Towards Meaningful Physics Recognition: What does this recognition actually look like?

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Towards Meaningful Physics Recognition: What does this recognition actually look like?

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In the February 2017 issue of *The Physics Teacher,* an article was presented that highlighted the importance of high school physics teachers in inspiring women in physics, particularly by recognizing them as being a "physics person."[1] Drawing on data from over 900 female undergraduates in physics, the article showed that the largest fraction became interested in physics careers during high school. In particular, being recognized by their physics teacher substantially increased the odds of their planning physics careers by the beginning of college. Since this article was published, questions have been directed toward us from physics teachers regarding the nature of recognition, e.g., how do we recognize a student meaningfully and what does recognition look like in the classroom? For example, one teacher wrote saying:

> I specifically wanted to tell you how much I appreciated this: …your closing note that not all recognition is meaningful, and that the key is high expectations for all and recognition of when [expectations are] met...I wrote in my margins on the page before, *"What does this recognition actually look like?"*

Given this candid feedback from teachers, the current article examines recognition a little further by presenting the case of a physics teacher, Dr. D, and his student, Kristina, to address the question: What are the ways in which a young woman perceives recognition from her teacher? We begin by providing some background for the theoretical framework (recognition as it relates to physics identity) and justifying why Dr. D and Kristina provide a relevant case to examine. The way in which Kristina feels recognized by Dr. D's actions is then presented in more detail.

Recognition in physics

Many students suffer from depressed attitudes and disinterest when studying physics.[2-4] Thus, it is important to identify and understand the ways in which we can scaffold students not only cognitively, but also affectively (emotionally) while learning physics, especially since affect (emotion) is closely related to persistence.[5] In particular, we employ a physics identity framework when studying affect because it allows us to explore what is meaningful to students for themselves. The conceptualization of physics identity includes whether students feel capable, their interest, and how recognized they feel in physics.[5]

While recognition by others is one part of identity development in a discipline, the centrality of recognition to identity development is clear in the literature.[5-9] As Gee[8] points out, identity can be formulated with respect to being "recognized as a 'certain kind of person.'" This includes perceived recognition by others (e.g., by teachers, peers, and parents), which can translate into self-recognition as a certain "kind of person."[5, 7] In other words, if a student perceives that others are recognizing her as a "physics person," she begins to see herself as a "physics person" also.

One complexity in studying recognition is that perceiving acts of recognition vary from individual to individual. For example, what one student may view as a teacher recognizing her as a "physics person," another student may pass off as an event not related to recognition. The latter case may apply more often to women in physics since they are significantly less likely to feel recognized[10] and are less likely to attribute successes to their own abilities.[11]

Methodology: The case of Dr. D and Kristina

The data were drawn from the classes of four experienced high school physics teachers (13-28 years teaching) in 2011. The four teachers were selected as part of a broader study on students' physics identity development.[12] Mr. B taught at a medium-sized public school (1000-2000 students) in the southeastern United States. Dr. D taught at a large public school (more than 2000 students) in the southern United States. Dr. P taught at a small private school (less than 1000 students) in the northeastern United States. Mr. S taught at a medium-sized public chool in the southeastern United States.

Data collected included video recordings (one week, two to three classes per day, subsequent video recorded by teachers); field notes from two observers over one week of observation; two interviews with each teacher (during the week of observation and after the course ended); teacher surveys (background and practices; information about students and student interactions); student surveys (background, physics experiences, and physics identity); student grades; and interviews with students. Survey data were collected from 34 of Mr. B's students, 28 of Dr. D's, 31 of Dr. P's, and 53 of Mr. S's. Interviews were conducted with 29 of these students, seven to eight per teacher, of whom Kristina was one in Dr. D's class. Note that names mentioned are pseudonyms that mask the identity of participants. Quantitative student survey data and teacher survey data from all four classrooms were used to analyze differences in student and teacher perceptions of

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students being a "physics person." In describing Kristina as a case study, interview and observation data were used from Dr. D's classroom.

Why focus on Dr. D? As part of the surveys, we asked students to respond to a six-point anchored scale item asking, "Does your physics teacher see you as a physics person?"with 0 being "No, not at all" and 5 being "Yes, very much." For each of the students in their classes, we asked the physics teachers to respond to a similar item,"Would you consider this student to be a physics person?" with 0 being "No, not at all" and 5 being "Yes, very much." Figure 1 displays the means of the responses for each of the teachers. The pattern is clear for three of the teachers; the teachers rate their students higher than their students rate their perceived recognition by the teacher. In the case of Dr. D, however, the students perceive recognition from Dr. D more than he, on average, rates them.

