A model of the factors influencing teaching identity among life sciences doctoral students

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Abstract
One barrier to the adoption of evidenced-based teaching practices may be that faculty do not see teaching as an important part of their identities as professionals. Graduate school is a key time for professional identity development, and currently we know little about how doctoral students develop identities as college teachers. In this qualitative study, we aim to characterize the factors that promote and hinder teaching identity among 33 life sciences doctoral students with diverse career interests at one research university. We collected data using semi-structured interviews and analyzed it using qualitative analysis closely aligned with grounded theory. Our analysis involved iteratively and collaboratively analyzing interview transcripts while considering existing literature about socialization and professional identity and remaining open to novel ideas in the data. From this analysis, we developed a mechanistic model of the factors that influenced teaching identity in our participants. Independent teaching experiences, teaching professional development, and teaching mentors contributed to salient and stable teaching identities among doctoral students. Being recognized by faculty as a teacher was also important, but rare. The professional culture that doctoral students perceived acted like a blizzard that they had to navigate through to develop a teaching identity. This culture strongly valued research over teaching, resulting in a sometimes cold and isolating environment for students interested in teaching. The culture also made it harder to see existing opportunities for teaching development and made it more challenging to move toward these opportunities, much like the deep snow and driving winds of a blizzard. The mechanistic model described in this work is an important first step in understanding how doctoral training influences teaching identity.
This model serves as a hypothesis that should be tested and refined through additional empirical work across contexts.

**KEYWORDS**
culture of science, graduate students, life sciences, professional development, professional identity, teaching identity

1 | INTRODUCTION

Undergraduate science instructors have been slow to adopt evidence-based instructional practices (National Research Council, 2012). Among instructors who make attempts to adopt these practices, many abandon their efforts or implement the practices ineffectively (Andrews, Leonard, Colgrove, & Kalinowski, 2011; Henderson, Dancy, & Niewiadomska-Bugaj, 2012). Thus, researchers are carefully considering what is necessary to support undergraduate instructors in changing their teaching (Ebert-May et al. 2011; Henderson, Beach, & Finkelstein, 2011). Instructors often describe a lack of time, training, and incentives as barriers to using evidence-based practices (Andrews & Lemons, 2015; Dancy & Henderson, 2010; Shadle, Marker, & Earl, 2017). However, Brownell and Tanner (2012) hypothesize that addressing these barriers is insufficient to foster meaningful change within a professional culture of science that promotes the development of research identities but not teaching identities.

Graduate school is a key time for professional identity development (Austin, 2002), but currently we know little about how doctoral students develop professional identities as college teachers. As a first step in addressing this gap, this study aims to better understand what can promote and hinder a professional identity as college teacher among life sciences doctoral students. This study was informed by theory and empirical research related to socialization, identity theory, and professional identity development.

1.1 | Guiding theoretical frameworks

Socialization is an ongoing process of becoming a member of a community of practice (Lave & Wenger, 1991), and graduate students are simultaneously being socialized in multiple communities because they are joining a community of graduate students, a department, a discipline, and more (Austin & McDaniels, 2006). In a department, faculty serve as full members of a community of practice and graduate students are newcomers who learn about and make sense of the community by participating in it (Lave & Wenger, 1991; Wegner & Nückles, 2015). Newcomers to a community learn what is expected and what is needed to succeed in the community (Turner & Thompson, 1993). This involves learning about and coming to adopt the culture of the community, including the practices, norms, values, and discourse of the community (Bieber & Worley, 2006; Sfard, 1998; Wegner & Nückles, 2015).

While the culture of a community has great influence, individuals also have agency to push against this influence (Barker, 2005; Bourdieu, 1977). Graduate students may develop values and engage in behaviors that are not highly valued in their department or discipline (Thiry, Laursen, & Liston, 2007). However, individuals who demonstrate characteristics of more valued identities may receive more resources from the community (Hall & Burns, 2009). For example, Thiry et al. (2007) propose that graduate students in the sciences anticipated that disapproval from their advisor about participating in science outreach activities might result in loss of research support, delays in dissertation approval, and less support for job and fellowship applications.
The culture of a community of practice, such as an academic department, is communicated formally through degree expectations, and also tacitly as students observe and participate in routine interactions in the department (Turner, Miller, & Mitchell-Kernan, 2002). Doctoral students figure out what it means to be a faculty member in the discipline through observations and experiences with faculty before and during graduate school, but often fail to develop a full understanding of what faculty work involves (Austin, 2002; Bieber & Worley, 2006). Doctoral students report receiving mixed messages about faculty responsibilities and priorities, such as rhetoric from upper administration about the importance of undergraduate teaching contrasted with their personal observations of the work for which faculty are rewarded (Austin, 2002). Graduate students continuously work to make sense of the culture of the communities in which they participate and to compare the culture to their own values and interests (Austin, 2002; Bieber & Worley, 2006). By participating in communities of practice, students come to construct and enact their own professional identities (Szelényi, Bersonis, & Mars, 2016; Weidman, Twale, & Stein, 2001).

Professional identity includes how a person defines themselves professionally, including workplace values, roles, and responsibilities, and how the person is seen by those around them (Hall & Burns, 2009). An individual’s professional identity is multifaceted and is one of many identities an individual uses to make sense of themselves (Beijaard, Meijer, & Verloop, 2004; Coldron & Smith 1999; Stets & Serpe, 2013). For example, a faculty member may have professional identities as an undergraduate teacher, a mentor, and a geneticist, as well as identities as a Latina, a mother, and a political liberal (Stets & Serpe, 2013). Some identities are more salient than others. A salient identity is consistently invoked across situations and is more likely to be invoked in any given situation (Stets & Serpe, 2013). Professional identities can be tenuous in that different identities may be invoked depending on the situation, but they can also become stable over time if they are repeatedly and habitually invoked across contexts (Carlone & Johnson, 2007).

Constructing a professional identity is an ongoing process where an individual observes and interprets experiences to make sense of oneself (Coldron & Smith, 1999). Work from business management has examined how people transition into new professional roles. Newcomers observe role models to see what makes them successful and to determine in what ways they see themselves as similar and dissimilar from role models (Ibarra, 1999; Ronfeldt & Grossman, 2008). They also experiment with professional identities by engaging in authentic professional activities, then assessing and modifying their enactment of the identity. For example, graduate school can offer the opportunity to take on roles and responsibilities of a researcher, an undergraduate instructor, and a research mentor. A graduate student evaluates themselves in these roles and pays attention to external assessments. By trying out an identity, a newcomer can consider the degree to which an identity aligns with how they see themselves and how others see them. They then make decisions about what parts or whole professional identities to retain and what to discard (Ibarra, 1999).

