatigue [on students, who become] really, really tired. [...] It's part of a mindset thing."
>
> **Khary:** "I think it's just a lack of resilience, they [are] fatigued. I especially notice that with the pandemic just like the fatigue to dig deep to do something sustained. [...] So executive functioning for my age group, anyway, seems to be the Achilles Heel of kids who are capable, but just cannot get their act together."

The lack of executive functioning skills and intimidation surrounding physics were mentioned throughout the teachers' responses. Many teachers responded to this consideration of students with empathy and an interest in fostering students' growth mindsets and resilience. In discussing students' struggles, Lou stated, "I feel that [students] should be a little bit uncomfortable anyway, just in learning, or else you don't learn." The need to improve academic skills through resilience in failure was a common thread in teacher responses. Some teachers, such as Thia, adopt a particularly responsive and supportive view, actively seeking to mitigate student anxiety and reduce psychological barriers. This pedagogical approach is informed by recognizing that students need emotional and psychological support in addition to academic support.

C. Diverse Needs, Interests, and Cultures Lead to Differentiation and Cultural Relevance

Teachers stress the importance of tailoring support to meet the varied needs of students. Thrin stated, "I'm not naive enough to realize that if I just do one thing and only one way that everybody's going to learn the same amount, because everybody's different." This theme was strongly echoed across many of the teachers interviewed. Timothy recounted the inequity in students trying to make sense of physics in contexts they are not familiar with.

> **Timothy:** "I think [it's important to] really take into account the experiences of the students, and looking in from the student's point of view in the student's eyes. What are they going to really understand? If you're introducing this concept to them, you know, making it relatable to them, making sure that they are a part of the lesson in that way, because, if not, you're going to lose them from the start because they don't understand the situation at all."

Other teachers discussed providing students with the specific support they need, such as scaffolding or additional time, to ensure equitable outcomes.

> **Thia:** "with equity, you think everybody gets the same [things]. But oftentimes, it's realizing what students need and trying to give them the scaffolding they need. [...] What are the scaffolds? Is it extra time? Is it the extra remediation? You know, going back, grabbing something out of your closet, and doing another demonstration."

Thia's quote indicates an equity-oriented conception of her students. Aside from two responses, most teachers rejected a one-size-fits-all approach to teaching. The response to an acknowledgement of different student needs was to provide different supports and strategies. Despite different starting points, teachers also mentioned holding students to the same level of performance.

D. Diverse Goals Lead to a Focus on Relevance

Teachers frequently observed varying levels of student motivation and engagement with the material. Luke emphasizes meeting students "where they are" and acknowledges that many students may not become physicists or engineers but need basic knowledge.

> **Luke**: "I recognize that most of those students aren't destined to become physicists and engineers because it's not what they want to do. And so trying to kind of find them there. You know where they're at, and try to help them get the base knowledge they need for their future careers."

Luke's quote is echoed by other teachers who recognize that not all students are going to be going into the STEM profession, technical skills may be more relevant than conceptual understanding for some, and for others, grades are of the utmost importance. Ben mentioned that some students are satisfied with a passing grade just to progress in their studies, while others are more grade-conscious.

> **Ben:** "Some of the students are happy with a C because that allows them to progress to their studies [...] once they become an engineer, their grades don't matter anymore. They instantly disappear. So C+/C is just fine in physics, whereas others are much more grade-conscious, and that's like in the same class, people that are basically on the same train."

Ben's statement implies that he sees students as strategically navigating the system, particularly those who are aiming for engineering careers. Ben's comment that grades "disappear" after graduation implies an awareness

of the limits of the school metrics. He may view some academic expectations as misaligned with real-world engineering success. Sherry re-frames low motivation by considering why some of her students go to school

> **Sherry**: “School’s a place you just have to survive, because the government makes you go there every day to keep you off the streets, right? When I ask my students, ‘Why do you go to school?’ they would say, ‘Either my parents make me, or the government wants to keep us off the streets.’”

Recognizing that students’ purposes for being in a physics class differ widely helps teachers respond to low motivation and engagement with an asset-based and self-reflective approach. Teachers who consider the different reasons students are in their class respond to low motivation and engagement with a need to make physics relevant and to provide foundational skills that can help students move toward their future goals. When teachers acknowledge that most students are not planning to become physicists, it allows an asset-aligned reason for lower engagement. Teachers also express interest in making the curriculum relevant to students, both academically and personally. This suggests a responsive approach that values students' current context, goals, and motivations. Lastly, teachers have a functional view of physics education, recognizing it is often a stepping stone for future careers.

E. Capability and Curiosity Lead to an Inquiry-Based Approach

Teachers recognize the value of engaging students through hands-on learning, group work, and practical tasks. This practice is connected to teachers’ conceptions of students as capable, curious, and able to be knowledge creators in the classroom. Khary’s practices of having her students lead professional development for teachers and create their own physics libraries position her students as capable knowledge creators. Sheldon and Timothy mention using interactive activities to engage students and help them enjoy the learning process.

> **Timothy:** "I think students do well in my class. I think that they have fun, and they are engaged in the learning because of different activities we do in class. I've seen them really experience science through their experiences and through the phenomenon that we present, and the questions that we try to answer within our class."

Timothy's quote reflects a student-centered and experiential conception of learning. Similar to other teachers’ responses, this view of students implies a conception of students as capable and curious learners who benefit from active, inquiry-based instruction. These conceptions align well with an ambitious science teaching approach, or other phenomenon-centered practices where students learn science through their own experiences and by grappling with phenomena and questions. This also suggests that teachers in this study value authentic, real-world learning and recognize students' lived experiences as imperative to learning science.

VII. CONCLUSION AND DISCUSSION

The findings of this study illustrate that physics teachers developed nuanced conceptions of their students that extended beyond academic ability. Teachers recognized the interplay between cognitive skills, cultural, personal, and socioeconomic backgrounds, which influences student engagement and success in physics classrooms. Through the themes identified, student diversity, external challenges, executive functioning struggles, mindset and resilience, equity in support, and learning strategies, the teachers revealed their efforts to create responsive and equitable learning environments. Their conceptions suggest that effective physics instruction requires an understanding of students' lived experiences and a commitment to fostering both academic and personal growth.

The teachers' conceptions highlight a shift from deficit-based thinking to asset-based approaches in physics education. Rather than attributing students' struggles solely to a lack of intelligence or motivation, teachers should acknowledge systemic and personal barriers, such as economic disparities and external stress. This perspective aligns with research on culturally relevant pedagogy, emphasizing that recognizing students’ backgrounds can inform equitable instructional strategies [11].

Furthermore, teachers emphasize the importance of a growth mindset and resilience in overcoming the perceived difficulty of physics. This is consistent with Dweck’s [23] work, which shows that students who view intelligence as malleable are more likely to persist through challenges. By normalizing struggle and fostering productive failure, teachers help students build problem-solving capabilities.

A key challenge from these findings is the need for individualized support structures. Teachers recognize that equal treatment does not guarantee equal outcomes. Therefore, differential instruction is crucial. However, most teachers struggled to name how they could teach physics in ways that were culturally responsive. The acknowledgment that students have varied motivations, ranging from certain academic aspirations to minimal investment in physics, supports the argument for more student-centered learning approaches that tailor instruction to diverse needs.

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