Unequal Socialization: Understanding Inequality in STEM Doctoral Education Across Different Developmental Stages

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A Dissertation

Presented to

The Faculty of the School of Education and

Human Development

University of Virginia

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

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by

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May 2024

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Degree Program: Education (PhD) Higher Education

Date of Defense: 3/28/2024

This doctoral dissertation has been approved by the Graduate Faculty of the School of Education and Human Development in partial fulfillment for the degree of Doctor of Philosophy.

Approved Title of Doctoral Dissertation:

Unequal Socialization: Understanding Inequality in STEM Doctoral Education Across Different Developmental Stages

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Acknowledgements

There are many wonderful people in my circle of support who have provided guidance, motivation, and inspiration throughout this journey. I would like to take a moment to express my gratitude.

First, I want to thank the National Science Foundation, who made this research possible.

I also wish to thank the members of my dissertation committee – Dr. Josipa Roksa, Dr. Karen Inkelas, Dr. Peter Youngs, Dr. Allison Pugh and Dr. Brian Burt. More than anything, you are genuinely kind people who also happen to be remarkable scholars. Josipa, I am grateful for your thoughtful mentorship, dedication, and investment in me. It is an honor to call you a colleague and friend.

To my dear friends, my parents, and family – thank you for the support and encouragement. Justin, your friendship is truly a special gift. Thank you for the countless conversations and motivation throughout our mutual graduate school (and life) journeys.

Finally, to my wife and beautiful soul Victoria – you are my light, my love, and my laughter. I cannot imagine who I would be without you in my life these past 15 years. Thank you for your deep sense of care and compassion, and for loving me.

Beyond the Bachelor's: The Landscape of Inequality in Doctoral Education

While higher education facilitates opportunity and creates pathways to the middle class, it also fosters unequal access, experiences, and outcomes (Roksa et al., 2021). Scholars of education have spent considerable time exploring higher education's relationship to the larger society – including college's role in reproducing inequality. Colleges are important social contexts that can reinforce socioeconomic disparities (Collier & Morgan, 2008; Hamilton et al., 2018; Jack, 2016), reify gendered norms and expectations (Cech & Blair-Loy, 2014; Hart, 2006; Jacobs, 1996), and sustain racialized cultures that shape minoritized student experiences (Davis et al., 2004; Ray, 2019; Yosso et al., 2009).

As increasing proportions of individuals continue education beyond the bachelor's degree (Wendler et al., 2010), understanding how graduate education fosters inequality becomes increasingly important (Posselt & Grodsky, 2017; Torche, 2011). In terms of doctoral education in particular, previous research has noted differences in student experiences across race, class, and gender (e.g., Dinsmore & Roksa, 2023; Gardner, 2013; Griffin et al., 2018). This includes inequities across an array of developmental touchpoints within the social structure of graduate education that shape what is learned, how that learning occurs, and who doctoral students become as emerging scholars and scientists (Burt, 2019; Maher et al., 2019; Wofford et al., 2021). Understanding how distinct forms of inequality emerge, and are sustained, throughout specific stages of doctoral training in the STEM fields is critical to supporting the success of diverse scientists and future professionals in the workplace.

The manuscripts in this dissertation explore how inequality is manifested at specific points in time across the doctoral degree timeline in the biological sciences. They trace differences in doctoral student development through the role of relationships that mediate

pathways through graduate education and into the career. Below I outline the social foundations of student development in doctoral education, followed by a discussion of different dimensions of inequality that shape student trajectories.

The Social Foundations of Doctoral Education

There is a long history of higher education scholarship exploring how doctoral students are socialized for the discipline through engagement in their academic programs. By participating in multiple communities of practice (Wenger, 2010) that facilitate interactions with different people in the constellation of graduate student experiences, doctoral students learn disciplinary skills and knowledge. Among the most important sites of learning and development are experiences in the university community and in particular interactions with faculty advisors and peers (Golde, 2010; Weidman & Stein, 2003; Weidman & DeAngelo, 2020). Students participate in individual mentoring relationships with faculty (Antony, 2002; Austin & McDaniels, 2006) and social interactions with peers in the same academic or professional field (Gardner, 2008).

Over time, doctoral students adopt the norms of their disciplinary field – including the skills, competencies, knowledge, dispositions and identity transmitted through their academic learning experiences and relationships (Antony & Schaps, 2021; Baker & Lattuca, 2010; Gardner, 2009; Weidman et al., 2001). University experiences also include a range of field-specific learning practices (Golde, 2005). For instance, graduate students in science and engineering fields participate in research group experiences that serve as critical sites of social learning and identity development (Burt, 2017). Through progressive participation in the social structures of their disciplinary communities, doctoral students transition from students to emerging experts in their respective fields.

However, doctoral student socialization occurs within a social landscape that is subject to significant inequality. Previous literature reveals that graduate students with diverse backgrounds and career interests may have different socialization experiences which have critical implications for their success (Twale et al., 2016). Socialization is mediated by social backgrounds that interact with program structures, cultures, and practices in the graduate school ecosystem – including gender, race/ethnicity, and first-generation status. This is especially the case in the culture of STEM fields (Science, Technology, Engineering, & Math), where inequities in student experiences may be amplified (Griffin et al., 2020; Posselt, 2020).

Gender

Higher education research has increasingly explored how gender shapes student experiences in STEM doctoral programs (Maher et al., 2019). Doctoral program cultures in the STEM fields reinforce masculine norms (Bostwick & Weinberg, 2018; Sallee, 2011) and women experience less supportive relationships with their faculty advisors (Dinsmore & Roksa, 2023; Noy & Ray, 2012). Women may struggle to balance gender identity with the demands of scientific practice (Clark et al., 2016), and performing the graduate student role involves gendered expectations, creating tensions between family responsibilities and the structural pressures of the academic environment (Lynch, 2008). Social interactions with faculty and peers may play a more prominent role for women in their socialization and professional identity development as scientists (Šaras et al., 2018; Szelenyi et al., 2016). Advisors provide critical support to women (Tao & Gloria, 2019), but doctoral students' gender identities may also create systemic disadvantages in mentorship experiences (Curtin et al., 2016). The culture of scientific labs can foster sexism, requiring women to seek alternative social support beyond their advisors (Wofford & Blaney, 2021).

Race and Ethnicity

Doctoral education in the STEM fields also presents unique obstacles for students from minoritized racial and ethnic groups, who confront racialized academic cultures that have negative consequences for their experiences and outcomes (Griffin, 2018; Gildersleeve et al., 2011; Williams et al., 2018). For example, minoritized students describe more negative mentoring experiences with faculty (Brunsma et al., 2017; McCoy et al., 2015) and encounter racialized interactions that foster self-doubt in adequately performing the scientific role (McGee, 2020). Institutionalized discrimination shapes the socialization experiences of minoritized doctoral students, resulting in unequal access to professional developmental opportunities and faculty mentorship (Ramirez, 2017). Racial identity can also mediate graduate student career paths. Doctoral students' social and racial identities shape their research group experiences and understandings of faculty life, which has implications for their pursuit of professorial pathways (Burt, 2019).

First-Generation Status

Studies have also revealed some of the cultural barriers that first-generation college students must manage in their pursuit of the PhD. First-generation students in doctoral programs struggle to understand the 'hidden curriculum' of graduate school and faculty expectations (Gardner & Holley, 2011; Wofford et al., 2021), manage imposter syndrome in successfully performing the graduate student role (Gardner, 2013) and confront isolation from peers (Wallace, 2022). First-generation students pursuing graduate degrees often encounter additional psychosocial challenges, including amplified feelings of self-doubt and social disconnection within the larger student community (McCain & Roksa, 2023; Wallace & Ford, 2021). They often must work harder to understand the tacit rules of educational practice (Gable, 2021) and may not be aware

of what they do not know (Vasil & McCall, 2018). In addition, first-generation students begin graduate programs with different professional and academic knowledge bases than their continuing-generation peers who may have family members or family friends with graduate degrees (Kniffin, 2007).

How Inequality is Manifested at Different Developmental Stages

The professional socialization of doctoral students occurs across a series of interactive developmental stages as students' progress from novices to experts in their chosen fields over the course of their programs. Theories of graduate student socialization conceptualize student development across four sequential and interactive stages. This includes pre-program expectations in the anticipatory stage, coursework in the formal stage, research and mentorship with the advisor in the informal stage, and identity transformation in the personal stage (Weidman & DeAngelo, 2020). Across the interactive stages of socialization, doctoral trainees engage in the institutional culture of their programs through social interaction, integration, and learning – ultimately building towards professional commitment and identity formation (Sweitzer, 2009; Weidman, 2010; Weidman et al., 2001). As students' progress through the social structures of graduate school, they learn the skills, knowledge, attitudes, dispositions, and values of their chosen disciplinary community and professional field (Austin & McDaniels, 2006).

Previous research has in general focused on doctoral student experiences at different developmental touchpoints, including how graduate students develop research skills (Burt, 2017; Craswell, 2007; Feldon et al., 2019), the different roles of doctoral advisors (Curtin et al., 2016; Noy & Ray, 2012; Posselt, 2018), and professional identity development (Burt, 2019; Golde, 2010; Sweitzer, 2009). Importantly, the graduate student socialization model also extends into

the point of career entrance, where doctoral students transition to the labor market and become novice professional practitioners (Weidman & Stein, 2003).

The transition to work is a critical stage of continued development, yet little is known about doctoral student experiences at the point of job entrance. Some emergent research in doctoral education has begun to examine how diverse career destinations shape student socialization experiences – and especially differences in academic and non-academic pathways (McAlpine et al., 2021; Porter & Phelps, 2014). The career destinations of PhD graduates have never been more diverse, and doctoral degree holders are increasingly finding themselves in positions outside of academic settings. Indeed, the majority of PhD graduates now hold non-academic positions, regardless of career intentions (Vitae, 2016). Even so, very few studies focus specifically on understanding differences between student experiences in academic and non-academic careers – including implications for identity development (e.g., Guerin, 2020; Skakni et al., 2022). Examining students' experiences in academic vs. non-academic pathways is especially important as women, minoritized, and first-generation students are significantly underrepresented among faculty ranks, especially in the STEM fields (Casad et al., 2021; Dupree & Boykin, 2021; Morgan et al., 2022).

Data and Methods

The data for this dissertation are drawn from a large-scale collaborative project funded by the *National Science Foundation* (awards 1431234, 1431290, and 1760894). The Early Career Research (ECR) Project is a mixed-methods study of student development and equity among doctoral students in the biological sciences. This longitudinal study follows a national sample of over 300 doctoral students throughout graduate school and into the career transition. Each year, student participants completed surveys about their experiences and a subset of graduate students

participated in semi structured interviews. The number of respondents varies across chapters based on a specific set of questions examined in the dissertation.

The ECR Project focuses on student experiences across different stages of the doctoral program timeline, including the development of research skills and expertise, relationships with faculty mentors, and professionalization for the career. The STEM fields are a critical site of large-scale scientific training for the professional workforce, and the biological sciences play a particularly prominent role in this wider landscape, training the second largest number of doctoral students in the U.S. among all STEM fields (NSF, 2021). The culture of STEM and scientific labs also raises critical questions about marginalized student experiences, who must navigate environments with intense cultural pressures where inequities are often more amplified (Posselt, 2020).

Across the three chapters, I employed a constructivist methodological approach to qualitative analysis of narrative interview data (Creswell & Creswell, 2020). Qualitative research is particularly effective for understanding processes of meaning-making that people enact to interpret their experiences, including within social structures such as educational institutions (Corbin & Strauss, 2008). Interpretivist approaches to analysis are necessarily 'grounded' in the language of the participants, and center on how experiences, understandings, and perceptions shape important aspects of reality (Charmaz, 2000; Thanh & Thanh, 2015). As perceptions of reality embedded in social contexts, in-depth interviews can provide a variety of information – including how individuals understand cultural pressures (Pugh, 2013). The interviews in this dataset reflect how graduate students make meaning of experiences within the social structures of doctoral education and manage cultural pressures at different stages in their programs.

Outline of the Dissertation

The manuscripts in this dissertation explore how inequality is manifested in student experiences at different developmental stages in the doctoral student degree timeline. This includes the development of research skills and expertise in the earlier stages of doctoral study (year 3), the nature of relationships with faculty advisors in the later stages of socialization (year 5), and professional identity development during the career transition (year 7). The following manuscripts provide a critical window into understanding the role of inequality in STEM doctoral training at different points in students' developmental trajectories as scientists and professionals. More specifically, they reveal the racialized and gendered nature of research skill development, the role of family educational background in shaping faculty advisor relationship dynamics, and the influence of career destination on professional identity formation.

Manuscript 1 (Skill Building and Expertise): Beyond Technical Mastery: Inequality in Doctoral Research Skill Development in the Biological Sciences

While prior literature has noted other sources of inequality in doctoral student socialization experiences, few studies have examined the role of research skill development. Based on interviews with 87 doctoral students in the biological sciences, we explore how doctoral students describe development of their research skills. More specifically, we employ a constructivist approach to understand how doctoral students make meaning of their research skill development process, and how differences in perceived development might differ by gender and race/ethnicity. Findings reveal two emergent groups, 'technicians' who focus on discrete tasks and data collection, and 'interpreters' who combine technical expertise with attention to the larger scientific field. While both groups are developing important skills, 'interpreters' have a broader range of skills that are necessary for successful scholarly careers in science. Notably, group distributions reflect significant inequalities, with white men being overrepresented among

the ‘interpreters.’ The findings illuminate how the research skill development process is permeated by inequality and have important implications for equity in graduate education and beyond.