Evaluating a provisional identity hinges on implicit and explicit feedback from individuals who are firmly established in the profession. These meaningful others indicate how well a provisional identity is aligned with the values and expectations of the profession, and thus whether the student has potential in the profession (Ibarra, 1999; Carlone & Johnson, 2007). Positive recognition from meaningful others can be key to persisting in seeking out opportunities to enact an identity. When meaningful others in a community do not provide recognition, identity development may be disrupted or stagnated, ultimately influencing career intentions (Carlone & Johnson, 2007). In one study, Female doctoral students in science and engineering who were interested in becoming community educators or entrepreneurs felt that their doctoral programs and advisors did not support or value for these pursuits, and this led some participants to suppress these identities (Szelényi et al., 2016).
1.2 | Teaching identity among STEM graduate students

Brownell and Tanner (2012) hypothesized that the culture of science gets in the way of developing a professional identity as a college teacher and that faculty without this identity may be less willing to engage in instructional change. They proposed three tensions between a professional identity as a scientist and the adoption of evidence-based teaching practices. The first tension is that training as a scientist promotes the development of a professional identity as a researcher, but not as a college teacher (Brownell & Tanner, 2012). Despite the fact that about half of students in STEM start and end doctoral training interested in teaching undergraduates (Connolly, Savoy, Lee, & Hill, 2016), many programs provide little or no training in pedagogy and evidence-based teaching to graduate teaching assistants, or offer only voluntary training in these areas (Schussler, Read, Marbach-Ad, Miller & Ferzli, 2015). The second tension is that scientists, including doctoral students, may be afraid to “come out” as teachers because they fear they will not be taken seriously by the larger scientific community (Connolly, 2010; Brownell & Tanner, 2012). The third tension is that the professional culture of science considers teaching to be lower status than research, positioning scientists to feel they have to choose between the two (Brownell & Tanner, 2012). Current and future faculty may feel that to be seen as “real” scientists they need to shy away from spending time on their teaching and teaching development (Thiry et al., 2007; Brownell & Tanner, 2012).

Though Brownell and Tanner’s (2012) essay is one of the most commonly cited papers published in *CBE-Life Sciences Education*, indicating that their ideas resonate with the community, few studies have empirically examined professional identities among future and current science faculty (Kendall et al., 2013). One study examined the professional identities of 24 graduate students from groups underrepresented in science and engineering who participated in a K12 education outreach program (Thiry et al., 2007). These students perceived that their involvement in science outreach was in opposition to being considered a “real scientist” by peers and faculty. Their advisors encouraged them to minimize time spent away from research and they experienced negative reactions from other faculty and peers about their involvement in the science outreach program. These experiences led them to feel like they were outsiders within their department and discipline (Thiry et al., 2007). The outreach program provided an alternative community of like-minded individuals whom they saw as sharing their values and interests. Even though many of these students were personally interested in outreach and teaching, they “found it difficult to let go of academic research as a career goal” because they recognized “the lower status granted to teaching as compared to research” (Thiry et al., 2007, p. 407). They also worried that the science research community might be closed to them as their identities as science educators became more salient.

Other research has focused on teaching development and teaching experiences for graduate students, which may be related to teaching identity. A longitudinal study of STEM doctoral students at three research universities revealed that most (84.6%) students participated in at least some teaching professional development. These experiences improved their feelings of competence as a teacher and their sense of community with their peers (Connolly et al., 2016). Furthermore, participation in teaching development programs did not negatively affect time to degree completion. Teaching experiences during doctoral training helped students explore teaching as a career option, and resulted in less bias against faculty teaching jobs. These experiences confirmed interest in faculty teaching jobs and also resulted in students deciding that they did not want positions that included teaching. Despite these benefits, doctoral students were often discouraged from spending any more than the minimum required time on teaching and teaching development (Connolly et al., 2016). Thus, the experiences of these STEM graduate students seem to align with much of what Brownell and Tanner (2012) hypothesized. Further research is needed to understand the mechanisms of how doctoral training influences teaching identity (Kendall et al., 2013).
Our objective in this research was to undertake a qualitative investigation of the experiences and perceptions of life sciences doctoral students who had diverse career interests to better understand the factors influencing professional identity as a college teacher. Specifically, we aimed to elucidate what promotes and hinders professional identity as a college teacher among doctoral students in the life sciences, and to develop a mechanistic model of how doctoral training influences identity as a college teacher. The model produced by this work is grounded in the experiences of our participants, and can serve as a hypothesis to be tested and refined through additional qualitative investigations. It also lays the groundwork for larger scale quantitative investigations.

2 | METHODS

2.1 | Context

Investigating the role of socialization necessitates clearly describing the context in which this research was situated. We investigated the experiences of participants in several life sciences departments at a large university classified by Carnegie as “highest research activity.” Participants’ major advisor acted as a research advisor, dissertation chair, academic advisor, and often a key source of stipend funding. All departments guaranteed the same stipend funding to all of their students for at least five years, either through research or teaching assistantships, and students received full tuition waivers. Most students receiving research assistantships were paid for research that would be a part of their dissertation. Doctoral students in these departments were expected to work at least the equivalent of a 40-h work week, including time spent in classes, conducting research, and working as a graduate teaching assistant.

The nature of research in the life sciences and how it is funded influences doctoral training. Most research projects are collaborative. Doctoral students typically work on research ideas developed by their advisors, and research is funded to be completed by a particular date. They generally conduct research within a laboratory, and may have a designated “bench” space and desk space. The term “lab” is commonly used to refer to the collective space that includes laboratory benches, research equipment, and student desks. It is also used to refer to the hierarchically organized group of individuals overseen by the research advisor, including laboratory technicians, postdoctoral researchers, graduate students, and undergraduate researchers, all of whom work in close physical proximity.

The university where this research was situated has both discipline-based education researchers employed as tenure-track faculty in science departments and a Center for Teaching and Learning that may support teaching endeavors of graduate students. Most life sciences departments have at least one tenure-track faculty member who is a discipline-based education researcher and these individuals are seen as opinion leaders for undergraduate education by faculty (Andrews, Conaway, Zhao, & Dolan, 2016). The Center for Teaching and Learning at this institution employs six or more full-time staff to support teaching development and recognition.

The experiences and perspectives of the lead researchers are also relevant to interpreting our results. AKL and TCA led all data collection and analysis. Both AKL and TCA have been graduate students in life sciences departments and TCA is faculty in a life sciences department. Both were members of life sciences departments within the focus university.