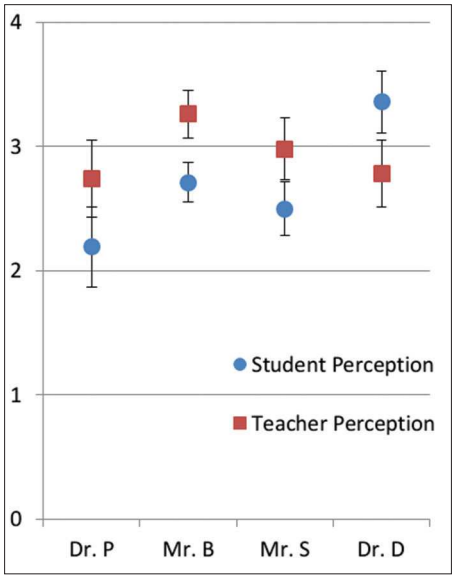

Fig. 1. Means (±SE) for the four teachers on their perceptions of students being a "physics person" and their students' perceptions of teacher recognition as a "physics person."

In order to determine whether the patterns observed were significantly different across teachers and not dependent on the achievement or interest of the students, we built regression models predicting student/teacher perceptions that compared the teachers and controlled for students' physics achievement and science interest in physics. The results are summarized in Table I. We found that Dr. D was not significantly different from the other teachers in terms of his perceptions of his students, even after controlling for student interest and achievement, both of which might influence teachers' perceptions of whether they see their students as a physics person. This is shown in Table I under the "Teacher Perception" column where "Sig" is noted to be "ns" or not significantly different. However, Dr. D's students had significantly higher perceptions of his recognition of them than did the students of the other teachers, which is shown in the "Student Perception" column in Table I where "Sig" is noted to be significant at the level $p<0.01$ or $p<0.001$ (** or ***) when comparing Dr. D with Dr. P, Mr. B, and Mr. S. This is important because students' perceptions that their teacher saw them as a physics person was strongly correlated ($r=0.82$, $n=145$, $p<0.001$) to their self-recognition of being a physics person (i.e., "I see myself as a physics person") – more correlated than the teachers' perception itself or any other variable we measured. In addition, Dr. D's students were also significantly higher in their self-recognition than the students of the other teachers.[12] Thus, despite his beliefs about them, it is likely that Dr. D was better at helping his students feel recognized and identify with physics.

Why focus on Kristina? Kristina is a Hispanic female (self-identified) who was planning to pursue a career in the health sciences, specifically to be a physician's assistant. When we initially interviewed Dr. D for suggestions on which students were not a physics person (during the process of selecting students for interviews), he repeatedly gave us Kristina's name. During our classroom observations, Kristina appeared to be relatively disinterested in the class, sitting toward the back, not appearing to pay much attention, looking frustrated when working on problems, sometimes putting her head down on the desk, and working alone when other students were working together on problems. Note that the latter was not because she did not have friends in the class —she worked with others outside of class as well as with her boyfriend, who was also in the class.

Explicating a little on Dr. D's character, he was described by one student as an "observer" of his students. If Dr. D was basing his assessment of Kristina on his observations of her behavior, then her actions in class would clearly make her seem more reticent to learning physics as compared to other students. In addition, Kristina's grades in the class were average (C's), and the students who Dr. D saw as a physics person had higher grades. Thus, *based on observed behavior and grades*, it is not surprising that Dr. D did not see Kristina as a physics person. Although Dr. D did not change his view of Kristina after the school year was over (even though she had

Table I. Regressions comparing Dr. D to other teachers on students' perceptions of teacher recognition and teacher's recognition of students (with controls for students' prior science interest and physics grades).

	Student Perception			*Teacher Perception*		
Predictor	**Estimate**	**Std. Error**	**Sig.**	**Estimate**	**Std. Error**	**Sig.**
Intercept	-2.79	1.14	*	-5.39	1.27	***
Controls						
Science Interest	0.42	0.07	***	0.23	0.08	**
Physics grades	0.05	0.01	***	0.09	0.01	***
Teacher (as compared to Dr. D)						
Dr. P	-1.13	0.34	**	-0.32	0.38	ns
Mr. B	-1.02	0.36	**	-0.34	0.40	ns
Mr. S	-1.15	0.32	***	-0.40	0.35	ns
Adjusted R^2	0.28			0.23		

ns = not significant, * $p<0.05$, ** $p<0.01$, *** $p<0.001$

passed the AP exam, which he was surprised about), he did speak of her in somewhat contradictory terms, saying "she's confident" and a few seconds later that she needed "a boost to her confidence." This may be an indication that he had trouble understanding her, which may have been why he called her an "interesting case." Despite his perception of her (he rated Kristina a 1 on the 0 to 5 scale mentioned above), Kristina felt that he saw her as a physics person (she marked a 5 for whether he saw her as a physics person). Thus, the way in which Kristina felt recognized does pose an interesting case in how a teacher can make a student feel recognized even if the student may not be exhibiting external behaviors related to having a physics identity.