Manuscript 2 (Faculty Relationships): Support Without Status: Inequities in Student-Advisor Relational Dynamics Between First-Generation and Continuing-Generation Doctoral Students

One of the most important developmental relationships in the doctoral student experience is that of the faculty advisor, and yet we know little about whether and how advisor relationships vary between first-generation and continuing-generation doctoral students. Drawing on qualitative interviews with 83 late stage doctoral students in biological sciences, we explore differences in student perceptions of their relationships with advisors. Narratives reveal a continuum of relationship types including strained, evolving, supportive, and equal. In equal relationships, doctoral students feel more like collegial partners working alongside their advisors. While continuing-generation and first-generation students are similarly represented among strained and evolving relationships, first-generation students rarely attain equal relationship status. Presented findings have important implications for understanding how inequality shapes student-advisor relationships, the role of collegiality in doctoral education’s hidden curriculum, and the supports needed to foster equity for first-generation students in graduate programs.

Manuscript 3 (Professional Identity Development): Am I a Professional? Differences in Identity Development for PhD Holders in the Sciences On Academic and Non-Academic Career Paths

Despite the steadily increasing number of PhD holders who decide to pursue careers outside of academia, little is known about their experiences transitioning to different kinds of work. Drawing on qualitative interviews with 53 doctoral graduates in the biological sciences who recently began employment in academic and non-academic settings, this study explores differences in professional identity formation for PhD holders on diverse career paths. Interviews

reveal significant differences in the developmental trajectories of graduates within or beyond the academic workplace. Doctoral graduates who pivot to roles in the non-academic workplace encounter a new social context that galvanizes professional identity by validating expertise and fostering equal status with colleagues. In contrast, graduates who remain in academic contexts as postdocs have more independence but experience developmental stagnation – expressing a lack of identity progression in roles that mirror the labor conditions and non-professional status of graduate school. Findings have critical implications for supporting doctoral graduates navigating diverse career paths, and understanding how academic and non-academic social contexts foster unequal opportunities for professional development during career entrance.

Author Contributions

As the data for this dissertation were part of a larger collaborative project, it is important to outline the specific contributions made by each author across the papers.

- I conceptualized the core ideas, led the data analysis process, and wrote the first drafts of all three manuscripts.
- For *Beyond Technical Mastery* and *Support Without Status,* Josipa Roksa assisted with theoretical framing, argument structure, and peer debriefing at the analysis stage.
- For *Support Without Status*, Stephanie Breen contributed to the initial coding of the data, development of the codebook, and peer debriefing at the analysis stage.
- The last manuscript, *Am I a Professional?*, was conceptualized, written, and refined independently.

Publication Timeline: Manuscript Status as of March 2024

Beyond Technical Mastery: Inequality in Doctoral Research Skill Development in the Biological Sciences (McCain & Roksa)

- Published in *Studies in Graduate and Postdoctoral Education*
- Link: https://doi.org/10.1108/SGPE-05-2022-0037
- Presented at AERA 2021

Support Without Status: Inequities in Student-Advisor Relational Dynamics Between First-Generation and Continuing-Generation Doctoral Students (McCain, Roksa, & Breen)

- Resubmit with minor revisions in *Education Sciences* special issue – *Reimagining Equitable Student Support Across Phases of Graduate Education*
- Presented at ASHE 2023

Am I a Professional? Differences in Identity Development for PhD Holders in the Sciences On Academic and Non-Academic Career Paths (McCain)

- Complete manuscript draft written
- Planning to submit to *Studies in Higher Education*
- Planning to submit to ASHE 2024

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Beyond Technical Mastery: Inequality in Doctoral Research Skill Development in the Biological Sciences

Abstract

Purpose - This study examines how doctoral students in the biological sciences understand their research skill development and explores potential racial/ethnic and gender inequalities in the scientific learning process.

Design/methodology/approach - Based on interviews with 87 doctoral students in the biological sciences, we explore how doctoral students describe development of their research skills. More specifically, we employ a constructivist grounded theory approach to understand how doctoral students make meaning of their research skill development process, and how that may vary by gender and race/ethnicity.

Findings - The findings reveal two emergent groups, 'technicians' who focus on discrete tasks and data collection, and 'interpreters' who combine technical expertise with attention to the larger scientific field. While both groups are developing important skills, 'interpreters' have a broader range of skills that support successful scholarly careers in science. Notably, white men are over-represented among the 'interpreters,' while white women and students from minoritized racial/ethnic groups are concentrated among the 'technicians.'

Originality/value - While prior literature provides valuable insights into inequalities across various aspects of doctoral socialization, scholars have rarely attended to examining inequalities in research skill development. This study provides new insights into the process of scientific learning in graduate school. Findings reveal that research skill development is not a uniform experience, and that doctoral education fosters different kinds of learning that vary by gender and race/ethnicity.

Keywords: Doctoral education, research skills, inequality, STEM

Article type: Research paper

Introduction

Despite the growing representation of women and minoritized racial/ethnic groups in doctoral programs in the U.S., notable disparities in academic careers persist (Espinosa et al., 2019; National Science Foundation, 2018). Almost 90% of tenure-track faculty in the US are white and close to 60% are men (National Center for Education Statistics, 2022). The underrepresentation

of women and minoritized racial/ethnic groups is even more pronounced in STEM fields (Bennett et al., 2020). While much has been written about various factors that contribute to these disparities, prior literature has dedicated less attention to understanding how gender and racial/ethnic inequalities among faculty may be related to graduate school experiences, and in particular research skill development. Developing research skills is fundamental to doctoral education as students' progress from novices to independent researchers through learning the practices of their discipline or field (Austin & McDaniels, 2006; Golde, 2006) and developing their scholarly identities and intentions to pursue research careers (Burt, 2019; Forbrig, 2021; Holley, 2009). Thus, inequitable opportunities for research skill development could have notable implications for transitions into the labor market and pursuit of academic careers.

Prior literature on graduate students' experiences has noted ample ways in which women and students from minoritized racial/ethnic groups have less positive interactions with both peers and faculty (Garcia et al., 2020; Grim et al., 2021; McGee & Martin, 2011; Williams et al., 2018). This literature, however, has rarely paid attention to research skill development. Based on interviews with 87 third-year doctoral students in biological sciences, we find that graduate students discuss research and their scientific practice in two different ways: 'technicians' focus on discrete tasks and data collection, and 'interpreters' understand their research practices as part of a larger process of scientific discovery. Notably, distribution of students across those two groups varies by gender and race/ethnicity. White males are overrepresented among the 'interpreters', while women and students from minoritized racial/ethnic groups are concentrated among the 'technicians.'

These findings illuminate a crucial dimension of inequality in graduate education. While all doctoral students are developing important research skills and knowledge, only 'interpreters'

(who are disproportionately white men) are acquiring broader skills that help them situate their scientific work in the larger disciplinary field. Although prior literature has noted other sources of inequality in socialization experiences, these findings illuminate research skill development as an important site of inequality. Inequality in research skill development has notable consequences for scientific learning that may reverberate beyond graduate school, hampering equity in academia more broadly.

Conceptual Framework and Literature Review

Graduate Student Socialization and Research Skill Development

Socialization has been the primary framework for understanding graduate student experiences (e.g., Gardner, 2009; Weidman, 2010), and is understood as a process of internalization where students learn the skills, knowledge, attitudes, dispositions, and values of their disciplinary community (Austin & McDaniels, 2006). Doctoral study cultivates a number of different skill attributes, qualities, and professional competencies including the ability to conduct intensive scientific research (Craswell, 2007; Gilbert et al., 2004). Development of research skills is central to doctoral student socialization as graduate students' progress from novice to independent researchers (Golde, 2006) and transition from consumers to producers of knowledge (Weidman, 2010).

Although developing research skills is a crucial aspect of graduate education and identity development, relatively few studies have examined how students develop research skills (e.g., Feldon et al., 2011; Feldon, Maher, et al., 2016; Feldon et al., 2019; Harrison & Schunn, 2004). In a recent study, Feldon and colleagues (2019) relied on a longitudinal sample of graduate students to examine trajectories of research skill development over time using latent growth cure analyses. The findings revealed substantial differences in research

skill development and showed that students who had postdocs or senior graduate students actively involved in laboratory discussions exhibited more positive trajectories of research skill development. Other socialization experiences, such as teaching (Feldon et al., 2011), co-authorship (Feldon, Shukla, et al., 2016), interactions with postdocs (Blaney et al., 2020), and supervised research with faculty (Kaur et al., 2020; Overall et al., 2011) have also been identified as contributing to research skill development. These studies, however, rarely consider how research skill development may vary across sociodemographic groups.

Inequality in Graduate Student Socialization Experiences

While inequality has not always been a prominent dimension of socialization research, recent work has illuminated how race and gender produce inequities and shape student experiences in doctoral science programs (Griffin et al., 2018; Maher et al., 2019). Graduate program cultures in the STEM fields tend to support masculine norms (Bostwick & Weinberg, 2018; Sallee, 2011) and women report less supportive relationships with advisors (Dinsmore & Roksa, 2020; Noy & Ray, 2012). In addition, peers may play a more prominent role in their socialization experiences (Saras et al., 2018). Experiences with faculty and peers have important implications for perceived fit between gender identity and scientific practice (Clark et al., 2016), and shape emerging identities for female graduate students in STEM disciplines (Szelenyi et al., 2016).

Students from minoritized racial/ethnic groups contend with racialized cultures that have negative consequences for their experiences and outcomes (Griffin, 2020; Gildersleeve et al., 2011; Williams et al., 2018). One of the crucial experiences in doctoral education is mentoring, and minoritized students describe more negative mentoring experiences (Dinsmore & Roksa, 2020; McCoy et al., 2015; Ramirez, 2017). Ramirez (2017) described how institutionalized racism shaped the experiences of Latinx doctoral students, resulting in unequal access to

professional development opportunities and faculty mentorship. More generally, marginalized students encounter racialized experiences that foster self-doubt in performing the scientific role (McGee, 2020). Burt (2019), for example, reported that Black doctoral students' social identities actively shaped their research group experiences and understandings of faculty life, which had direct implications for their pursuit of professorial pathways. The socialization process is thus infused with inequality as organizational life is meaningfully shaped by gender and race/ethnicity.

While prior literature provides valuable insights into inequalities in socialization experiences, scholars have rarely attended to examining inequalities in research skill development. Moreover, a few recent studies addressing this dimension of socialization often focus on first-year doctoral students and provide mixed results. For example, Lachance and colleagues (2020) found that perceived skill self-efficacy increased during the first semester of doctoral training equally for women and men, while Flaster and colleagues (2020) indicated that women and minoritized students reported significantly lower levels of perceived disciplinary knowledge than their male and white counterparts (see also Owens & Lilly, 2017). One study that has considered research skill development beyond the first year reported no gender or racial differences (Feldon et al., 2019).

The present study advances this nascent area of inquiry by examining perceptions of research skill development among Ph.D. students in biological sciences at the end of their third year of doctoral education. More specifically, we examine how students' perceptions of their research skills vary by gender and race/ethnicity. This exploration has important implications for understanding inequalities in scientific learning and development of independent researchers.

Research Design

Institution and Participants

Data for this project are based on the interview portion of a mixed-methods study of students who entered biological science Ph.D. programs in the U.S. in the Fall of 2014. More specifically, the study is focused on "bench biology" – doctoral programs in fields including microbiology, cellular and molecular biology, genetics, and developmental biology. Students participating in the study complete annual surveys. In addition, a sub-sample of survey respondents were invited to participate in interviews. Given our interest in inequality in students' experiences, interviews were conducted at the institutions that had study participants from minorized racial/ethnic groups. Analyses presented herein are based on interviews with 87 students: 24 students from minoritized racial/ethnic groups (including African American, Latinx, and American Indian), 45 white women, and 18 white men. We did not disaggregate the minoritized category by gender due to the small number of cases (only 8 men and 16 women).

At the start of the study, participants completed a survey where they self-identified race/ethnicity and gender. Racial/ethnic categories included: American Indian or Alaska Native, Asian or Asian American, Black or African American, Latino/Latina, Hawaiian and Other Pacific islander, Other [fill in], and White. They could select multiple categories. We include any student who has selected African American, Latinx, or American Indian as one of their racial/ethnic categories as being a member of the minoritized racial/ethnic group. Overall, 10% of students in the sample selected more than one racial/ethnic category. In the case that students selected multiple racial/ethnic identities, that is noted in the text. Moreover, the survey included two gender categories (male and female). During qualitative data collection, participants were asked to indicate their preferred gender pronouns. Although given the opportunity, none of the participants changed their gender identity from what was indicated in the survey.

The third year is the ideal setting for addressing our research questions. Students in biological sciences rotate through different laboratories in their first year. They begin working in their permanent laboratories in their second year and are established in that space by the third year. They have become integral contributors to the research in their labs by that point in time, as well as started to conduct their own studies. This time represents the crucial nexus between being a graduate student and becoming an independent researcher, i.e., learning the skills and beginning to practice them in one's own work. Moreover, focusing on a STEM field is warranted given extensive literature documenting challenges women and racial/ethnic minorities face in the STEM disciplines (e.g., Chang et al., 2011; De Welde & Laursen, 2011).

Data Collection and Analysis

The qualitative portion of the study relies on in-depth semi-structured interviews (Patton, 1990). The analysis presented in this paper is based on interviews conducted via phone between June and September 2017. We focus on questions related to students' perceptions of research skills, including: What research-related skills or knowledge have you developed this past year? How would you describe your research-related strengths and research-related weaknesses?

We employ a constructivist grounded theory approach to data analysis (Charmaz, 2000). Constructivist approaches stress a relativist ontology that is epistemologically subjective (Denzin & Lincoln, 2000). This approach was a good fit for the study because we were interested in understanding how student perceptions of research skill development reflect meaningful distinctions in the nature of scientific research. Grounded theory aims to generate concepts inductively and is particularly useful in understanding individuals' lived experiences as they navigate social processes (Corbin & Strauss, 2008).