2.2 | Participants and recruitment

We interviewed a wide range of graduate students, including students from multiple departments, with diverse career interests, and at different stages of graduate training. We aimed to maximize the
variation in our sample so that we could identify patterns across students, while also revealing the unique experiences of different individuals (Patton, 1990). We started by recruiting participants from one life sciences department to control for effects of departmental culture and to allow us to recruit multiple students with the same major advisor. However, initial analysis revealed that only a few of these participants identified as college teachers. Therefore, we recruited participants from additional departments, including some with a demonstrated interest in teaching and some who were not interested in teaching. We recruited all participants by email, including up to three reminder emails and also gave a brief presentation at a student association meeting. We asked potential participants to complete a short survey asking about their career interests, years in school, and semesters as a teaching assistant. We offered a $25 gift card as incentive for interview participation.

Our final sample included 33 doctoral students earning degrees in four life sciences departments at one university. Over half of the students (n = 18) were from the first department in which we sampled. These students represented about 39% of the graduate student population in that department and 59% of the research groups with graduate students. Additional sampling yielded 15 students working toward doctoral degrees across three other departments. Sixty-four percent of our participants were female and less than a third were international students (Table 1). Participants had been in their doctoral programs for a median of four years (SD = 1.7). The number of semesters participants spent as teaching assistants varied, but two semesters was the median (SD = 4.4). The median number of semesters on a research assistantship was three1 (SD = 3.3). It is important to note that one reason these numbers vary across participants is because they have been graduate students for different lengths of time. In these departments, doctoral students are funded 12 months of the year and are guaranteed tuition waivers and stipend funding for at least five years. Semesters not funded by a teaching assistantship are funded on a research assistantship or fellowship. Nearly all (91%) of our participants had advisors who had already earned tenure.

### Table 1

<table>
<thead>
<tr>
<th>Teaching identity</th>
<th>No. of participants</th>
<th>% female</th>
<th>% international</th>
<th>Median (SD) year in PhD</th>
<th>Median (SD) terms as TA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salient and stable</td>
<td>12</td>
<td>58</td>
<td>0</td>
<td>5 (1.2)</td>
<td>6 (4.6)</td>
</tr>
<tr>
<td>Nascent</td>
<td>7</td>
<td>86</td>
<td>14</td>
<td>1 (1.5)</td>
<td>1 (1.1)</td>
</tr>
<tr>
<td>None</td>
<td>14</td>
<td>57</td>
<td>64</td>
<td>4 (1.5)</td>
<td>3 (4.5)</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>64</td>
<td>30</td>
<td>4 (1.7)</td>
<td>2 (4.4)</td>
</tr>
</tbody>
</table>

SD = standard deviation.

1These data exclude one participant for whom this datum was missing.

2.3 Data collection

We conducted one semi-structured interview that lasted 30–90 min with each participant. AKL completed and audio recorded all interviews. We used one interviewer to ensure consistency across data and because we anticipated that students would be more forthcoming in their answers with a peer.

We developed an interview protocol based on prior research on professional identity (Austin, 2002; Bieber & Worley, 2006; Pratt, Rockmann, & Kaufmann, 2006) and refined it iteratively using pilot interviews. Pilot interviews are not included in the final data set. We designed our final protocol to learn about participants’ thinking and experiences related to (a) their career plans; (b) teaching,
development as a teacher, and training for teaching; (c) whether they saw themselves as researchers and teachers and why; (d) their advisors’ views on research and teaching; (e) their opinions about tensions proposed by Brownell and Tanner (2012). Based on early interviews that are included in the dataset, we added three questions to the protocol for participants who expressed interest in college teaching. These questions probed more directly about how participants felt others viewed their interest in teaching. Interviews were transcribed verbatim and checked for accuracy. All interview questions are available as Supporting Information.

2.4 | Qualitative data analysis

Our data analysis aimed to identify and describe factors that promote or hinder professional identities as college teachers, and to organize these factors into a theorized mechanistic model depicting relationships among factors. We organized our analyses within Atlas.ti and all four authors contributed to the data analysis. We used an analytic approach that aligned with grounded theory in many ways. We remained open to ideas emerging from our data, wrote detailed analytic memos, used constant comparative analysis, organized codes into conceptual categories, and further organized these concepts through diagramming relationships between them (Charmaz, 2006). We generated a comprehensive theory in the form of our model of the factors influencing teaching identity among life sciences doctoral students. Our approach did not align with grounded theory in all ways. We did not repeatedly seek new data through theoretical sampling (Charmaz, 2006). Additionally, we were guided by prior theoretical frameworks related to professional identity, socialization, and science identity and therefore did not generate an entirely new theory (Charmaz, 2006). We describe our methodology in more detail below.

2.5 | Identifying and describing all potentially relevant ideas

We systematically identified and described participants’ thinking and experiences relevant to our research questions. Each researcher listened to the same subset of interviews while considering guiding questions about the participant’s career goals and teaching identity. The full research team then met and discussed these questions. This process produced an initial list of ideas and experiences related to teaching identity. Next we formally analyzed a single transcript by dividing it into sections of text that communicated a discrete idea and labeling these sections with codes to summarize their content. Codes consisted of short phrases that described the content of the text and a summary of the ideas captured by the code, including nuance across participants. Codes emerged from our analysis, rather than from an a priori list (Charmaz, 2006; Saldana, 2013). We applied codes to any section of interview transcript that contained the corresponding idea. These sections are quotes and ranged in length from sentences to paragraphs. We continued with the remaining interviews, adding, omitting, combining, and splitting codes to best capture the thinking and experiences of our participants. As codes changed, we reanalyzed data we had previously coded (Saldana, 2013). We completed each part of this process in pairs or small groups to allow for constant comparison of our interpretations of the data.

During this phase, we also read all quotes within each code numerous times. This allowed us to refine codes so that all quotes within code addressed the same core idea. We simultaneously worked on groups of related codes to compare and contrast codes (Saldana, 2013). When this step was completed, we had catalogued and extensively described the thinking and experiences recounted by our participants. Many themes in the data were evident at this point, but subsequent analysis helped reassemble the data to understand connections among ideas.
2.6 | Elucidating relationships to develop a mechanistic model

The second phase of our analysis aimed to identify emergent themes and describe relationships between themes. This was done iteratively and in concert with revisiting the literature to view our results through multiple lenses. We categorized participants based on their identities as teachers to make systematic comparisons among them to better understand the experiences associated with a teaching identity. Developing identity categories was iterative and involved making comparisons among participants to elucidate their level of interest in teaching, how they saw themselves (i.e., their thinking), and the experiences they had pursued related to teaching (i.e., their actions). We grouped participants into three identity categories, which are described in more detail in the results.