Results: Kristina's feelings of recognition

Resonating throughout Kristina's interviews was the perception that Dr. D's behavior towards her was the same as his behavior toward the rest of the class, which endorsed her feelings of being recognized (as much as anyone else). She repeatedly articulated Dr. D's ethos in sincerely wanting students to understand physics: "Yeah, like, he wants us to get this stuff and that's what, like, encourages us to do better because, like, we have a teacher who's actually caring and, like, trying to push us to understand these topics." So how did Dr. D's actions communicate this ethos to Kristina? In the following sections, we present four different themes that connect recognition with the classroom behaviors of Dr. D.

Recognition through high expectations and challenge

Kristina described that Dr. D required deep thinking by asking students to take on challenging problems and believing they could master them. For example, Kristina mentioned the challenge in the problems: "It makes you think more because if you have, like, simple problems, well then you're not really going to learn anything so it's better that he challenges us," "And, like, this is just, like, over one topic so it's going to be a lot harder." We also observed this during the class when Dr. D assigned challenging homework problems, saying, "They are both very nice problems and you should give them the attention they deserve, about 30 minutes each," while also affirming that they all could do such problems. Repeatedly, Kristina mentioned Dr. D's approach as his "trying to push us to understand these topics" while trying to "challenge our minds." This sent an implicit message that he recognized the students, including Kristina, as capable of mastering difficult work.

Recognition through devoting resources

Despite giving students challenging tasks, Kristina also described Dr. D as providing her and other students with many resources to accomplish these challenges. These resources included (i) providing many opportunities to ask questions, (ii) providing extra attention/time so no one is left behind, and (iii) creating a class community outside of school. Example evidence of these resources from the qualitative data are:

(i) Opportunities to ask questions: "Um, he always asks us, like, if we understand a thing and he always gives us opportunities to ask questions." This is a resource that was provided to students by Dr. D during class and also before and after school during informal office hours.

(ii) Extra attention: "He works with us more, more, most classes they pretty much just, like, let you go on your own but he does that, too, but he actually works with us and makes us understand it and then he, like, lets us go on our own and challenge our minds and most of the classes they just, like, leave you on your own." During observations of group work, Dr. D repeatedly initiated interactions with Kristina even though she was often working alone.

(ii/iii) Outside of school, extra time: In addition to informal daily office hours where students could ask questions, Dr. D provided even more support prior to a test. Specifically, he asked his students to meet him in the evening at a local coffee shop, a more informal setting, so they could work through practice problems. These sessions were endorsed by parents and were a regular occurrence throughout the year. "I like the way we have [coffee shop study session] today because we all get to work together and whatever I don't understand right now he'll help me with or my students, or like my fellow people will help me, which helps, helps it more better, like, and then we have, like, a few extra days to study so it makes you feel better during the test."

In and of themselves, these resources are not a source of recognition. However, since many of these resources were directly provided by Dr. D and required him to expend time and energy to help Kristina learn, they served as recognition artifacts that endorsed her belief that she could be a "physics person." For example, she commented:

> [H]e's a doctor and he's here. There was [sic] so many other things he could have done, made a lot more money… he [sic] rather work here where he can be with kids who are willing to learn than go off to a college with kids that probably don't even really care about the subject. He'd rather push us more.

The effort that Dr. D made towards helping students learn physics in multiple tangible ways was perceived as an implicit recognition that they could do it. Why else would he put in so much effort?

Recognition through student-centered learning

Dr. D's class was often a platform for recognition opportunities by peers through student-centered learning during which students could serve as leaders in problem solving and

course content generation. For example, he enabled students to direct their own learning while scaffolding them in groups to help one another in solving challenging problems. The challenge made it necessary for students to rely on and ultimately recognize one another. Kristina commented on this by saying: "He's there and, like, you're in your own groups and you have people helping you and then, like, if you still don't understand it he'll come and, like, explain things for you but, like, not give you the answer. He only gives, like, a certain thing that makes you think about it and then you pick it up yourself." Kristina feeling like she could "pick it up" herself showed an emergence of self-recognition. Another female student elaborated on being recognized by peers during these group work sessions: "A student would ask me [a question] and they would ask me, okay, well, how did you understand this way, can you explain it to me in a simpler form? And that—we would exchange ideas." When we observed these problem-solving sessions during class, the students appeared to be empowered to develop their skills while Dr. D was always available for questions, so they did not feel abandoned in this mission.