All interviews were recorded, transcribed, and coded using Dedoose software. In line with a grounded theory approach to data analysis, the first author developed an initial set of open codes based on reading through all of the manuscripts. As analysis progressed, we moved from more concrete codes to conceptual themes and categories that reflected the larger meaning that participants gave their experiences. This stage involved the use of axial coding wherein we used open codes and memos to make connections between categories. Finally, selective coding was used to craft a narrative about how the process of research skill development is given meaning by doctoral students. Both authors reviewed the codes and revised the codebook until reaching a consensus about the central categories (Saldaña, 2013). Through this process, two primary themes emerged for each question: a) science as technical activities (focusing on data collection and scientific procedure) and b) science as interpretation (emphasizing meaning and context in the larger field). We coded each question (research skill development, strengths, and weaknesses) as falling either in the 'technical' or 'interpretation' category. Following, we classified participants as either technicians or interpreters.

Students in the technical classification (technicians) contained no interpretation codes across any of the questions. This means that they were coded as 'technical' across all questions (research skill development, strengths, and weaknesses). The interpreter category included a few students who were coded as interpreters across all three questions. The majority (83 percent) of students in the interpreter category contained both technical and interpretation codes across the three interview questions.

Technicians focused on collecting data, technical and methodological procedures, and empirically carrying out their research. Interpreters engaged in technical activities as well, but they also discussed the meaning of their research and its relationship to the greater disciplinary

field of knowledge. Based on our analytical logic, the coding scheme reflects more of a continuum than a binary. Interpreters were also procedurally proficient, but their perceptions of the research process extended beyond technical execution towards understanding the broader context and scientific implications of data. To protect the identities of the participants, we use pseudonyms throughout our discussion of the interviews and do not disclose participants' institutions.

Trustworthiness and Positionality

By engaging in a constant comparative approach to data analysis, our codebook captured emergent findings and reinforced consistency in core themes. The initial codebook was generated collaboratively, and we followed peer debriefing protocol in making sense of the data through critical discussion of interpretation (Carspecken, 1996). To ensure trustworthiness, the first author coded all transcripts independently and wrote detailed analytic memos (Saldaña, 2013) focusing on specific excerpts, patterns, and themes across the narratives. Memos were then shared with the second author for review and critical discussion. Qualitative research analysis has been characterized as a "dialogic collaborative process" (Paulus et al., 2008) that involves substantial interaction between researchers (Creswell & Creswell, 2018). Collaborative dialogue was vital in establishing rigor and transparency throughout the analysis, and key findings were shaped through ongoing conversations grounded in the data. In addition to these steps, another researcher who is not an author on the paper coded 25 percent of the transcripts. The intercoder reliability was 90 percent, which meets the common standard used in the field (Barber & Walczak, 2009; O'Conner & Joffe, 2020).

In any endeavor of knowledge creation, researchers' subjectivities play a meaningful role across each stage of the study. Because interviews for this study are part of a larger project, the

authors did not collect the interview data. Interviews were conducted over the phone by researchers who identified as a white woman and an African American woman. The authors of this manuscript identify as a white man and a white woman. In addition, the authors hold advanced degrees in sociology and higher education. Thus, we are positioned as cultural outsiders in the context of natural sciences and bring a social scientific lens to bear on these environments.

Limitations

While this study makes important contributions to research on doctoral education there are a few limitations worth noting. First, it is important to acknowledge the limitations of interview data at one point in time. While this approach provides a valuable window into the lived experiences of the students in this study midway through their programs, it does not reveal how these patterns may evolve over time. In future research, it would be especially valuable to explore how students' understanding of skill development and the patterns of inequality may change over time. In addition, this study is focused on a specific discipline. While our results in the biological sciences may be more generalizable to experiences in similar STEM doctoral programs with lab settings, future studies are needed to examine how students' understandings of their research skill development vary across different disciplinary contexts, including the social sciences and humanities.

Findings

Data analysis revealed two distinct ways of practicing science that reflect significant differences in how students develop research skills and knowledge as emerging researchers. The first group, representing 60 percent of the overall sample, which we term 'technicians,' practiced science by focusing on discrete task execution, mastering specific techniques, and collecting data.

Conversely, the second group, which we call ‘interpreters,’ practiced science more like a scholar or PI would: they engaged the larger context of scientific knowledge creation by considering interpretation and meaning of their data, as well as contribution to the discipline.

Technicians and interpreters not only differed markedly from each other in their practice of science but also revealed notable inequalities across race and gender. White men were greatly over-represented in the interpreter category, while white women and students from marginalized racial/ethnic groups were over-represented among the technicians. More specifically, 72 percent of white men were interpreters, compared to only 31 percent of white women and 33 percent of students from minoritized racial/ethnic groups (see Table 1).

Table 1. Distribution of participants across analytical categories

	Interpreter	Technician
Minoritized racial/ethnic groups	33%	67%
White women	31%	69%
White men	72%	28%

Technicians and Skill Mastery

The experience of technicians was defined by an intense focus on the production of data through task mastery and technical skills. For technicians, being a scientist involved the increasingly more efficient performance of technical skills that signify proficiency. While producing data is a vital scientific skill, technicians did not make explicit connections between their data and its importance to the field.

Research Skills and Knowledge

Technicians understood the research process as the efficient execution of techniques. They focused on disciplinary technical expertise, efficiency, and the production of data. When asked what research related skills and knowledge she had developed over the past three years in her doctoral program, Ashley, a white woman explained, “I have developed a lot of technical lab skills. I have also been analyzing some deep sequencing data. With that, I’ve developed a lot of bio and grammatic tools.” A focus on expertise-oriented language and specialization was echoed in the responses of many technicians. Technicians understood their development as researchers in an empirical fashion that emphasized technical mastery. As Aaron, an African American man, noted the following when asked about his research skill development, “I’ve learned how to do a lot of new techniques for my project. I learned how to do chemistry… and a lot of new techniques for PCR and computation analysis as well.”

Technicians centered their skill and knowledge development around learning and mastering particular methodologies rooted in disciplinary expectations. In this sense, technicians understood being a scientist as executing discrete mechanical tasks with enhanced precision and confidence. When asked about her development as a researcher so far, Claire, a white woman, focused solely on conducting basic routines in the lab, “A lot of statistics and data analysis I would say. During my first two years I got pretty comfortable just doing the basic lab procedures that we do every day.” In a similar fashion, Justin, a white man, discussed how his development had centered on perfecting the same technical skills over and over again: “I would say I'm doing a lot of the same techniques in lab. I would probably say overall, I'm improving in them, just more practice.” Technicians often emphasized the repetitive nature of learning and relearning how to perform their technical craft more effectively. Doing was made more effective over time as students engaged in a seemingly endless flow of task-based behaviors. At times, doing lab

tasks in repetition seemed to overwhelm everything else. As Aaron further explained: “I just keep doing repetitions and keep doing everything to…try to learn it.” Chase, a Latinx man, reinforced this perspective when commenting, “science is just repeat, repeat, repeat.”

Technicians understood the practice of science as the production of data and efficient mastery of procedure above all else. They framed their development as researchers through empirical skills with little attention to the larger scientific process.

Perceived Strengths and Weaknesses

When asked about their strengths as researchers, technicians routinely emphasized technical ability and characteristics that allowed them to execute tasks. They stressed uniformity and consistency in the performance of specialized skills. Mary, a white woman, elaborated on these themes:

> I think one of my biggest strengths is that I’m very technically capable. I have a lot of research experience, as I mentioned, and that has given me the foundation to be able to very reliably do experiments, and very complicated experiments, and do them well.

Here technicians emphasized their confidence in reliably generating data with precision. Similar to their descriptions of skills and knowledge, responses stressed the value of tangible practices that relied on disciplinary expertise. Students often highlighted the value of consistency and repetition in their strength as a researcher. As Victoria, a white woman, said: “I’m extremely detail oriented. I always make sure that whatever I’m doing, I do to the best of my ability and make sure that I really think things through and perform the protocols the same way as every replicate.”

Technicians emphasized concrete procedures such as data collection and research design, with little engagement beyond procedural prowess. They focused on the performance of

scientific practices to produce and manage data. Tyler, who identified as an African American, American Indian, and white man, focused heavily on data collection as his primary strength, "I think my strengths would be data collection and analysis. I'm really good at actually collecting data." The designing of experiments was another common topic of discussion among the technicians. As Diana, an African American woman, related when asked about her strengths as a researcher:

> […] being able to design experiments and choose the right application for those experiments and answer the questions that I ask. Figure out which assays [scientific procedure in biology], what's best, I think that has been a great strength for me thus far.

Diana's response is typical of technicians, whose understandings of personal strengths focused on concrete actions and scientific procedures.

Perceived weaknesses revealed similar patterns of understanding. When discussing weaknesses, technicians routinely reflected on gaps in their sub-disciplinary expertise, talking in length about increasingly specialized aspects of biological science. David, a Latinx man, talked about not feeling comfortable with a specific procedure because of his lack of knowledge: "I didn't do physics in my undergrad or my grad program. When it comes to electrospinning, it's a lot of reading and intuition and hoping things go right…my limitation is my lack of knowledge in certain areas." The specialized nature of disciplinary research skill development was notable in its singular focus. Technicians defined their value as researchers through the routine execution of discrete tasks. When asked about her weaknesses as a researcher, Amber, a white woman, noted: "One of my weaknesses and something I've really been trying to work on is a lot of my bio-informatics knowledge." Amber distilled her research development goals even further than a set of technical practices to focus on a single, more specialized skill. Others echoed a similar

language of technical skill proficiency when speaking about their weaknesses. Casey, an African American man, quickly identified technical skill mastery as his most important area for improvement, noting, "I would definitely say I'm not as good at some of the technical skills in our field…I think that's definitely something that I'm working to become more technically proficient."

The graduate students in the study all worked in research labs and technicians often expressed the tension of meeting lab expectations in light of their previous research experience and training. At times this tension spilled over in discussing weaknesses, where technicians relayed the importance of having to become fast experts in specialized techniques. When asked about her weaknesses as a researcher, Brooke, a white woman, said:

> …my previous experience working in a research lab, I never had any exposure to programming. In that sense, I'm kind of starting from ground zero. It's like learning a new language…that's also why I haven't started to analyze my own data that I'm collecting is because I just don't know how to yet.

Across all of the questions addressing their research development, technicians focused on technical capability that dominated their conceptions of the research process.

Interpreters and The Larger Field

The second group of students, which we term interpreters, practiced and understood science in more expansive ways. Interpreters understood the practice of science as a combination of task completion and interpretation – i.e., framing their data within the larger field of science. Interpreters paired skill mastery with ways of thinking that imbued data with meaning and context.

Research Skills and Knowledge

Interpreters understood the research process in ways that stressed conceptual context beyond technical skills. Interpreters fused technical skills with qualitative aspects of scientific practice that imbued data with additional meaning. Interpreters talked about the discretionary aspects of knowledge production such as creative thinking, idea generation, analysis, judgment, and how their results fit within the bigger picture of the scientific enterprise. When discussing their development as researchers, interpreters often stressed the importance of understanding the larger scientific process implicated in conducting research. Eric, a white man, described the value of this knowledge when outlining his own development in graduate school, noting: "I came to grad school more to acquire skills and learn the scientific process and to become an expert in that."

At times interpreters made direct connections between the broader disciplinary narrative and theory development. When asked about developing skills and knowledge, Mark, a white man, shared this perspective: "…how to connect the dots and put together what the current, broader literature is saying about a particular aspect that I'm studying…you realize what's feasible and what's easily approachable and testable with the current limits of science." Mark echoed the language of other interpreters, highlighting important components of the larger scientific enterprise that shapes individual research. When asked what research related skills and knowledge she had developed over the past three years in her doctoral program, Megan, a white woman, noted: "This last year, well, I did a lot of idea development…I spent a lot of time trying to see how my ideas fit into the literature and what was novel about my ideas and what wasn't." Megan's conception of research skills and knowledge is multifaceted and includes attention to the meaning of data for the larger field.

Interpreters often described the importance of learning how their data could tell a story for the greater community of scholars. As Helen, a white woman, explained when discussing her development over time, she has learned to move beyond doing experiments "without clear purpose" to the ability to recognize how data relates to the larger field:

> We're more developing skills and trying to get the project to a point where it's publishable. I'm thinking more in terms of, "What can I do now to make this a part of my publishable story?," instead of just getting experiments done.

Interpreters used language in a more conceptual fashion than technicians, and their responses highlight notable differences in perceptions of the research process. While technicians emphasized detail, precision, routine and specificity, interpreters tended to speak about larger contexts, scientific generalities, and narrative arcs across time. Theresa, a Latinx woman, honed in on the value of learning what we don't know based on previous research: "After going through all the literature, being able to recognize what we don't know and what we need more work on and why it's important, I think is also an important thing to be able to do." As a whole, interpreters contextualized the products of science through an awareness of the larger field that gave data importance. For interpreters, the research process included the ability to identify how data contributed to a wider scientific conversation.

Perceived Strengths and Weaknesses

When discussing their strengths as researchers, interpreters talked about understanding the bigger picture of science as a vital aspect in their development. As Matt, a white man, noted: "A strength of mine, I think, would be seeing the bigger picture a little bit more. Not getting stuck down in the details or the specifics of the data, but looking more so at the bigger story."

William, another white man, expressed how the practice of science involves a connection between doing scientific procedure and understanding the larger context: “I would probably say knowing the field fairly well and being able to design experiments in an intelligent way using that knowledge.” When talking about her strengths as researcher, Cynthia, who identified as a Latinx and white woman, stressed the analytical and discretionary aspects of research skill development, noting: “My strengths are in creative thinking, in reasoning, and putting clues from the literature together.”