This phase also involved creating iterative drafts of a visual representation of the factors influencing teaching identity and the relationships among these factors. On multiple occasions, each researcher independently developed and presented a visual representation. Discussing and synthesizing these representations revealed similarities and differences in our thinking, which then guided additional analysis (Charmaz, 2006). We constantly compared drafts of the model to written descriptions of results and to full transcripts to build a final model representative of the experiences of our participants.

2.7 | Trustworthiness in qualitative analysis

We employed multiple strategies to maximize the trustworthiness of our qualitative work. We used deliberate sampling to address our research questions (Mays & Pope, 1995; Charmaz, 2006). We also aimed to be transparent in describing our methods to increase the confidence in our interpretations and make our analysis as understandable and replicable as possible (Denzin, 1978). Additionally, we completed all analyses in a team. This adds trustworthiness because it requires extensive discussion and consensus making and counters individual biases towards the data. All authors were fully immersed in the data over a long period of time, providing us with ample knowledge to critically consider the data and interpretations (Eby, Hurst, & Butts, 2009). Last, we sought feedback from experts who were both experienced qualitative researchers and faculty within life sciences departments.

3 | RESULTS

We classified our participants into three categories: graduate students who had a salient and stable teaching identity \((n = 12)\), those with a nascent teaching identity \((n = 7)\), and those who did not have a teaching identity \((n = 14)\) (Table 1). Participants with a salient and stable teaching identity were interested in college teaching and had repeatedly pursued the chance to teach undergraduate courses and to improve in their teaching, which meant seeking opportunities beyond what was required by their doctoral programs. Participants with a nascent teaching identity were interested in college teaching, and had the potential to develop a salient and stable teaching identity, but may or may not seek opportunities that would foster this identity. Participants without a teaching identity were not interested in college teaching and were unlikely to seek additional opportunities related to teaching due to their lack of interest.

There were a few differences between these groups besides their identities as teachers. Participants with nascent teaching identities had been in a doctoral program for less time than individuals in the other categories and had taught fewer semesters as graduate teaching assistants. In contrast, all participants with a salient and stable teaching identity were in at least their third year of doctoral studies. Additionally, most students with nascent or salient and stable teaching identities were from the United
States, but over half of our participants without a teaching identity were citizens of countries other than the United States (Table 1).

The remainder of the results describe what influenced teaching identity among our participants. These factors are summarized in a visual depiction of the factors influencing teaching identity (Figure 1), and described in detail below. We draw heavily on the words of our participants to present our results. We have lightly edited some quotes for grammar and clarity, but always endeavored to maintain the intended meaning. We use pseudonyms to refer to all participants and to other individuals.

3.1 The professional culture perceived by participants

The way that they perceived the professional culture in the life sciences, their departments, and their research groups had a pervasive influence in the experiences of our participants. We found it
productive to use a metaphor to describe the role that their perceptions of professional culture had on their teaching identities (Figure 1). The professional culture in which they worked acted like a blizzard that doctoral students had to navigate through to develop a teaching identity. Students commonly experienced a negative response to their interest in teaching from individuals in their departments, which made the environment feel cold and isolating like a blizzard. The culture resisted movement toward opportunities to develop as teachers, much like deep snow and driving winds push back on people trying to navigate in a blizzard. The culture also made it harder to see the opportunities that existed related to teaching, much like blizzard conditions make it hard to visually discern objects, even those that are close by. Thus, we propose that doctoral students in the life sciences have to brave a blizzard to develop an identity as a college teacher (Figure 1).

Participants widely perceived that teaching was less valued than research in the life sciences and in some of their labs and departments. This perception was informed by their observations and experiences within and beyond their institution, and was not limited to those with salient and stable teaching identities. Importantly, these perceptions were not the result of single interactions or the influence of any one individual. Rather, they developed over time and were a general impression of the culture.

Many participants had formed perceptions of what was valued in the work environment by observing faculty. Participants noticed that many faculty minimized the time they spent on teaching and improving as teachers because they garnered prestige and rewards as a result of their research, rather than their teaching. For example, Priya reasoned that tenure-track faculty at research-intensive universities want to focus on their research, even if they like teaching, because it is more important to their career success:

“...I think I understand why [tenure-track faculty in the life sciences] really want to just be focused on their lab work because that is what is giving them credibility as a scientist because it’s either publish or perish, that’s unfortunately the culture right now... even if they enjoy interacting with students, [it] is not going to give them the grants.”

Participants also perceived that faculty saw teaching as a focus for people who were less successful in research. Andrew explained it this way:

“I feel like there is a certain attitude that if you’re into [teaching] then you’re no good at anything else that you do...it is just something that we have to do and it should not be an area of focus for a real scientist, right? A real scientist only cares about their research and they teach because they have to.”

Andrew described how this perspective made him doubt himself:

“So that’s something that kind of makes you want to–when you worry about whether you’re weird, or you’re wrong, or you’re just not good at actual science? And maybe that’s why you’re into teaching...so I must’ve been bad at what I’m doing because I like doing this other thing, so it must mean that I’m not good at research. Certainly I’ve felt that.”

Some participants explained that their advisor or lab subscribed to these beliefs. For example, Julia said:

“I think in general in my lab, what is important is the science, the bench part. We are not supposed to become teachers. That is secondary. That’s something that we have to do, but it’s not what we are supposed to do.”
Similarly, when Joshua was asked if it would be looked upon favorably in his lab for a student to dedicate time to being a good teacher, he responded “No, not at all. The work we do takes a lot of time, and teaching, at least in all of our point of view, takes a lot of time out of our actual work.” This idea and others may be learned from advisors. For example, Rahul explained “I think I should really mention that a lot of my viewpoints that I have about teaching and science comes from discussions with [my advisor] or listening to him speak.”

The attitude that teaching is less valued than research may dissuade students from seeking teaching opportunities even if they have an interest in teaching. Maria was aiming to be a faculty member at a large, research-intensive university and had a nascent teaching identity. She “really enjoys” teaching and sees it as one motivator for her career plans. Similar to other participants, Maria saw teaching experiences where she has “autonomy over the presentations” as important training for her future career. However, time spent away from research is seen unfavorably by her advisor:

“Actually, my mentor, he’s very adamant about – as a graduate student, you do your research. And really what matters to get you to the next level is the research. Your teaching experiences kind of come second. So, if anything negatively affects the research, then it should be something that gets placed second priority.”

Maria believed she is unlikely to get any more teaching experiences, and even less likely to have teaching experiences that include ownership while in graduate school.