Often, Dr. D would ensure positive recognition, for example, by looking at students' papers to make sure they calculated the correct answer before cold calling a student for an answer. Kristina also commented on the laboratory portion of the course: "Yes, like, he'll give us labs [we] have to do and stuff like that before we start doing the topics, like, that we get, like, an idea, and we pick it up on our own before we actually learn it and if we have any questions that's how he helps, we help him help us to learn more." In the classroom, we observed Dr. D provide time for students to ask and answer questions, and, in one instance, when answering a question posed by Dr. D, a male student addressed the class in a friendly and confident manner, first saying, "I got this." Dr. D also prompted students to assist in the generation of lecture content by saying things like, "What more do I need to know?" and "What do you think I'm going to ask you next?"For most of these observations, students were encouraged to be active participants in the learning process, but Dr. D. supported them in ways that facilitated success and recognition, and avoided inciting feelings of embarrassment or complete failure.

Recognition through affirmation and responses (explicit recognition)

According to Kristina (and our classroom observations), Dr. D verbally affirmed both his valuing of students' learning physics as well as students' capabilities. For example, Kristina stated, "Yeah, like, he wants us to get this stuff and that's what, like, encourages us to do better because, like, we have a teacher who's actually caring." This type of affirmation, in addition to his other actions, may have expanded the possibility of authoring a physics identity for students. Kristina believed that anyone could be a physics person, stating, "Oh, yeah, all you have to do is set your mind to it in order to be a physics person." This was the ethos Dr. D projected—learning physics could be achieved by anyone really working at it. In addition, we observed, and Kristina reiterated in her interview, Dr. D's patience and uniformity in his responses and questions to students. This served to equalize students. For example, "If we ask a question even if it seems like a dumb question, he'll still end up, like, explaining it so you can understand everything." In addition to his consistency in student treatment, he also attempted to minimize the barrier of the hierarchical student-teacher relationship; for example, when working through a problem in class, Dr. D said, "I want to go through this so that *you're entirely with me.*" This and other teacher positioning cues used by Dr. D and their impact on student engagement and physics identity are described in more detail elsewhere.[12]

Finally, the interviews with Kristina allowed us to shed light on her classroom behavior. She described herself as "super shy" and as having extreme anxiety when answering questions and taking tests ("I get really nervous," "I'll just freeze and totally forget," "I end up going blank"). Furthermore, her working alone was not a sign of her disengagement with physics as is evident in her saying:

> I kind of prefer to work by myself because I'm not going to have someone there with me during a test and the only time I like getting help is if I really, really do not get it, then I'll ask but I really don't like working in groups because I'm not really going to have anybody the big day.

Kristina exemplifies the case of a student who, because of Dr. D's modes of recognition, began to see herself as a physics person despite appearances to the contrary.

Conclusions

Both Dr. D and Kristina based their perceptions of each other on their observations of the other's actions/behaviors—actions that did not necessarily reflect their beliefs. Thus, private beliefs do not always translate into actions (as perceived by others), nor do actions (as perceived by others) necessarily translate into a person's beliefs or, in this case, physics identity. Although Dr. D perceived Kristina in one way based on her actions (he did not see her as a physics person), she felt another way based on her perception of his actions (she believed Dr. D saw her as a physics person). Thus, it is important for teachers to know that regardless of whether they believe a student is a physics person, it is likely that their actions/behaviors are what enable students' physics identity development. Kristina never sensed in any way that Dr. D did not see her as a physics person because his actions spoke the contrary to her.

There are a few important conclusions of this work. First, teachers' actions can speak louder than their private beliefs to enable students' physics identity development. Second, it is likely important for teachers to show both implicit and

explicit forms of recognition in order for students to have the opportunity to internalize this recognition. The forms that we observed in Dr. D's classroom include:

- Having high expectations and providing challenges (e.g., assigning challenging problems with expectations of how much time they will take)
- Devoting resources both inside and outside the class (e.g., formal and informal opportunities to work together and ask questions)
- Optimizing recognition opportunities in student-centered activities (e.g., calling on a student after ensuring that she has figured out a problem, facilitating students relying on each other)
- Affirming capability to meet challenges (e.g., encouraging students to persist in their efforts, framing physics learning as something to work at).

The case of Kristina and Dr. D provides examples of what these forms of recognition concretely "look like" in the classroom. What is clear is the importance of balancing active instances of cognitive challenge with affective (emotional) and behavioral (resource) support both inside and outside the classroom.[12] Finally, in order to understand students' physics identity development, it may be insufficient to observe student behaviors. Students who are shy or anxious may be developing a physics identity (and require this development to be nurtured) even when they appear disengaged. Had we not surveyed and spoken in depth with Kristina, her outward behavior (social performances), both from our perspective and the perspective of Dr. D, may have resulted in a misinterpretation of her actions and an incomplete representation of how she saw herself with respect to physics. Perhaps this is one reason why she surprised others when she passed the AP exam.

Acknowledgments

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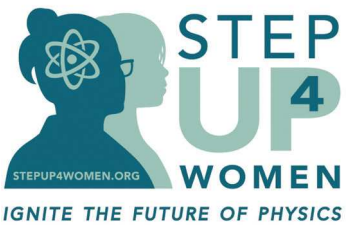

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