Jake, a white man, spoke in length about science on a grand scale that involves the interconnection of disciplinary ideas. When asked about his strengths as a researcher, he emphasized the value of synthesizing knowledge across multiple fields in order to make novel contributions to science as a whole, saying, “I think my biggest strength would probably be combining fields, combining ideas, making connections that other people would never think of.” Jake’s language is typical of interpreters, who understood scientific practice as an endeavor that requires a combination of technical and conceptual mastery.

Interpreters maintained similar language when discussing their weaknesses. They were aware that research involved more than technical skills but expressed a lack of confidence in their ability to think through the larger context. When asked about her weaknesses as a researcher, Emily, a white woman, noted: “I still have problems coming up, I would say, with big-picture future directions for a project.” Students sometimes framed grasping the “big picture” as an obstacle in finishing their graduate programs. As Greg, a white man, explained when discussing his weaknesses as a researcher: “I'd say that sort of big picture, asking—trying to figure out what are the right questions to ask. It's probably something that I definitely feel like I struggle with. It has…even backed up my Ph.D. career.”

Whereas technicians consistently emphasized the value of increasing specialization, interpreters reflected on the dangers of scientific tunnel vision. They emphasized cultivating disciplinary skills without losing sight of the grander narrative that shapes the research process, or as Katrina, who identified as a Latinx and white woman put it, of "being able to summarize everything." Interpreters often noted the importance of understanding the literature in order to fit their work into meaningful scientific context. From their perspective as emerging researchers, a command of the literature enabled them to give data meaning. Tim, a white man, reflected on his constant struggle to keep up with new academic knowledge in the field: "One weakness is just not knowing the full breadth of my field yet, so I always feel like I'm coming into something that I'm not an expert on yet, but being expected to operate at expert level."

Discussion

While research skill development is critical for development of scholarly identity (Burt, 2019) and transitioning from novice to independent researchers (Austin & McDaniels, 2006; Golde, 2006), few studies have examined how the research skill development process may vary by race/ethnicity and gender. Based on interviews with 87 students enrolled in biological science PhD programs, we find that doctoral students develop research skills unevenly, revealing notable inequalities. White men are substantially overrepresented in the interpreter category. Interpreters contextualize their research within the larger field of inquiry, while women and students from minoritized racial/ethnic groups are concentrated in the technician category. Technicians tend to focus on data production without attention to the larger field, often attending primarily to executing specialized tasks.

These findings indicate that certain aspects of the graduate student socialization process are not uniform experiences, and that doctoral education can foster different kinds of scientific

learning that vary by gender and race/ethnicity. Doctoral education supports different kinds of research skill development including both concrete technical knowledge and more abstract and contextual thinking (Bryan & Guccione, 2018; Mowbray & Halsey, 2010). Presented findings reveal inconsistencies in research skill development that help doctoral students situate their work in the larger field. Historically, the socialization literature has not given sufficient attention to the role of inequality in the transmission of skills, values, and dispositions (Twale et al., 2016). With traditional socialization models primarily reflecting a process in which students assimilate into the culture of their graduate programs, they have not always adequately captured the experiences of women and students from minoritized racial/ethnic groups. Our findings contribute to the more recent literature illuminating how graduate student socialization involves a critical interplay between structures and student identities (see Weidman & DeAngelo, 2020).

While our study reveals inequitable patterns of research skill development, it is not designed to explain them. Prior literature, however, describes how socialization is mediated by racialized and gendered structures that have significant impacts on the experiences of diverse graduate students (McCoy et al., 2017; Ramirez, 2017; Williams et al., 2018). In particular, experiences with advisors may be a crucial site in the cultivation of unequal socialization outcomes, including research skill development. Advising relationships play a powerful role in doctoral student experiences and supporting emerging scholarly identities (Barnard, & Shultz, 2020; Curtin et al., 2016; Lechuga, 2011; Wofford et al., 2021) and prior research demonstrates that gender and race mediate doctoral student advising relationships (Griffin, 2020; Noy & Ray, 2012).

Presented findings also may have important implications for inequality in scholarly career paths. Previous research indicates that faculty tend to value more interpretive skills such

as independent thinking and creativity among their doctoral students (Lechuga, 2011), and students from diverse backgrounds may be less aware that developing these kinds of skills is part of graduate training (Wofford et al., 2021). Tenure-track academic faculty emphasize the kind of "bigger picture" knowledge that is more typical of interpreters as these skills are valued among future professors in the academic workplace. Alignment between interpreter orientations and faculty expectations could have notable implications for raced and gendered differences in career outcomes. With white males disproportionately represented in the interpreter category, they are likely to be best positioned for faculty positions, further reinforcing and reproducing systemic inequalities among the professoriate.

Implications for Practice

Our findings indicate that graduate programs are cultivating different versions of scientific practice that vary by race and gender, which raises important concerns about equity in science. College learning environments have historically served as spaces of exclusion (McGee, 2020), and graduate students from all backgrounds should be actively supported in developing robust research skills. Administrative leaders and faculty in graduate programs would benefit from integrating unwritten disciplinary expectations into learning opportunities for graduate students such as the publishing process, professional practices in the field, and academic writing for a specific disciplinary community. In particular, they need to prioritize the explicit teaching of interpretative skills throughout the program. This could include implementing required workshops or courses that better prepare students to think more like scholars as part of their research development – with a deliberate focus on moving beyond the technical aspects of scientific work. It could also mean urging faculty to make different types of skills explicit throughout the curriculum. In addition, graduate mentor training could emphasize the importance

of developing interpretive and contextual thinking skills in working with doctoral students on their research projects. Instead of assuming that students will 'get it' through observation mentors could explicitly teach interpretive skills. These endeavors could be buttressed by summer bridge programs for students historically excluded from STEM that demystify academic science and explicitly discuss different forms of skills and knowledge needed to excel in an academic context (see Winkle-Wagner et al., 2020).

In addition, faculty mentors have the crucial responsibility of nurturing the next generation of scholars. While faculty may have benign intentions, mentoring is still subject to implicit race and gender-based discriminatory practices that may result in disempowering scholarly identity for women and students from minoritized groups (McCoy et al., 2015). Faculty mentors must actively empower women and minoritized students to see themselves as scholars. Minoritized doctoral students in STEM may be especially likely to benefit from research-based community practice opportunities and a sense of care in their advising relationships that promotes deeper personal connections (Griffin et al., 2020). By training faculty advisors to be more intentional in cultivating interpretive contextual thinking skills for all students, graduate programs can help disrupt patterns of inequality in skill development. Mentors cannot only provide doctoral students with opportunities to engage in the discrete practice of scientific data production; they need to be intentional about encouraging the type of conceptual thinking required to interpret data's meaning in the larger scientific field.

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Support Without Status: Inequities in Student-Advisor Relational Dynamics Between First-Generation and Continuing-Generation Doctoral Students

Abstract: One of the most important developmental relationships in the doctoral student experience is that of the faculty advisor, and yet we know little about whether and how advisor relationships vary between first-generation and continuing-generation doctoral students. Drawing on qualitative interviews with 83 late stage doctoral students in biological sciences, we explore differences in student perceptions of their relationships with advisors. Narratives reveal a continuum of relationship types including strained, evolving, supportive, and equal. In equal relationships, doctoral students feel more like collegial partners working alongside their advisors. While continuing-generation and first-generation students are similarly represented among strained and evolving relationships, first-generation students rarely attain equal relationship status. Presented findings have important implications for understanding how inequality shapes student-advisor relationships, the role of collegiality in doctoral education's hidden curriculum, and the supports needed to foster equity for first-generation students in graduate programs.

Keywords: first-generation students, doctoral education, STEM education, student-advisor relationship, cultural capital, inequality

Introduction

There is a long history of scholarship in higher education that explores the experiences of first-generation college students.[1] While a considerable amount of research has focused on the unique challenges encountered by first-generation students in undergraduate education (e.g., Ives &

[1] When we use the term first-generation, we refer to students who come from families where neither parent or legal guardian has completed a four-year college degree. This is an important clarification because definitions of first-generation students vary across the literature (Toutkoushian et al., 2018).

Castillo-Montoya, 2020; Pascarella et al., 2004), scholars have less often examined their experiences in graduate school. Given that a third of doctoral students in the U.S. are the first in their families to attend college (NSF, 2021), understanding how first-generation students experience the structures of doctoral education is crucial to supporting the specific needs of first-generation students in advanced education, ensuring their successful transition to professional careers, and creating the conditions for more equitable visions of graduate education.

Previous research on graduate education has revealed some of the barriers that first-generation doctoral students encounter in their pursuit of the PhD – including struggling to understand the 'hidden curriculum' of graduate school and faculty expectations, self-doubt and imposter syndrome, and social isolation (Gardner & Holley, 2011; Vasil & McCall, 2018; Wallace, 2022; Wofford et al., 2021). While describing the general challenges experienced by first-generation doctoral students, few studies have more closely examined their specific experiences in core aspects of graduate student life (see a discussion in Gardner, 2013). In particular, little is known about how first-generation doctoral students understand their relationships with faculty advisors, and how these perceptions may differ from their continuing-generation peers. This omission is critical, given that faculty advisors are among the most important relationships that shape doctoral student socialization, identity development, and career preparation (Burt, 2019; Sweitzer, 2009; Weidman & DeAngelo, 2020). Faculty advisors play a particularly prominent role in science, technology, engineering, and mathematics (STEM) fields, where students work in lab settings and confront cultural environments where inequities may be amplified (Burt et al., 2021; Maher et al., 2019; Posselt, 2020). If doctoral students from first-generation families understand the role of their advisors differently, it raises important questions about structural inequities that mediate the socialization process. Moreover, differences

in relational dynamics would have important implications for faculty, who may need to employ different mentoring strategies when advising students from first-generation and continuing-generation backgrounds.

The present study explores how first-generation and continuing-generation doctoral students in the biological sciences discuss their relational dynamics with faculty advisors in the later stages of their programs. As role models for how to successfully do the work of scientific and scholarly practice, faculty advisors, who often serve as students' principal investigators (PIs), play a central role in mediating how doctoral students experience the professional practice of research (Maher et al., 2013; McCain & Roksa, 2023). Faculty mentorship is particularly important in the later stages of the doctoral career, where students are expected to transition from novices to independent scientists and scholars (Golde, 2010). The later stages of the PhD are an intense educational phase with professional pressures during the dissertation process that exert heightened levels of stress and anxiety on doctoral students (Sverdlik & Hall, 2020). Because they often manage additional psychosocial, familial, and financial stressors in pursuit of the PhD, first-generation graduate students are particularly vulnerable to increased risks of attrition as they work to cross the finish line of their doctoral programs (Seay et al., 2008; Wilcox et al., 2022). Understanding differences in faculty relationship dynamics in STEM is crucial because these relationships play an important role in developing the next generation of professional researchers – including supporting students with diverse backgrounds, such as first-generation students, who are significantly underrepresented in STEM fields (Bettencourt et al., 2020; Dika & D'Amico, 2015).

Drawing on interviews with 83 fifth year doctoral students in biological sciences, we find that students characterize their relationships with advisors along a continuum including strained,

evolving, supportive, and equal. First-generation and continuing-generation students share similar experiences in strained and evolving relationships. Among more positive relationships, there are nuanced yet important differences. First-generation students often had instrumentally supportive advisors who fulfilled their academic and professional needs, but they rarely built collegial relationships with their advisors. In contrast, a much higher proportion of continuing-generation students expressed growing collegiality and understood their advisors in ways beyond sources of support: they were collaborative partners who felt more like peers with equal status. The existence of relationships that doctoral students describe as equal is notable, and challenges typical conceptions of relational hierarchies and power imbalances that permeate the culture of academia. Furthermore, substantial underrepresentation of first-generation students within these experiences is an important finding, which draws attention to more nuanced forms of inequality embedded in the social realities of graduate school's hidden curriculum.

By exploring the spectrum of relational dynamics that underlie faculty advisor relationships in the later stages of doctoral study, our findings reveal how relational inequities meaningfully shape student experiences in doctoral STEM education. In addition, understanding differences in how students understand their faculty advisors across diverse educational backgrounds is a central aspect of furthering equity in doctoral education. These relationships serve as developmental bridges to the profession and play a foundational role in doctoral student socialization. First-generation students rarely attain collegial status, which could have wide-ranging implications for professional development and career trajectories.

Conceptual Framework and Literature Review

This study uses theories of social reproduction, specifically cultural capital and habitus (Bourdieu, 2018; Nash, 1990) to understand the socialization experiences of first-generation

students in doctoral education (Weidman & DeAngelo, 2020). Socialization theory has been a predominant framework in studies of doctoral education, and especially in American educational contexts (Acker & Haque, 2015). This lens is often used to explore how doctoral students navigate educational milestones and experience developmental transitions across the course of their studies (Gardner, 2010). While scholars of doctoral education have increasingly attended to race and gender inequities in student experiences and outcomes (Crumb et al., 2020; Noy & Ray, 2012; Wofford & Blaney, 2021), they have less often considered first-generation background. Within the landscape of critical approaches to doctoral education, there are a few notable exceptions that have drawn on sociological frameworks to better understand the socialization experiences of first-generation and working-class doctoral students (e.g., Gardner & Holley 2011; Gopaul 2011, 2019). Following and extending this work, we rely on Bourdieu's (2018) concepts of cultural capital and habitus. Through this lens, doctoral education can be understood within a larger social context, in which educational systems serve as engines of inequality that reinforce inequities in society (Bourdieu & Passeron, 1977; Lamont & Lareau, 1988).