Participants also got the message that specialized training was unnecessary to be an effective teacher. Some advisors explained that learning to teach occurs when a faculty member teaches their first class, making any formal preparation a poor use of time. Karen described conversations with her advisor about preparing for teaching responsibilities:

“He doesn’t see the value in taking classes or TA-ing a lab for the experience or anything like that. For him, it’s all about the science. And so, I’m sure that I have adapted some of that throughout my career.”

Some participants struggled to figure out what experiences they needed to pursue to prepare them for a career involving teaching. For example, Matthew wanted to teach at a community college, but found that most of the people he spoke to about it “didn’t really know 100% what they were talking about.” Faculty and peers at his institution communicated that “all you should be doing is publishing and that’s going to get you a job,” whereas individuals who worked at smaller colleges told him, “that’s important, but if you don’t do the teaching experience...you’re not going to be getting a teaching job.” This “difference in voices” made him feel conflicted. Should he prioritize the more dominant and common perspective communicated by faculty he sees every day or the perspective of a few faculty at the type of institution to which he aspired?

One consequence of the blizzard-like culture was that students who were interested in teaching questioned their identities as scientists. Matthew’s evolving thoughts exemplify this struggle. He questioned how his choice to teach at a community college would impact his science identity, “Do I still get to call myself a scientist once I become a full time teacher?” To Matthew, the day-to-day responsibilities of being a college teacher were divorced from those of a scientist. He explained:

“I still say that I would be a scientist, but I feel like I’m almost relying on my degrees to call myself a scientist rather than what I’m practicing, you know?...I’m kind of up in the air on it to be perfectly honest.”
Later in the interview, Matthew seemed to expand his definition of what it means to be a scientist to include teaching. He said, “I would say pretty firmly that I’m still conducting some critical inquiry and I’m not going to stop being a scientist just because I’m not conducting publishable research.”

Though many participants with salient and stable teaching identities described questioning their decisions to pursue a career focused on teaching, they also described personal resiliency which helped them persist in an environment where their aspirations were discouraged. Catherine recalled interactions with her committee in which they tried to dissuade her from taking on teaching responsibilities:

“My committee members have not been the most supportive of my teaching. One has called it PhD suicide and another has really just told me that I need to stop teaching and focus on research.”

However, Catherine continued to pursue what she thought was best for her own professional development. These participants were not unaffected by the professional culture that they perceived in their work environment, but they worked to minimize the effect of others’ values on their own decisions. Anna explained that she had developed “thick skin” and that discouragement from faculty had made her “even more determined.” Similarly, Justin recognized that teaching-focused careers were less respected by some, but was steadfast in his career goals:

“So I guess...public perception that these types of jobs are a step-down has kind of gone through my head, but then I think about it more and then I’m like, ‘I don’t really care what people think. This is what I want to do’.”

Participants with salient and stable teaching identities almost all intended to pursue careers at institutions that focused more heavily on undergraduate education than their graduate institution, including primarily undergraduate institutions and community colleges (Supporting Information Table S1). They anticipated that the institutions where they aspired to work would value teaching more than their current institutions and this contributed to their resiliency. Robert explained that he wanted to work at a small, primarily undergraduate institution because he thought these jobs were more likely to prioritize “teaching and developing your art as a teacher.” He loved teaching, wanted to improve at teaching, and saw research-intensive universities as placing little value on teaching and a scholarly approach to teaching.

3.2 Interest in college teaching

Interest in college teaching was key to a teaching identity. Opportunities to teach before and during graduate school were often responsible for piquing interest in teaching. Interest in college teaching only transformed into interest in a career involving teaching when doctoral students were aware of viable career options (Figure 1). Some participants discovered their interest in teaching as graduate teaching assistants. Justin came to graduate school because he was interested in research. He worked as a teaching assistant during his third year to fulfill a departmental requirement. After this experience, he was again supported on research assistantships and he missed teaching. He felt that it had been the most rewarding part of graduate school, and recalled thinking, “Well, if that’s what I value and that’s what brings me happiness, then I should pursue a career where that’s kind of the goal.” Other participants became interested in college teaching prior to graduate school. As an undergraduate, Elizabeth aspired to become a dentist, but interacting with an inspirational professor and serving as an undergraduate teaching assistant showed her other possibilities (Figure 1).
Though some participants, like Elizabeth, went to graduate school because they were interested in a teaching career, most participants did not begin graduate training aware that they wanted a career involving college teaching. Therefore, opportunities to teach as a graduate student were critical for exploring career interests. Participants were best positioned to make informed decisions if they had the opportunity to teach undergraduate courses early in graduate school because this gave them time to develop as teachers. Recognizing their own interest in teaching motivated students to seek teaching professional development and independent teaching experiences (Figure 1). Kelsey explained:

“\[I\] hear from other people in other departments, where they don’t even have teaching requirements at all, and they will teach their last semester and they’re like, ‘Oh, I actually really like this and now I’m screwed because I haven’t developed my teaching skills’.”

Participants with salient and stable teaching identities described how much they enjoyed working with students and watching them learn. They discovered this through teaching experiences. For example, Justin found that he appreciated the chance to “have a really close connection” with students, and push students to think more deeply until they had a “wow moment.” Kelsey explained, “I really enjoy the students. I enjoy interacting with them. I really enjoy like in lab when they’re all talking to each other and I’m walking around and it’s just fun.”

Teaching experiences helped some participants confirm they were not interested in careers involving teaching. Emma had taught for three semesters. Teaching experiences confirmed her belief that she was not good at teaching and did not enjoy it. She explained: “I haven’t had any bad experiences really. It’s not like I saw something and was scarred for my whole life. I just have never liked being a teacher. . .I’m not good at it.” Not all students who were uninterested in teaching saw themselves as bad teachers. Others felt frustrated by undergraduates, especially when “dealing with people who aren’t intellectually invested in what’s going on in the course.” Another explained that “teaching comes with a lot of responsibilities which I don’t like.” These students often intended to pursue positions outside academia because they did not want any teaching responsibilities.

Other participants were interested in teaching, but may not pursue opportunities to develop as a teacher because they do not see viable career options that included teaching (Figure 1). Marco, a first year student, discovered an interest in teaching during his first graduate teaching experience, which was mandatory. “I’ve been learning like, ‘Oh teaching is also probably not a bad idea’ because I kind of enjoy it.” Despite having a nascent teaching identity, Marco was not seriously considering a career involving teaching because he was unaware of careers involving teaching beyond being faculty at a research-intensive university, and he was not interested in that career path. His lack of awareness of other career options left him thinking that he would be unable to pursue dual interests in research and teaching, and therefore may hinder him from pursuing opportunities that would strengthen his teaching identity. Robert had the same perspective until he learned, through a teaching professional development program, about the wide variety of positions available in higher education that involve teaching.

International participants did not always see opportunities for careers involving teaching in their home country. Some expected positions that involved teaching undergraduates to be rare or unavailable, or anticipated that they would be overqualified for these positions after earning a doctorate. Not surprisingly, doctoral students who did not see teaching in their future chose not to pursue additional chances to teach or participate in teaching professional development, both of which were important for coming to have a salient and stable teaching identity.
3.3 | Teaching professional development

Teaching professional development fostered teaching identities among our participants by helping them gain teaching knowledge and skills, helping them identify teaching mentors, and introducing them to other like-minded peers who were also interested in teaching (Figure 1). Additionally, formal teaching professional development helped students prioritize teaching preparation, even when they felt too busy to find time for additional work.

Not much teaching professional development was required for doctoral training in the life sciences at this institution, so students interested in developing as teachers had to pursue opportunities themselves. Depending on their graduate teaching assignments, doctoral students were required to take one or two 1-credit courses related to pedagogy. Participants received little or no teaching professional development within their teaching assignments, Anna explained:

“Like when we TA, the professors do not do anything with teaching development when you’re TAing. You’re there to TA. You’re there to do whatever it is that you’re supposed to do. It’s not about you gaining teaching experience or teaching skills.”

Some doctoral students pursued teaching professional development beyond what was required. The university provided two formal, elective teaching professional development programs for graduate students across disciplines: a certificate in undergraduate teaching and a future faculty program. Any student could earn the certificate, but there was a yearly selection process for 15 students to be part of the future faculty program. Of the 12 participants with salient and stable teaching identities, 9 were working toward the certificate and 5 had participated in the future faculty program. Participants without salient and stable teaching identities were not pursuing either of these programs (Supporting Information Table S1). The teaching certificate program was self-guided, and generally required over a year to complete. It entailed teaching four sections as a graduate teaching assistant, designing a teaching project and showing its effectiveness in the classroom under the guidance of a self-selected mentor, disseminating the results of the teaching project, and completing three elective pedagogy courses. The future faculty program included a twice monthly meetings facilitated by a staff member from the Center for Teaching and Learning to talk about and improve their teaching. All participants in the future faculty program had previously won a departmental or institutional teaching award.

Participants described benefits from the teaching certificate. It helped participants hold themselves accountable for participating in teaching professional development. Ryan was glad that he had committed to the teaching certificate early in graduate school because, “You start getting to your second and third year and you start losing motivation for anything extra. It was good that I had sort of made up my mind early on.” Other participants said the certificate forced them to take pedagogy classes and work on a teaching project. They welcomed this push because they might otherwise have prioritized research. Interestingly, the certificate program provides no external accountability. Students could have stopped working toward the requirements at any time without consequence other than not earning the certificate. They used the structure of the requirements to hold themselves accountable for participating in training they saw as valuable.

Participants especially discussed the value of the pedagogy courses they completed to meet certificate requirements. The courses provided the chance to build knowledge and skills, as well as access to teaching mentors. These courses were generally taught using evidence-based instructional practices and participants saw benefits in taking classes that were taught using the methods promoted in the courses. Participants described learning about a range of topics in these courses including writing teaching philosophies, active-learning strategies, “how to actually grade writing and science,” course design, and creating a syllabus.
Some participants were surprised by how much they gained from pedagogy courses. At first Catherine “wasn’t super excited about taking the courses” because she thought that “being in the classroom is probably the best way to learn about teaching.” However, she also said, “I got far more than I expected to get out of these courses.” Many participants who took these courses described building connections with the instructors as an important benefit. For example, one of Catherine’s instructors became her teaching mentor (Figure 1).

The future faculty program helped students identify like-minded peers (Figure 1). Robert asserted that the future faculty program was a primary factor in his decision to pursue a teaching-focused career because it “opened my eyes to the vast amount of teaching opportunities” beyond large research-intensive universities. Discussing teaching with people who shared his passion helped Robert realize that he wanted a teaching career. He recalled, “their enthusiasm and love for teaching really kind of rubbed off on me to where I was like, ‘This is what I want to do.’” Like the teaching certificate program, the future faculty program provided a chance to build relationships with teaching mentors. Robert described the future faculty program leader as “the ultimate role model” for teaching because he “cares about his students more than anyone I’ve ever seen.”

Some participants did not intend to participate in either of these formal teaching professional development programs because they were unaware of what was required and the potential benefits. For example, Rahul described the teaching certificate this way, “I’m sure I’m missing something, but I do not know what I am missing.” Although the program is advertised in one of the required pedagogy courses, some participants did not have the information they needed to make a decision.

### 3.4 Teaching mentors and like-minded peers

Participants benefited from relationships with faculty who acted as mentors and advocates, and from relationships with like-minded peers. Participants commonly identified mentors and built these relationships through teaching professional development programs (Figure 1). Mentors provided advice, materials, encouragement, and inspiration, which helped foster their identities as teachers. Teaching mentors and like-minded peers also encouraged participants to engage in independent teaching experiences. Catherine explained what her mentor provided her, “I’ve been in some scenarios in which I really needed her mentoring voice to kind of guide me through those scenarios in teaching and [she] really has kind of developed me as an instructor.” Stephanie developed a mentoring relationship with the primary instructor for one of her teaching assignments. Stephanie explained that her mentor provided more than just advice and opportunities, “It’s nice to know that I’m passionate about something and she kind of reciprocates that and is encouraging my passion.”

Teaching mentors, unlike research mentors, are not a standard part of doctoral training in the life sciences. Participants only found these mentors if they sought them out or sought out experiences that brought them into contact with potential mentors. Kelsey explained that graduate students may not know faculty or other students who are interested in teaching, “I think a lot of students don’t know about that little [teaching] community and where it is, especially graduate students.” A few participants found teaching mentors by identifying faculty in their department who had a reputation for being invested in teaching. However, Megan described teaching mentorship as a limited resource. Megan identified only one potential mentor in her department and explained that one person may not be enough to serve all the interested graduate students. Notably, major advisors typically were not seen as teaching mentors. Participants rarely described their advisors providing teaching feedback or directing them to teaching opportunities. A few participants even wanted advocacy from other faculty to convince their advisors to support them in their teaching development. Furthermore, many faculty supervise teaching assistants, but most were not seen as providing teaching training or mentorship.
Advocates helped participants convince their advisors that opportunities to develop as a teacher were worthwhile. One faculty member, who we will refer to as Alison, was described as an advocate by two participants from the same department. They saw Alison as willing to talk to their advisors on their behalf to advocate for more teaching opportunities. Specifically, Alison spoke to other faculty about the importance of teaching experience on the job market. Catherine described Alison as being

“A voice for me in the department as well, making sure that I have an opportunity to do all the teaching that I want to do and have the best opportunities that I can. Alison has encouraged the department to allow me to do things and encouraged my PI to allow me to do more teaching-related things.”