Doctoral Socialization and the Role of Faculty Advisors

Scholars of higher education have often drawn on socialization frameworks to understand learning and development in doctoral education (e.g., Gardner, 2008; Weidman, 2010). As students' proceed through the social structures of graduate school, they learn the skills, knowledge, attitudes, dispositions, and values of their chosen disciplinary community and field (Austin & McDaniels, 2006; Weidman & DeAngelo, 2020). Doctoral education is a progressive developmental journey that cultivates personal transformation over time – from knowledge acquisition, investment, and involvement in the earlier stages of study, to identity transformation and new role commitment in the later program stages (Burt, 2019; Gardner, 2008; Sweitzer,

2009; Weidman, 2010). Thus, the later years of doctoral study are an especially important developmental phase, where student trainees begin to make the critical transition from novices to professional scientists (Baker & Pifer, 2014; Golde, 2010).

In navigating the structures of graduate education, doctoral students participate in a constellation of social relationships that facilitate learning and development during their studies (Baker & Lattuca, 2010), including interactions with peers (Gardner, 2007), postdocs (Blaney et al., 2020), professionals (Sweitzer, 2009), and in particular, experiences with professors in their field including faculty advisors (Austin & McDaniels, 2006). Faculty advisors are critical agents of socialization (Burt, 2019), and their relationships with doctoral students play a primary role in student development across the program timeline (Sweitzer, 2009). Their role is especially critical during the later stages of study, where doctoral students' emerging professional identities begin to crystallize during the transition to independent researchers. In STEM fields, and especially the laboratory sciences, faculty advisors (or PIs) play a particularly prominent role in shaping students' experiences. For example, the nature of faculty advisor relationships in doctoral education influences persistence decisions (Maher et al., 2020), skill building and career paths (Blaney et al., 2022), and development as independent researchers (Wofford et al., 2021).

In addition, there is growing research examining the different types of relationships doctoral students have with their advisors, including how inequality mediates student experiences (Crumb et al., 2020; Noy & Ray, 2012; Sallee, 2011). Faculty advisors serve in a wide range of developmental roles for their students including mentors, mediators, supervisors, managers, and role models (Bieber & Worley, 2006; Schneijderberg, 2021). Beyond academic assistance, faculty advisors also provide psychosocial and emotional support, behavior modeling, and career sponsorship (Curtin et al., 2016; Posselt, 2018). Doctoral students may have negative

relationships with advisors who feel inaccessible, transactional, unhelpful, or uninterested (Barnes et al., 2010). There is also increasing research on the role of racialized experiences and sexism in shaping inequitable doctoral student advising, including differences in student perceptions of their advisors (Dinsmore & Roksa, 2023; McCoy et al., 2017; Rose, 2005). Noy and Ray (2012) found that race and gender influenced how students understood their advisor's role, revealing a spectrum of types including affective, instrumental, intellectual, available, respectful, and exploitative. Moreover, in a study of racially minoritized STEM doctoral student advising experiences, Griffin et al. (2020) noted that students valued advisors who demonstrated personal care and relational support. Doctoral students' perceptions of their advisors offer insights into social dynamics that have important consequences for their success, especially for marginalized students who may particularly benefit from closer relationships with faculty (Burt et al., 2021).

Less common, however, are studies that specifically examine first-generation college students pursuing graduate education (Gardner, 2013), and especially their relationships with faculty advisors. While some recent work has problematized socialization models to better account for the structural conditions that shape the experiences of students with marginalized backgrounds (e.g. Gopaul, 2019; Posselt, 2018), those frameworks do not adequately account for the unique challenges that first-generation college students may encounter. In order to understand the experiences of the students in this study, we complement socialization with a structural approach by relying on Bourdieu's cultural tools: cultural capital and habitus.

Cultural Capital, Habitus, and First-Generation Students

Theories of social reproduction draw attention to the resources, in the form of capital, that provide access to educational institutions and foster success in navigating their requirements.

According to Bourdieu, individuals cultivate economic, cultural, and social capital throughout the life course through previous experiences, family socialization, and community membership (Bourdieu, 2018). Capital is activated through one's habitus, or "web of perceptions about opportunities and the possible and appropriate responses in any situation" (Walpole, 2003, p. 49). Habitus can be understood as the internalization of social structures that shapes attitudes, perceptions, and actions. An individual's habitus creates dispositions towards opportunities and relationships, which may be rewarded based on the larger social context, or field, in which the struggle for resources takes place (Bourdieu, 1977). In studies of educational systems, habitus has often been used to understand differences in student expectations and dispositions towards engaging with education institutions and their agents (i.e., faculty and staff).

As a bounded lens of perception about what is possible in any given situation, habitus is often expressed through socioeconomic status and education. People from the same social class tend to have shared expectations that shape social interactions in mutually beneficial ways (Bourdieu & Passeron, 1977; Walpole, 2003). Differences in social class impact thoughts, feelings, and behaviors, and inform dispositions towards authority (Manstead, 2018). For example, individuals from working-class backgrounds may tend towards deference while the middle-class learn entitlement and personal advocacy. These tendencies inspire specific behaviors, shaping interactions with authority figures and understandings of how they should or should not engage in these relationships (Lehmann, 2014; Reay, 2004). Bourdieu argued that social institutions, such as universities, expect and reward the cultural knowledge, competencies, and expectations associated with more advantaged social classes (Bourdieu, 2018; Nash, 1990). Among these tendencies are help-seeking behaviors like asking faculty questions and attending office hours (Jack, 2019; Richards, 2020), actions that require college students to be confident in

working directly with those in a position of power. As a result, students from socioeconomically advantaged backgrounds can more effectively navigate educational institutions and draw on their cultural knowledge to cultivate the kind of relationships that translate into educational success and rewards. This process involves the accrual of knowledge, or cultural capital, about how to successfully navigate doctoral education and the hidden curriculum of graduate school (Calarco, 2018), including how to interact with faculty advisors and build collegial relationships. While rarely defined explicitly, in a doctoral education context, collegiality has been described as a form of peer learning, a professional relationship, and a symbol of agency as students become active participants in their graduate training (Brown, 2021; McAlpine & Admundsen, 2009).

While ample literature on undergraduate education has relied on a cultural capital lens, (Armstrong & Hamilton, 2013; Collier & Morgan, 2008; Jack, 2019; Reay et al., 2009), that is less often the case for studies of doctoral education. Bryan Gopaul's work is the most significant example of using social theory to understand how inequality impacts the socialization experiences of doctoral students, and the role of doctoral education in exacerbating social inequality (Gopaul, 2019). His research reveals the crucial role of cultural capital and habitus in navigating the unwritten rules of doctoral education (Gopaul, 2011, 2016). For example, drawing on interviews with 15 doctoral students in engineering and philosophy, Gopaul found that students struggled to understand the implicit expectations of doctoral study that enabled success in their programs, and instead relied on faculty to act as translators (Gopaul, 2015). Because habitus includes perceptions that structure possible modes of action, it has important implications for how doctoral students understand and engage with their faculty advisors.

The role of capital is a critical perspective in discussions of first-generation college students, given that first-generation background, family income, and socioeconomic status are

closely interrelated (Nguyen & Nguyen, 2018; Terezini et al., 1996). Indeed, existing work on first-generation doctoral students has often drawn on cultural capital and habitus to explain student experiences (Gardner, 2013; Gardner & Holley, 2011; Holley & Gardner, 2012). Based on semi-structured interviews with 20 first-generation doctoral students across a diversity of disciplines, Gardner and Holley (2011) found that first-gen students often struggled to understand the "hidden rules" of academic life that are instrumental to success in a doctoral program including program expectations and navigating the system of academia. In a follow up paper using a similar interview structure, Holley and Gardner (2012) noted that first-generation doctoral student experiences were highly influenced by discipline-specific cultures and norms (such as working with faculty advisors). First-generation students tend to enter graduate school without comparable professional models in their families and generational knowledge that shape expectations of what doctoral study requires (Gardner, 2013; Kniffin, 2007). For first-generation students, socializing relationships such as interactions with faculty advisors play a particularly prominent role in orienting expectations and a "cognitive map" for how to engage in graduate school (Lovitts, 2001). Drawing on autoethnographic interviews with two doctoral students in music education, Vasil and McCall (2018) noted that first-generation students are not always aware of what they do not know and this impacts their performance of the doctoral student role. As a whole, doctoral students from first-generation families often have to work harder to understand the unwritten rules and norms of educational practice – and this includes navigating graduate school (Gable, 2021).

Doctoral students from first-generation families encounter specific cultural challenges that shape their experiences including feelings of imposter syndrome and social isolation, and these challenges are amplified by racial inequities (Wallace, 2022; Wallace & Ford, 2021).

While there are no known differences in representation for first-generation doctoral students by gender, racially minoritized doctoral students are more likely to be first-generation than white students (19%), with Latinx (52%), American Indian/Alaska Native (51%), and Black (41%) students identifying at the highest rates (Mitic, 2022). Using a narrative inquiry approach, Wallace and Ford (2021) conducted interviews with seven Black first-generation doctoral students and found that students experienced racialized self-doubt, feelings of invisibility, and lack of institutional support in explaining how to navigate the doctoral education process. In addition, first-generation students may have different experiences and expectations in working with their faculty advisors. Wofford and colleagues (2021) interviewed over 100 early stage doctoral students in a STEM discipline and found that first-generation and continuing-generation students had similar overall expectations of their advisors, but they tended to ascribe different meanings to the same concepts. Most first-generation students expected more direct, skill-based guidance while their continuing-generation peers typically expected independence and support for their specific needs. Importantly, the expectations of the continuing-generation students in this study were more closely aligned with how faculty tend to think about doctoral student development.

In the present study, we extend prior literature on doctoral education and first-generation student experiences by focusing on relationships with faculty advisors in the later stages of socialization. More specifically, we examine how students describe and understand their advisor relationships during the fifth year – a critical stage where students have undergone a transition from novices to more independent researchers. While previous research has revealed differences in doctoral socialization experiences by educational background (Gardner, 2013; Gopaul, 2015; Roksa et al., 2018; Wallace & Ford, 2021), few studies have explored how first-generation

students understand and make meaning of their advising relationships towards the end of their programs. We thus ask the following research questions:

1. How do fifth year doctoral students in biological sciences characterize their relationships with faculty advisors?
2. How do understandings of these relationships vary between first-generation and continuing-generation students?

By examining doctoral students' perceptions of their relationships with advisors, we provide important insight into how first-generation and continuing-generation students understand the purpose of faculty advisors – and their own role within that relationship.

Methods

Data Collection

The data for this manuscript is drawn from the interview portion of a national mixed-methods study of 336 biological sciences PhD students across 53 research intensive universities who began doctoral programs in the U.S. in Fall 2014. The biological subfields included represent "bench biology": microbiology, cellular and molecular biology, genetics, and developmental biology. To recruit participants, we reached out to program directors and department chairs of the 100 largest biological sciences doctoral programs with information about the study and a request to share information with their incoming graduate students. To further diversify the prospective pool of study participants, we also contacted relevant departments in public flagship universities (research intensive), historically Black colleges and universities (HBCUs), and Hispanic-serving institutions (HSIs). In addition, emails outlining the study and eligibility requirements were shared over several STEM related professional listservs. All participants gave

their informed consent to participate in the study, and this research was conducted in accordance with social science ethical review guidelines.

The doctoral students were followed over time throughout the course of their programs and into career entrance. Each year, participants completed a survey about their experiences in graduate school. In addition, a sub-sample of survey respondents were invited to participate in semi-structured interviews each year (average length of 45 minutes) to capture more depth about their specific experiences – including skill development, professional intentions, and important relationships within and beyond their doctoral programs. Using theories of graduate student socialization as a guide, follow up questions asked students to elaborate in particular on their ongoing relationships with faculty advisors.

Context of STEM and the Lab Sciences

While the developmental role of faculty advisors is prominent for all doctoral students, the STEM fields have specific characteristics that may amplify the importance of this relationship. Doctoral students in the lab sciences are often financially dependent on advisors and their professional activities are constrained by the parameters of their advisor's research projects and grants (Maher et al., 2019). In addition, student trainees tend to work in very close proximity to their advisors within the physical space of the lab and must follow rigid time requirements – often spending considerable hours each day participating in the work of scientific practice alongside their advisors (Maher et al., 2013). In the STEM fields, PhD students' social and professional worlds are more closely tied to their advisor's experiences and expectations. In addition, the nature of funding and structure of the research process create an environment where faculty advisors play a particularly prominent role in student experiences and their development as scientists. Biology is also an especially important context to explore within the larger STEM

education space. The biological sciences have an outsized influence in the wider landscape of scientific professions, training the second largest number of graduate students in the U.S among all STEM fields (NSF, 2021).

Interview Participants

The present study is based on interviews with 83 doctoral students in the summer after their fifth year of graduate study, including 61 continuing-generation students and 22 first-generation students. Among continuing-generation students, participants included 44 women (72%) and 17 men (28%), 48 white students (79%), 5 Black students (8%), 3 Latinx students (5%), 3 Asian students (5%), and 2 students who identified with multiple racial/ethnic groups (3%). The first-generation students in the sample included 14 women (64%) and 8 men (36%), 12 white students (55%), 4 Black students (18%), 2 Latinx students (9%), and 4 students who identified with multiple racial/ethnic groups (18%). The fifth year occurs towards the end of the degree timeline, and thus is an ideal time to examine the culmination of socialization experiences that shape the later stages of the doctoral program, including how students understand their relationship with faculty advisors. Interviews were conducted virtually and subsequently transcribed and coded.

Analysis

This is a descriptive qualitative study, based on identifying themes and patterns within the text of long form narrative interviews (Creswell & Creswell, 2020). Qualitative methods center on processes of meaning-making that individuals enact to make sense of their experiences (Hesse-Biber & Leavy, 2010; Patton, 2003). We relied on a grounded approach to data analysis, shaping core concepts inductively through close readings of interview transcripts (Charmaz, 2000). Inductive approaches stress the importance of language and ways in which participants' words reflect deeper understandings and dispositions. This methodological lens is particularly effective

for understanding how people draw meaning from lived experiences and interactions in social structures such as educational institutions (Corbin & Strauss, 2008).

All interviews were recorded, transcribed, and coded using Dedoose qualitative analysis software. An iterative approach to data analysis was employed given limited research on this topic and our interest in understanding differences between first-generation and continuing-generation students' advisor relationships in the later phases of doctoral study. We focused on questions related to student-advisor interactions and relationship development, including: How has your relationship with your faculty advisor changed or evolved over the past year (if at all)? Can you tell us more about the nature and quality of that relationship? In addition, follow up questions focused on the role of faculty advisors in student success and career development. Throughout the interviews, students were encouraged to talk openly about relational dynamics with their advisor, including reflections on their perceived role in the later stages of the doctoral program. We began with open coding to identify descriptive topical areas in student responses followed by axial coding to organize the key characteristics of different advisor types (Corbin & Strauss, 1990). After initial rounds of coding, we relied on selective coding to clarify important characteristics among the responses and ensure consistency. All three authors reviewed the codes and revised the codebook throughout the analysis stage (Saldaña, 2013). During this process, sets of descriptive codes began to emerge that clustered around four different types of relational dynamics. Strained relationships were marked by interpersonal challenges, and included descriptions such as 'conflict,' 'tension,' and 'negative emotions.' Evolving relationships were defined by positive changes and language of transition, and included descriptions such as 'working past challenges,' 'improvement,' and 'getting better.' Supportive relationships were characterized by general satisfaction and instrumental support, and included descriptions such as

‘good relationship,’ ‘contentment,’ and ‘professional support.’ Lastly, equal relationships were described as collaborative partnerships with shared collegiality, and included language such as ‘collaboration,’ ‘validation,’ ‘colleagues,’ and ‘peer status.’ These groups reflected different relational dynamics doctoral students’ described during their experiences with advisors in the fifth year of their programs. After identifying the four main relational dynamic typologies, we compared distributions for first-generation and continuing-generation students.

Trustworthiness and Positionality

The role of the researcher is an important methodological consideration in any research process, and this is particularly salient in the social context of qualitative work (Reyes, 2020). Following the interpretivist tradition, we aimed to strike a balance between our own preconceptions and the language of participants. To ensure trustworthiness and reliability (Denzin & Lincoln, 2000), multiple team members completed an initial round of coding independently and created analytical memos focusing on themes, patterns, and concepts within the student narratives (Saldana, 2013). We then met multiple times as a full research team to compare notes and engage in collaborative dialogue towards reaching consensus on core themes (Paulus et al., 2008). In addition, we followed peer debriefing protocol throughout this process to discuss our interpretations and refine them over time (Carspecken, 1996), and the codebook was generated collaboratively. Team-based qualitative research analysis is a social process that requires ongoing interaction between researchers to ensure rigor and transparency in making sense of the data (Creswell & Creswell, 2018).

We also acknowledge our own preconceptions as participants in this project and grapple with this subjectivity in order to explore the meaning embedded in the experiences of others. While this meaning is distinct from our personal beliefs, our perceptions are necessarily shaped

by our own lived experiences. As scientists, we are attuned to the characteristics of a methodologically rigorous research process, but our positionality is operating in tandem with the work. It is especially important to note that all three authors were first-generation college students and hold experiential knowledge that is particularly relevant to the context of this project. This unique perspective may have aided in understanding the lived experiences of the first-generation students in this study. At the same time, this vantage point may have made it more challenging to interpret the data objectively without expectations about student experiences. In addition, all authors are social scientists and as such occupy a different cultural landscape than the STEM disciplines, and thus may not be as attuned to particular aspects of student experiences in the lab sciences.

Limitations

While we offer important insights about student-advisor relationships and inequalities based on first-generation status, a few limitations are worth noting. Students in this study were asked to describe any changes in their advisor relationships over the past year, but the interviews are cross-sectional and not longitudinal. We are thus not capturing how student-advisor relationships may change throughout graduate study. It is possible that more students develop collegial relationships with their advisors as they progress through the doctoral program. Given that we have interviewed students toward the end of their PhD programs (summer after the fifth year), we are likely capturing most of the collegial relationships. In addition, while we acknowledge students' gender and racial identities, we intentionally amplify their first-generation backgrounds for the purposes of this study. We did not approach this study with the intention to explore within-group variation when students held multiple marginalized identities, and the small number of students in racially minoritized categories prevents us from exploring intersectional

experiences. We recognize that first-generation students are not a monolithic group, and the role of intersectional identities in doctoral advisor relationship dynamics is an important area for future research. Finally, advisor relationships are central to doctoral education across fields, but the specific dynamics described in this study may manifest differently in graduate contexts outside of lab sciences in the STEM fields. The disciplinary cultures of the lab sciences are structured to facilitate the practice of scientific research in settings where students work particularly closely with their faculty advisors.

Findings

We explored doctoral students' relationships with faculty advisors in the later stages of socialization, a key transition period in their development as independent scientists. Results revealed a spectrum of relationship types, including strained, evolving, supportive, and equal, summarized in Table 1. Moreover, we examined how relationships may vary between first-generation and continuing-generation students. The results indicate that first-generation and continuing-generation students were similarly distributed among strained and evolving relationships. However, there were significant differences among more positive relationships, with first-generation students much less often discussing relationships in which they are treated as equal or seen as colleagues (see Table 1). We begin by briefly highlighting similar experiences and then focus on examining key differences in more depth.

Table 1. Distribution of Participants by Relationship Type

Relationship	Description	Cont gen	First gen
Strained	Relationship marked by interpersonal challenges	30% (18)	23% (5)
Evolving	Relationship with recent improvements	21% (13)	23% (5)
Supportive	Instrumentally supportive relationship	23% (14)	45% (10)
Equal	Collegial partnership with shared status	26% (16)	9% (2)

Similar Experiences in Strained and Evolving Relationships

Nearly half of all participants noted relationships that were strained or evolving. Strained relationships were defined by conflict and tension with advisors, while evolving relationships were notable for a focus on recent improvement. Similar proportions of first-generation and continuing-generation students experienced these relationship types. The presentation of results mirrors that distribution and includes quotes from both first-generation and continuing-generation students.

Strained Relationships

Strained relationships were characterized by challenges. Often, students with strained relationships described navigating situations with their advisor that involved conflict and escalating emotions. In general, these relationships were defined by interpersonal conflict. As Claire, a white continuing-generation student, noted:

> There was definitely some, I don't know if you'd call 'em fights, but my PI obviously wasn't happy that I started being very ambitious and motivated and plugged in to get this paper published, and then I just finally crashed and hit a wall.

When talking about her current faculty advisor relationship, Claire emphasized mounting tensions that boiled over into conflict. Many of the students with strained relationships emphasized negative or hostile interactions. Hazel, a white first-generation student, shared similar thoughts when discussing her advisor relationship. She focused on interpersonal conflict and managing the stress of these experiences:

> Yeah, it was really bad. She was very verbally abusive, tried to sabotage me and stuff. She was just not a good person. She's an amazing scientist but not a good person…I would break out in hives I was so stressed out.

Brandon, a white first-generation student, noted how his advisor's behavior resulted in frustration, saying, "He wants me to develop this abstract, in preparation for that, which, at times, is difficult, because I'll prepare something, and he won't really look at it, and say that, 'You need to go work on this.' Sometimes, it's a little frustrating there." As a whole, students with strained relationships emphasized conflict and emotionally challenging interactions as defining features of their advisor experiences. Experiences with negative interactions were echoed by Amelia, a Latinx continuing-generation student, who focused on arguments with her advisor, noting, "We've had a few—not—kind of, I guess, more antagonistic conversations lately. I mean not like yelling matches or anything, but we've had some arguments."

Evolving Relationships

When discussing interactions with their faculty advisors, another group of participants stressed experiencing recent improvements in relationships that were evolving. Among doctoral students who affirmed evolving relationships, they described certain characteristics that defined those developments. Evolving relationships were characterized by working through challenges and associated improvements in relational dynamics. For example, Carter, a white continuing-generation student, reflected on a strengthening relationship that required putting past challenges behind:

> I think it's actually improved a lot, my relationship with my PI. We had some troubles to start off at the beginning of my career, but I think we've kind of put

> those past us. I've gotten over, just I guess, growing pains, per se. Actually, I think it's going pretty well.

Carter's response emphasized changes as his relationship has continued to develop over time. This tone was echoed by a number of participants, who focused on evolution as growing pains in their advisor relationships. Elaine, a first-generation student who identified as Latinx and Asian, expressed a similar sentiment, focusing on improved relations that were notably better than in the past, "It's gotten a lot better. We got new students in the lab, and I was the only person training them and stuff. I feel like she realized my value, I guess. Relations between us got better."

Evolving relationships were defined by notable improvement and working through challenges towards healthier relationships. When discussing the characteristics of her faculty advisor relationship, Allie, a white first-generation student, focused on how coming to terms with personal differences spurred healthy evolution in the relationship, saying, "I think they evolved. They definitely evolved. I kind of just accepted that he is the way he is and I am the way I am, and I didn't cower—or not cower." Relationships in flux shared similar characteristics – they stressed relational improvements in the later years of graduate study that often required navigating the growing pains of relationship building.

Inequality Across Supportive and Equal Relationships

Among more positive relationships, we identified two distinct types. Some students had generally supportive relationships with their advisors that met their basic expectations of academic and professional support in a doctoral program. A smaller group of students described a transformational shift in how they related to their faculty advisor. More specifically, they focused on increased collegiality and a sense of partnership – they felt more like equals than students. While we observed similarity between first-generation and continuing-generation

students in strained and evolving relationships, more positive relationship types reveal notable inequalities. Equal relationships were much more prominent among continuing-generation students than first-generation students, who were more likely to report generally supportive relationships. The discussion of results reflects this difference, emphasizing first-generation student quotes in the section on supportive relationships and continuing-generation in the section on equal relationships.

Supportive Relationships

Supportive relationships were characterized by general satisfaction and a focus on academic and professional support. Students often stressed how their relationship with their advisor had not changed much over the past year – relationships were supportive and static. Logan, a white first-generation student, noted little change in a generally "good relationship," and focused primarily on how his advisor continued to provide professional support:

> I would say they haven't really changed that much. I guess I've asked for a little bit more professional advice, postdoc advice, stuff like that. Whereas, I always got professional advice, but I think maybe in the past we weren't really talking in definitive terms…I think he is supportive in all research-based questions…we have a good relationship.

Logan's language is emblematic of generally supportive relationships: they were satisfactory and largely the same as in years past. When asked how her faculty advisor relationship has evolved or changed over the past year, Stacey, a Latinx first-generation student, noted a similar sense of stasis, "No. I don't think so. I mean if I'm not mistaken, I mean, my PI and I have had a good relationship since I started my program and that hasn't changed at all." This perspective was shared by Josh, a white continuing-generation student, who stressed general contentment and

lack of significant changes in his advisor relationship: “I would say not much has changed over the past year. We still have a good relationship.”

Students with supportive relationships often highlighted their advisor’s focus on academic and professional support. When describing her advisor relationship, Emma, a white continuing-generation student, emphasized instrumental support:

> Good. Very supportive…she’ll just come into the grad student office sometimes and chat with us, and—or we’ll do the same. We’ll just pop into her office if we just wanna chat about something. She’s great about giving feedback and supporting my research and stuff…it’s a good relationship.

Madison, a white first-generation student, used similar words when reflecting on interactions with her advisor, who was supportive of her career goals:

> Our actual relationship together, I would still say is pretty strong. He’s definitely there when I need him to be and offers a lot of great advice and support. I will say he’s been very encouraging of a lot of the things I mentioned in the last question of career development, career exploration.

Madison’s response is generalized and affirmative – summing up the relationship as overall “pretty strong” while focusing on professional assistance. Her words express a general satisfaction with instrumental support that was echoed by other students. A white first-generation student named Camille used similar word choices to characterize her advisor relationship, “It’s strong, and it’s really, I guess productive and supportive… I would say it feels like a pretty strong relationship, and I’m happy to be in the situation that I’m in.”

When talking about her relationship over the past year, Elizabeth, a white first-generation student, expressed a similar sentiment and noted her advisor's support of professional opportunities:

> There's been some bumps in the road, but overall, I think we have a good relationship. She and I get along really well personally. She's been pretty supportive of me. She's supportive of my plans to apply for this fellowship, and—I don't know, I feel good.

Anthony, a white continuing-generation student, used parallel words when talking about his advisor relationship. Overall, he characterized the relationship as good and supportive with a general sense of contentment, following a common thread among supportive relationships:

> I have a generally really good relationship with my PI. I think she's been very supportive and happy with my progress, the progress that I've made. I mean, there's been very few, in this last year, disagreements. We're pretty generally on the same page…she's been very supportive and very—yeah, we've had a good relationship this past year.

In these and other examples, it was evident that students' supportive advisor relationships were defined by instrumental support and minimal developmental changes in the later stages of doctoral study. As a whole, students in supportive relationships used positive – and generalized – language in articulating the nature of relational dynamics with their advisors.