Doing more teaching was “not necessarily encouraged” in Catherine’s department, making Alison’s advocacy important to legitimize Catherine’s pursuits.

Peers who shared a passion for teaching provided participants with a forum to talk about teaching and teaching challenges. Participants met like-minded peers within their department and through teaching professional development. Elizabeth described the importance of being with people who can “support and relate to the good and the bads” of teaching, “when you’re in the trenches, nothing helps more than people who understand what you’re going through because they’re going through it too.” Matthew explained that his peers inspired him to become more involved with teaching opportunities, “having a cohort of people who are interested and passionate about [teaching]... pushes you because you feel left behind if you’re not pursuing the same opportunities.”

3.5 | Independent teaching experiences

Participants commonly desired independent teaching experiences. Such experiences provided opportunities to be recognized by others as a teacher and made participants more likely to recognize themselves as a teacher (Figure 1). Even participants without a teaching identity expressed interest in the chance to teach independently. Students who had not felt a sense of independence in their teaching did not get as much satisfaction from their teaching, and often were not excited about future teaching opportunities. Therefore, students who had experienced independence were motivated to seek more opportunities and students who had not experienced independence were less likely to know these opportunities existed or to seek them out (Figure 1).

Participants felt a teaching experience was independent when they had the chance to plan and implement their own class activities and have authentic, autonomous interactions with students. Different types of experiences could provide this, including guest lecturing, serving as instructor of record, and having freedom to make teaching-related choices in typical teaching assignments. However, this autonomy was not consistently available in teaching assignments. Andrew, who had a salient and stable teaching identity, explained that the standard teaching assignment was often insufficient for students to develop as instructors:

“I think that a teaching assignment requirement is a start and not necessarily a full complement of training, especially if that teaching assignment is something like grading for a lecture course. I think student interaction and then independent student interaction are key experiences that some grad students miss out on because they’re either, like I said, a grader or they’re in a lab with a professor there. They’re not making their own decisions about how to be in a class with students.”
Many participants with salient and stable teaching identities felt motivated to search for new teaching opportunities because they enjoyed previous independence in their teaching or found their prior teaching assignments too limiting. For example, Anna wanted more opportunities for independence because she had not been “asked to give lectures or design activities that often” in prior teaching assignments. Instead she often felt that her primary responsibilities were “babysitting,” making “sure students don’t light themselves on fire,” and helping with grading. When Anna expressed her interest in a teaching career, her major advisor invited her to guest lecture in his 200-student course. He was one of just a few advisors who helped participants find independent teaching opportunities. Anna described this guest lecturing opportunity as “absolutely one of the best teaching things I could have done just because it gave me experience giving not only just a lecture but a lecture to a larger class.”

After this successful experience, Anna wanted more opportunities to teach independently. She felt that having ownership in her teaching helped her learn about course design and gathering and using feedback from students. At the time of the interview, Anna was preparing to teach a course as instructor of record with mentorship from a faculty member. At this institution, the instructor of record has ultimate responsibility for planning and teaching a course, including developing the course plan and syllabus, designing each class period, and creating and grading assessments. Anna had just begun preparing for this role and was pleased that it was already a “valuable learning experience.”

Participants with nascent teaching identities or who did not have teaching identities also desired more ownership in their teaching. Participants who were not interested in teaching wondered if they would feel differently had they had more independence. Joshua explained:

“I do not share the passion of being a teacher. Which means, although I get excited while teaching, I don’t feel accomplished much afterwards. Maybe it has something to do with I have been teaching dependently. Dependently means I answer to another actual educator or teacher, that I work for him or her instead of having my own classes. So I don’t feel responsible to the students, instead I feel responsible to the teacher.”

Another participant, Lucas, had hoped for a teaching assignment similar to that of a friend who he described as “doing full lectures.” However, his teaching assignment primarily involved cleaning and preparing materials for a lab course, which disappointed him. Lucas explained, “So I wasn’t so excited about it and I just like gave up at the time and never thought about it again.”

### 3.6 External recognition as a teacher

Only a few participants—all of whom had salient and stable identities—described instances when they felt like others recognized them as a college teacher. Participants felt recognized as teachers when they were offered additional teaching opportunities and when they received positive feedback on their teaching from mentors (Figure 1). When she guest lectured, Anna received positive feedback from her advisor and a staff member of the Center for Teaching and Learning. She described receiving positive feedback and recognition from someone whose job was “helping people with teaching” as a powerful experience that made her “feel like I was being successful in teaching.” Catherine, a fifth-year graduate student, had more independent teaching experience than any other participant and therefore had the most opportunities to feel recognized as a teacher. She felt her department recognized her as a teacher when they asked her to teach a large lecture course, a responsibility not normally offered to graduate students. She was also asked to serve on a search committee for an instructor who would teach a course that Catherine had previously taught as instructor of record. Being recognized as a teacher by faculty in her department helped her recognize herself as a teacher. For example, she decided to mentor and share course materials with a new instructor in the department to “focus on making sure that she’s
a successful new hire to the university and mentoring her as she develops.” This is evidence that she sees herself as a college teacher capable of supporting other college teachers. Anna and Catherine are unique. Most participants did not describe any experiences in which they felt recognized as college teachers.

4 | CONCLUSIONS

Life sciences doctoral students perceived a professional culture that marginalized those interested in teaching. Students with salient and stable teaching identities persisted despite marginalization, but we suspect that not all students with nascent teaching identities will have the skills, resources, and agency to brave the blizzard of the professional culture in which they work. One result of this is that doctoral training at this institution, and probably many others, is propagating a narrow view of what it means to be a scientist. A traditional view of what it means to be a scientist seems to be limited to the individuals who lead novel research and publish peer-reviewed research. A contemporary view of what it means to be a scientist needs to be broader. Researchers are scientists, and so are those who are primarily engaged in science outreach, national science policy, entrepreneurial science, and science teaching (Ecklund, James, & Lincoln, 2012; Szelényi et al., 2016; Thiry et al., 2007). Broadening our view of how individuals contribute to the scientific enterprise may be vital to improving the diversity and preparation of STEM professionals.

Faculty at research-intensive universities train the majority of doctoral students in the life sciences, yet we are often ill-equipped to prepare students for careers besides our own for at least two reasons. First, our professional experience is often limited to working at research universities, and we may not be knowledgeable about the expectations in other careers. For example, associate, baccalaureate, and master’s institutions value teaching experience more highly than research experience or publication record, but faculty at doctoral institutions value research above anything else (Fleet et al., 2006).

Second, there is an inherent conflict of interest between what a life sciences faculty member at a research university needs to accomplish to be considered successful and the training students need for any role besides being a researcher. Life sciences faculty are expected to secure extramural funding for research and to fund the training of graduate students, both prior to earning tenure and throughout their careers. When they are awarded this funding, they are responsible to the funding agencies for accomplishing the proposed research, and failing to do so will negatively impact their ability to secure funding in the future. In this way, the funding of graduate students is linked to the production of research, and the rationale path for faculty is to prioritize research productivity. Recognizing this conflict of interest will allow us to rethink how graduate training could be designed to prepare students for other careers, including those in industry, policy, and academic institutions that are different than research universities. For example, Bruce Alberts and colleagues proposed that we move toward funding graduate students on training grants and fellowships rather than through research grants because it allows for more peer-review and federal oversight of how students are trained (Alberts, Kirschner, Tilghman, & Varmus, 2014). Doctoral programs that include time for all students to engage in significant professional development other than development as a researcher could also address this conflict of interest. A recent consensus report on graduate education in STEM written by the National Academies of Science, Engineering, and Medicine recommended that students be given ample time, resources, and space to explore diverse career options, and additional professional development is a key piece of this exploration (National Academies of Science, Engineering, and Medicine 2018). Additionally, we expect that life sciences faculty at research universities would welcome professional development aimed to help them better understand the various careers our graduate students pursue and what will make them competitive on the job market and successful in their job responsibilities. National funding agencies could
lead the way by stating that competitive training and fellowship proposals will explicitly invest in supporting graduate student preparation for diverse careers and diverse identities as scientists.

Our findings suggest several factors may be important for supporting doctoral students who aim to have careers as college science faculty. Students benefited from the chance to teach early in graduate school because it allowed them to explore their career interests. Presenting teaching as an opportunity for career discovery, rather than as a distraction from research, might help students seriously consider multiple career paths (Gibbs & Griffin, 2013). Doing so in the first years of graduate school will allow students to pursue additional training appropriate for their career interests.

Formal teaching development programs helped students gain knowledge and skills and were key to developing relationships that fostered their teaching identities, but were not widely accessed. The future faculty program was only available to students who had won a competitive teaching award, thereby selecting for students who likely already had a salient and stable teaching identity. The certificate program was viewed as too much of a time commitment by many students and faculty. Many students also lacked information about the program and its potential benefits. Thus, teaching professional development programs could better reach their potential by widely advertising directly to students, by assessing and advertising their outcomes, and through integration into typical doctoral training at an institution. Departments could play a role in this by encouraging students interested in teaching to participate in local or national teaching professional development programs. For example, the CIRTL Network (Center for the Integration of Research, Teaching, and Learning) offers online pedagogy courses, online discussions, and summer institutes (https://www.cirtl.net). Last, independent teaching experiences were highly valued by students. Graduate training recognizes the importance of increasing students’ ability to conduct research independently, but life sciences doctoral programs are not typically designed to foster teaching independence. Creating easier access to teaching mentors and feedback could help students work toward independence and provide more opportunities for students to receive recognition as a teacher from faculty.

One compelling approach for redesigning a graduate program to better foster teaching knowledge, skills, and identity is dividing the graduate affairs committee into a graduate research committee and a graduate teaching committee (Kendall et al., 2013). This change, which was made by a life sciences department at a research-intensive university, recognized the unique training and support needed for teaching and ensured that these matters were not overshadowed by a focus on research. This graduate teaching committee makes teaching assignments with the professional development of graduate students in mind, providing a chance to scaffold students into more independent teaching experiences. The committee also oversees feedback for teaching assistants, ensuring that graduate students receive peer feedback and feedback from faculty on their teaching each year (Kendall et al., 2013). Positive evaluations open doors for more independent teaching experiences, and even becoming involved in departmental teaching reform efforts. Thus, there are formal avenues for recognizing students as teachers. Furthermore, the committee makes recommendations to the departments regarding courses that could be offered within the department to support students in their development as teachers (Kendall et al., 2013). This is just one possible way to change graduate training to better support teaching identities. It is promising that it addresses major factors that fostered teaching identity in our study.

Almost all the students with salient and stable teaching identities intended to seek careers involving college teaching at primarily undergraduate institutions (Supporting Information Table S1). They had made this decision because they saw the values of a research university as out-of-line with their own values, and they expected other institution types to have a value system more aligned with their own. With one exception, the students in our sample who intended to seek careers as faculty at research-intensive institutions had nascent teaching identities or none at all (Supporting Information Table S1). Our sample is small, but these observations raise questions about what needs to change in doctoral
training and the professional culture conveyed to students so that students aiming for careers in research-intensive universities see the opportunity to develop as a teacher as worth their time.

This study has several limitations that must be taken into account in interpreting these data. First, we investigated the experiences of students in the life sciences. Investigations of students in other science disciplines, including chemistry, physics, and geosciences, will be important to determine the degree to which our findings are discipline-specific. Ecklund et al. (2012) observed different perspectives about science outreach between biologists and physicists. We cannot assume that the same factors will influence identity in the same way across disciplines. Second, we collected data at one time point for each participant, requiring them to recall prior experiences. This retrospective approach may not fully capture what has influenced their professional identity and how. Longitudinal studies will be an important step for understanding the development of teaching identities. Last, this work examines a single university. Clustering participants within a single context allows for deeper insight regarding the local culture, which was important to this study. However, it also means that our findings may not be relevant to all contexts. An important next step will be comparing and contrasting cultures and training programs to better understand the complexity of what influences teaching identity.

We have described a model of the factors influencing teaching identity among life sciences doctoral students. This is important groundwork for understanding teaching identity among future and current faculty. Future empirical work can build on this model by examining teaching identity among new faculty and elucidating how teaching identity impacts instructional choices and the use of evidence-based instructional strategies over time. We wonder if our findings will be unsurprising to people who have been in a life sciences department at a research-intensive university. This leaves us asking: if this reality is already well-known, what will it take to motivate us to change our training approaches to prepare students for diverse and valuable careers beyond research?

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**SUPPORTING INFORMATION**

Additional Supporting Information may be found online in the supporting information tab for this article.

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