Equal Relationships

In contrast to generally supportive relationships, some students talked about experiencing a transformative shift in how they related to their advisors. These students often used language that implied a newfound sense of shared status with their advisors, including characterizing the

relationship as one of collaboration between equal partners. As Emily, a white continuing-generation student, expressed when describing how she now related to her advisor in a fundamentally different way:

> I think what has shifted or changed or evolved is that I am not seeing him so much as an authority figure or a superior or a PI, if you will. I feel that he is my colleague, and consultant, and advisor. He's here to have somewhat a drawing board for me when I need someone to talk through how to do things or if I'm getting stuck, he'll help think through it with me. I definitely feel like we are evolving more to this place of equals than any type of hierarchical position in the relationship.

Emily's words illustrate a common theme among students in this category. Many of them understood the advising relationship in more expansive ways beyond sources of instrumental support, focusing instead on the meaning and impact of collaboration with their advisors as professional peers. For example, Mary, a continuing-generation student who identified as Latinx and white, discussed interactions that felt increasingly collaborative and collegial, which enabled her to more fully participate in the scientific process with her advisor on a higher level:

> …I think we're also able to talk at a little bit of a higher level about my science where we come as two equals to the conversation now instead of her mostly advising me on the things that I should do. I feel our relationship this year has gotten a lot stronger in which we're able to work off of one another instead of having more of a primarily advisory role.

Reflecting on interactions with her advisor over the past year, Mary emphasized a pivot from seeking guidance towards a relationship with more mutually shared input.

Doctoral students with equal relationships often experienced an identity evolution – from seeing themselves primarily as students to feeling more like professional peers working alongside their faculty advisors. This perspective was shared by Kyle, a white continuing-generation student, who said the following when asked about his advisor relationship, "I think they evolved more so to be more of a colleague relationship more than like a PI and graduate student." Here, Kyle noted a transition that changed how he related to his advisor and, in the process, his own identity as a scientist. When elaborating on her experiences, Tara, a white continuing-generation student, shared a similar perspective, noting an important shift from receiving information in the graduate student role to participating in scientific work with her advisor in a more collaborative way:

> Because as opposed to being taught something by my mentor, we were as colleagues working through this new information. I think that part of our relationship really changed in that instead of coming to him and asking for just tell me what you think, it was more of a discussion between the two of us…it really felt more like a partnership than it had in the past.

A number of students in this study connected status changes to increased engagement with their advisors in a more collegial way, for example, participating in scientific discussions on the "same level" as their advisors. This was emblematic of Anna's experience, a white continuing-generation student, who shared the following about interactions with her advisor, "I feel like in this last year, her and I have been somewhat on the same level, I would say. I'm very respected as being in my fifth year…so, my ideas mattered, and my contributions were more important." Morgan, a white continuing-generation student, used similar language, discussing

how working more closely with her advisor has shaped her overall relationship and growth as a scientist:

> I think in the past year, because I've grown so much as a scientist, we have maybe a more—like seeing each other on the same level type of relationship. We had to work together directly a lot more 'cause she's presented some of my work, and of course, working together to get it written up. I think I described this last time a little bit. She definitely has favorite students in the lab, and I don't know if I'm one of them, but I think that we've definitely developed a closer relationship in the past year…I think she just relates very differently to different students.

Molly, a white first-generation student, similarly discussed cultivating a closer relationship with her advisor, including working together on professional projects that strengthened collegiality:

> I think that this past year, I've gained a lot more reputability and respect, because the times that we have met and discussed things one-on-one have been because of bigger accomplishments, like I'm going to a conference. I'm working on this manuscript. I'm addressing revisions. I'm scheduling my defense. Those types of conversations made it feel more collegial.

This transition towards increased collegiality was shared by other students with equal relationships. David, a white continuing-generation student, summed up his relationship by describing an evolution from graduate student status to participating in elevated discussions that enabled him to identify more as a peer with his advisor, saying, "I think maybe if anything there was just a lot of growth in terms of the way in which we discuss more—we became more as peers discussing and much less graduate student, [advisor] relationship."

While first-generation students often understood their advisors as sources of general support and professional guidance, they rarely experienced changes in perceived status and how they related to their advisors. Continuing-generation students more often perceived their advisors as professional colleagues, reflecting growth in mutual status that enabled them to participate in science in a different way.

Discussion

Although previous scholarship has explored some of the general challenges experienced by first-generation students in doctoral programs (Gardner, 2013; Gardner & Holley, 2011; Vasil & McCall, 2018; Wallace & Ford, 2021), prior research has rarely attended to their relationships with faculty advisors. In particular, little is known about how perceptions of the advisor relationship may differ for first-generation and continuing-generation students during the later stages of their doctoral programs – a critical developmental stage where students are transitioning from novices to independent researchers. We address this omission by drawing on interview data with 83 doctoral students in the biological sciences. Our findings reveal a continuum of relationship types including strained, evolving, supportive and equal. First-generation and continuing-generation students described similar experiences among strained and evolving relationships. However, among more positive relationships with advisors, nuanced yet critical differences emerged. First-generation students were overrepresented among generally supportive relationships that met instrumental needs in the doctoral program, while continuing-generation students were overrepresented among equal relationships where students felt more like collaborative partners.

The presented findings extend prior work on graduate student socialization (Antony & Schaps, 2021; Weidman & DeAngelo, 2020) and the role of faculty advisors in doctoral student

development (Burt, 2019; Golde, 2015). The role of the faculty advisor is particularly prominent for doctoral students in the later stages of socialization, where advisors mediate entrance into the profession, helping usher students through the transition to fully independent scientists. Indeed, faculty advisors are critical agents of socialization and identity development for doctoral students, yet our findings demonstrate that students may experience very different relational dynamics. While there were similarities in the strained and evolving relationships, first-generation and continuing-generation students described significant differences in how they understood supportive relationships with faculty advisors. Continuing-generation students were much more likely to cultivate collegial partnerships with their advisors. These partnerships were important markers of perceived status and scientific growth, and enabled doctoral students to embody the professional role through collaboration with their advisors on an equal playing field, which makes this difference particularly meaningful. These results reveal that it is critical to consider not just whether faculty advisors are supportive of doctoral student success, but unpack the specific relational dynamics that shape how students interact with – and learn alongside – their advisors.

In addition, this study makes an important contribution to understanding the various ways that inequality shapes student experiences in graduate education and in particular experiences with faculty advisors. A few previous studies have used theories of social reproduction to explore first-generation students' experiences in PhD programs, emphasizing the cultural and social challenges they encounter in graduate school (Gardner & Holley, 2011; Gopaul, 2015, 2019; Holley & Gardner, 2012; Wofford et al., 2021; Wallace, 2022). Previous research has also noted how other marginalized identities, including race and gender, mediate doctoral student socialization experiences with advisors (Burt et al., 2021; Noy & Ray, 2012; Ramirez, 2017).

We extend this body of research by using cultural capital and habitus to understand differences in how first-generation college students understand faculty advisor relational dynamics in doctoral programs. First-generation students rarely understood their advisors beyond authority figures and resources for instrumental support, while continuing-generation students more often saw their advisors as collegial partners, engaging with them as equals in the scientific process. To understand these patterns, social reproduction theory provides a critical lens that centers structural inequality. Differences in cultural capital interact with habitus to shape perceptions of what is possible, expected, and rewarded within the social contexts of education (Bourdieu, 2018; Gopaul, 2016). These cultural forces operate in graduate training, where dispositions toward authority and mentorship play an important role in mediating doctoral student socialization and development. First-generation college students enter the cultural worlds of doctoral education with a set of learned preferences that are marginalized, and must manage mismatches in behavior and expectations that emerge through relational inequities (Wofford et al., 2021). The presented findings provide an important contribution for understanding inequity in doctoral education that reflects the nuanced spectrum of challenges, and cultural capital reservoirs, that shape student experiences in PhD programs.

While cultural capital and habitus provide a compelling lens for understanding observed differences, it is possible that other differences between first-generation and continuing-generation students contribute to these patterns. The most likely alternative explanation is a difference in career goals: if continuing-generation students are more likely to aspire to academic positions, it may follow that they would be more likely to build collegial relationships. However, that is not the case in this study. In reviewing career expectations, we find that both groups of students were almost evenly split between academic and non-academic career paths – with 52%

of continuing-generation students and 50% of first-generation students expecting to pursue an academic career.

Implications

The findings of this study also have important implications for practice in higher education. Mentorship is a core aspect of faculty life and doctoral advisors perform a variety of roles in guiding students through their programs (Bieber & Worley, 2006; Rose, 2005). Student-faculty relationships contain implicit power imbalances (Friedensen et al., 2023), and relational dynamics have critical consequences for student development and professional socialization. As key agents of socialization, faculty advisors should actively support and cultivate robust relationships with their doctoral students that provide opportunities for collaborative partnership. These relationships are especially important for first-generation doctoral students, who navigate the social landscape of graduate school differently and may rarely feel like partners. Faculty should emphasize the importance of working together on scientific problems and engaging in deeper discussions about research with their doctoral advisees. These kinds of pedagogical approaches and practices reflect the language of students with more equal relationships in this study who often focused on participating in 'higher level' scientific discussions with their advisors.

In addition, higher education institutions need to take seriously structural changes that support more equitable experiences for first-generation doctoral students. First-generation students may not expect or understand how to cultivate collegial relationships with faculty, which is a critical site of inequity in their experiences. For first-generation students in the pursuit of the PhD, reimagining more equitable support means actively demystifying the unwritten expectations of doctoral education that foster success, including interpersonal dimensions such as

building collegial faculty relationships. Success in graduate school requires students to understand the tacit rules of educational practice – or 'hidden curriculum' – that underlie expectations for how to perform the doctoral student role in ways that are professionally rewarded (Calarco, 2020; Pensky et al., 2021). Graduate programs should create and institutionalize initiatives that work to dismantle, and make transparent, the hidden curriculum of doctoral education. They could, for example, develop courses, workshops, and programming designed to make visible the cultural knowledge and social expectations of pursuing doctoral study, and especially the role of relational dynamics in socialization. In addition, universities should encourage more opportunities for peer socialization and collaboration among doctoral students, providing first-generation students more opportunities to see different ways of engaging with faculty. By intentionally creating more educational spaces where graduate students across different educational backgrounds can work alongside faculty together, doctoral programs can empower first-generation students to understand their faculty advisors in more expansive ways beyond sources of instrumental support. Serving the whole graduate student requires actively engaging with individual student needs, unique experiences, and overall sense of wellbeing as integral components of supporting doctoral student success (Syncox et al., 2017). Holistic support in doctoral education should take into account the unequal social playing field and specific cultural barriers that first-generation students encounter when navigating the interpersonal dimensions of faculty mentorship. Considering different dimensions of inequality is especially crucial in settings of STEM doctoral education and the lab sciences, where cultural pressures are often amplified and exacerbate inequities in student experiences (Posselt, 2020).

Understanding differences in first-generation and continuing-generation doctoral student experiences with faculty advisors is critical, given that these professional mentors mediate

student development throughout the graduate school journey and into career entrance. Scholars have noted that structures of doctoral student socialization can exacerbate existing inequalities and amplify cumulative advantage (Gopaul, 2019). The patterns observed in this study have implications for hampering equity in doctoral education by stratifying access to certain types of socialization experiences occurring at the interactive level of relational dynamics. If first-generation doctoral students rarely see themselves as colleagues and partners to their advisors, they may be less likely to pursue academic career paths or be less equipped to succeed in scientific roles that mirror their faculty advisors. Exploring, and rectifying, differences in how students with marginalized social identities understand and engage with core aspects of doctoral education, such as faculty relationships, is critical for advancing equity in graduate education.

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Am I a Professional? Differences in Identity Development for PhD Holders in the Sciences On Academic and Non-Academic Career Paths

Abstract: Despite the steadily increasing number of PhD holders who decide to pursue careers outside of academia, little is known about their experiences transitioning to different kinds of work. Drawing on qualitative interviews with 53 doctoral graduates in the biological sciences who recently began employment in academic and non-academic settings, this study explores differences in professional identity formation for PhD holders on different career paths. Interviews reveal significant differences in the developmental trajectories of graduates within or beyond the academic workplace. Doctoral graduates employed in non-academic workplaces encounter a new social context that galvanizes professional identity by validating expertise and fostering equal status with colleagues. In contrast, graduates who remain in academic contexts as postdocs have more independence but experience developmental stagnation – expressing a lack of identity progression in roles that mirror the labor conditions and non-professional status of graduate school. Findings have critical implications for supporting doctoral graduates navigating diverse career paths, and understanding how academic and non-academic social contexts foster unequal opportunities for professional development during career entrance.

Keywords: doctoral education; non-academic careers; professional identity; career trajectories

Introduction

While a considerable amount of research has explored student experiences navigating doctoral education, much less is known about life beyond graduate school. This is especially the case for PhD holders on non-academic career paths, even though roles outside of academia comprise the majority of post-graduate employment outcomes (McApline & Amundsen, 2016; Vitae, 2016).

For example, in the United States and Canada, less than 25% of PhD holders can expect to secure a tenure track position during their time on the job market (Etmanski et al., 2017; Hayter & Parker, 2019). This paradigm shift in expert labor raises critical questions for universities who must successfully prepare PhD students for careers beyond the university, including navigating the social landscape of diverse work cultures. Despite the sea change in doctoral degree destinations, there remains a substantial disconnect in practice, as most doctoral programs focus predominantly on preparation for academic careers (Gardner & Doore, 2020). This misalignment is significant, given that the majority doctoral graduates will not enter academic careers and instead will forge ahead into professional cultures unknown. With the lion's share of doctoral graduates now finding themselves in non-academic positions, understanding differences in how PhD holders experience the transition to work within and beyond academia is crucial to supporting their long term professional success.

Previous research on doctoral education and work transitions is limited. Existing research has explored the expertise, professional competencies, and application of skills from doctoral education to the career (Burt, 2017; Durette et al., 2016; Mowbray & Halse, 2010). Some recent studies have explored more specific relationships between doctoral education and employment, including career preparation, motivations, and intentions to pursue different types of careers (Bloch et al., 2015; Chen, 2021; Hayter & Parker, 2019; McAlpine & Amundsen, 2018). An emergent body of work has begun to explore doctoral graduate career transitions more closely – including social and cultural challenges during the transition to work beyond academia (Guerin, 2020; Skakni et al., 2022; Vitae, 2016). While describing some of the challenges experienced by PhD holders entering non-academic work settings, much less is known about how doctoral students experience professional identity development during the transition to diverse careers.

This is a critical omission, given that the career transition is an important stage of continued development and PhD holders encounter a wide array of work cultures after graduation. Professional identity is central to successful post-PhD careers as it enables individuals to better understand their role in the work environment, shapes confidence in job performance, and cultivates personal wellbeing (Holland et al., 2012; Toubassi et al., 2023).

Existing models of graduate student development acknowledge that socialization for the career involves work-related communities, but there is little research or theorization of how graduate students experience professional identity during the career transition – in particular across academic and non-academic contexts (Baker et al., 2013; Gardner & Barker, 2020; Sonnenschein, 2020). To contribute to this literature, the present study addresses the following questions: how do doctoral students understand their professional identities during the transition to work, and does this experience vary for students pursuing academic and non-academic career paths?

Conceptual Framework and Literature Review

Doctoral Student Transitions to Work

While scholars have spent considerable time understanding doctoral student experiences and development within their graduate programs (Weidman & DeAngelo, 2020), much less is known about how students experience the transition to employment. The career destinations of PhD holders have never been more diverse, and doctoral students are increasingly pursuing careers outside of academic settings (Vitae, 2016). Previous research has focused on how doctoral students choose their career paths (Hayter & Parker, 2019; McAlpine & Amundsen, 2018; Seo et al., 2020), including non-academic pathways (McAlpine et al., 2021), and the ways that the labor market shapes job preferences (Bloch et al., 2015). Doctoral graduates who intend to pursue

academic ambitions value the autonomy and intellectual challenge that scholarly positions provide (Alfano et al., 2021; Bloch et al., 2015). Conversely, those choosing non-academic positions tend to prioritize job stability, financial incentives, and opportunities to fulfill evolving career aspirations (Roach & Sauermann, 2017; Sauermann & Roach, 2014). Increasingly, researchers have explored the transferability of skills learned in doctoral education to non-academic roles (Blickley et al., 2013; Porter & Phelps, 2014). Within this work, scholars have drawn attention to possible mismatches between the expertise and skills developed in PhD programs and the expectations of employers (Barnacle et al., 2020; Ghosh & Grassi, 2020).

Studies that focus specifically on doctoral student experiences during the transition to work are scarcer. A few studies have examined the role of social networks in the job search process (Germain-Alamartine et al., 2021; Yang et al., 2022) and overall job satisfaction of PhD holders (Sinche et al., 2017; Van der Weijden et al., 2016). However, less common are studies that focus on how recent doctoral graduates actually experience the transition to work in academic and non-academic roles - including their perceptions of professional identity. The research that has been conducted in this area is limited, and primarily focuses on the challenges for doctoral students entering non-academic work cultures (Guerin, 2020; Skakni et al., 2022). This project contributes to this emerging line of research by exploring how STEM doctoral graduates who recently transitioned to work in academic and non-academic settings understand their professional identities.

Identity Development and Professional Socialization

Identity is a socially situated phenomenon that involves being recognized as a certain kind of person and identifying with a specific community (Gee, 2000; Stets & Burke, 2003). Identity development indicates an individual will assume certain values, ideas and norms based on

identification with a social community (Alvesson, 2000; Evetts, 2013). Identities also shape how people choose to present themselves and the social groups they engage and relate to (Lee & Roth, 2004). Identity theory (Burke & Stets, 2022) has progressed considerably over the past decade, increasingly acknowledging that people hold multiple identities connected to their performances in society that change across different social contexts (Gee, 2000). This includes work-related professional identity that reflects how one understands themselves as a professional in the work environment (Pratt et al., 2006; Stets & Harrod, 2004).

Professional identity development is the social process of becoming and being recognized as a professional kind of person (Nyström, 2009). Through professional identity development, individuals are able to order and understand their work environment, which contributes to personal wellbeing (Toubassi et al., 2023). Identity development is a critical component of professionalization because work is often an important aspect of one's sense of self (Billett, 2007; Tomlinson, 2013). Professional socialization is the cultivation of skills, values, attitudes, and knowledge within a specialized subculture that shapes identity for the career – and is especially relevant for individuals undergoing expert training such as graduate students preparing for career entrance (Page, 2005; Weidman & DeAngelo, 2020). The process of professional identity development explored in this project is focused on interactions between higher education and work (Nyström et al., 2008; Tomlinson & Jackson, 2021). Previous scholarship has investigated how professions are learned through higher education (Hodkinson et al., 2008) and in general have focused on individual transformation, personal sense-making, and student participation in professional identity development (Trede et al., 2012). By participating in the structures of doctoral education, novices in training develop professional identities over time across a range of social experiences.

Professional Identity in Doctoral Education

Professional identity development is a core outcome of doctoral education as graduate programs train specialized experts for professional roles. Doctoral education is a socialization process where students learn new skills, competencies, and knowledge mediated by social relationships (Antony & Schaps, 2021; Gardner, 2008; Weidman et al., 2001; Weidman & DeAngelo, 2020). A large body of scholarship draws attention to experiences within the university community and in particular interactions with faculty advisors and peers (Golde, 2010; Weidman & Stein, 2003). Here, socialization and identity development occur through individual mentoring relationships with faculty (Antony, 2002; Austin & McDaniels, 2006) and social interactions with peers in the same disciplinary field (Gardner, 2010; Golde, 2005). University experiences also include a range of field-specific learning practices (Golde, 2007). For example, doctoral students in science and engineering fields participate in research group experiences that serve as critical social sites of learning and identity development (Burt, 2017). Doctoral students engage in a variety of relationships at different stages throughout their educational journey from coursework and into the career. Increasingly, researchers are exploring how other social contexts, including interactions with professionals, contribute to graduate student development (Baker & Pifer, 2011; Burt, 2019; Sweitzer, 2009).

Less attention has been dedicated to understanding doctoral student professional identity development at the point of transition to work. Professional development continues throughout the career transition – a critical developmental stage where doctoral students experience immersion in the social context of the workplace and engage in interactions with colleagues. The present study explores how students understand their professional identity during the transition work, and how this experience varies for students in academic and non-academic settings. To

that end, I ask the following research questions: How do doctoral students understand their professional identities during the transition to full time work? And do their understandings vary depending on whether students pursue academic or non-academic careers? While previous literature has noted that work-related relationships play a role in student career preparation, little is known about how they contribute to professional socialization and identity development, especially when compared to experiences in academic positions such as post-docs. Moreover, prior literature on doctoral student development has not dedicated much attention to understanding variation in students' experiences pursuing academic and non-academic positions. By comparing the experiences of recent doctoral graduates during their transition to work in academic and non-academic settings, the present study illuminates key differences in identity development related to diverse career journeys.

Methods

This study employs qualitative research methods and specifically in-depth interviews (Gerson & Damaske, 2020) to understand how doctoral students experience changes in professional identity during the transition to work in academic and non-academic careers. Qualitative approaches amplify processes of meaning making that people enact to make sense of their lived experiences (Patton, 2003). Qualitative research methodologies are rooted in constructionist theories of knowledge which assume that reality is shaped through interactions between people and their social worlds (Charmaz, 2000; Denzin & Lincoln, 2000). In-depth interviews focus on facilitating open-ended responses that enable core analytical concepts to emerge inductively within the text or from 'the ground up.' Grounded methodological approaches aim to generate concepts derived organically from the language of participants and their experience of a phenomenon (Strauss & Corbin, 1998). Further, grounded approaches are particularly useful in

understanding lived experiences as individuals navigate social processes such as graduate education and the transition to work (Corbin & Strauss, 2008). This analytical approach is particularly useful in this study because identity development is a socially situated experience that involves interactions between people and their surrounding social and cultural contexts (Stets & Burke, 2003).

Interviews are a good fit for this project because I am interested in understanding how doctoral students give meaning to their transition into different types of careers – with a specific focus on their professional identity development. By varying career destination type, I can explore differences in how students make sense of their professional identity development during the transition to work in diverse career paths. To guide data analysis, I rely on a grounded approach to draw themes inductively from the language of the participants. This includes close reading of the narrative text to identify patterns across student experiences in their transition to the labor market, with special attention to any differences that emerge between academic and non-academic career destinations.

Recruitment and Data Collection

The data for this study are drawn from the interview portion of a national mixed-methods study of graduate students who began doctoral programs in the U.S. in the Fall of 2014. The graduate students were followed longitudinally across the course of their doctoral programs and into the career transition. The study focused on biological sciences, including subfields of microbiology, cellular and molecular biology, genetics, and developmental biology. Doctoral students were asked to complete annual surveys about their experiences in graduate school. In addition, a sub-sample of survey respondents were invited to participate in yearly semi structured interviews to

better understand their lived experiences in graduate school including important relationships, professional milestones, and career development.

The present study is based on interviews with 53 doctoral students in their 7th year who recently transitioned to full-time jobs in diverse contexts, including 28 students in academic positions (postdoctoral scholars) (53%) and 25 who were employed in non-academic contexts (majority research related roles in biotech, government, and health) (47%). The distribution of respondents across career paths is similar to current employment patterns for doctorate holders in the STEM disciplines (National Science Foundation, 2021). Interviews were conducted with participants who had been in their job 1-2 years, and time on the job did not systematically vary between the academic and non-academic career paths. Graduates in postdoctoral positions were all employed in different labs than where they completed their PhD. Racial and gender demographics by career path are summarized in Table 1, and a complete list of interview participants is included in Table 2. The underrepresented racial/ethnic minorities (URM) category includes students who identified as Black and Latinx, as the sole or one of multiple racial-ethnic categories; the non-URM group includes students who identified as White and/or Asian.

Table 1. Participant Demographics by Career Path

	Academic	**Non-Academic**
Gender		
Women	20 (54%)	17 (46%)
Men	8 (50%)	8 (50%)
Race/Ethnicity		
URM	8 (53%)	7 (47%)
Non-URM	20 (53%)	18 (47%)

Table 2. Interview Participants

Pseudonym	**Race/Ethnicity**	**Gender**	**Career Path**
Emily	Latinx	Female	Academic
Matt	White	Male	Academic

Heather	White	Female	Academic
Lauren	White	Female	Academic
Annie	White	Female	Academic
Derek	Black	Male	Academic
Morgan	White	Female	Academic
Rachel	White	Female	Academic
Sarah	White	Female	Academic
Brooke	Black/White	Female	Academic
Ernest	Latinx	Male	Academic
Adrian	Latinx	Male	Academic
Erica	White	Female	Academic
John	White	Male	Academic
Claire	White	Female	Academic
Brian	White	Male	Academic
Stephanie	Latinx	Female	Academic
Candace	Black	Female	Academic
Hannah	White	Female	Academic
Michelle	Black	Female	Academic
Ashley	White	Female	Academic
Julie	White	Female	Academic
Robert	White	Male	Academic
Erin	White	Female	Academic
Harper	White	Female	Academic
Alex	White	Female	Academic
Mark	White	Male	Academic
Dana	White	Female	Academic
Carlos	Latinx	Male	Non-academic
Blake	White	Male	Non-academic
Amber	White	Female	Non-academic
Grace	Latinx/White	Female	Non-academic
Molly	Black/White	Female	Non-academic
Evelyn	White	Female	Non-academic
Isabelle	Latinx/White	Female	Non-academic
Natalie	Am Indian/White	Female	Non-academic
Ethan	White	Male	Non-academic
Ophelia	White	Female	Non-academic
Madison	White	Female	Non-academic
Chloe	White	Female	Non-academic
Victoria	White	Female	Non-academic
Taylor	White	Female	Non-academic
Katie	White	Female	Non-academic
Adam	White	Male	Non-academic
Jasmine	Black	Female	Non-academic
Courtney	White	Female	Non-academic
Jacob	White	Male	Non-academic
Ben	Asian	Male	Non-academic
Layla	White	Female	Non-academic
David	Black	Male	Non-academic
Megan	White	Female	Non-academic
Michael	White	Male	Non-academic
Julia	Asian	Female	Non-academic

The interview questions for this study focused on how students understood their identity development during the transition to work in academic and non-academic contexts. More

specifically, students were asked to explain meaningful aspects of the transition between graduate student and work life, with a particular focus on whether they feel more like a professional in their new social context – including identifying any perceived changes. In addition, questions elicited information about their larger career goals and motivations for pursuing their intended career paths. Whenever possible, participants were encouraged to share specific examples from their lived experiences. Illustrative examples of personal experiences are crucial because they allow interviews to capture the meaning of social processes in action (Seidman, 2006; Weiss, 1994). Further, recreations of experiences in real time provide critical ethnographic details for analysis and identifying important patterns within personal narratives (Pugh, 2013).

Analysis

All interviews were conducted over the phone or on zoom, and subsequently transcribed verbatim and analyzed using Dedoose qualitative analysis software. I relied on a grounded approach to qualitatively analyze the text of narrative interviews. Qualitative methods are inductive in nature, and I followed a three stage iterative process to analyze the data (Corbin & Strauss, 1990; Saldana, 2013). This included open coding to get a general sense of the language and break the data into discrete parts, axial coding to group codes into larger categories, and selective coding to finalize core themes that shaped my central findings. In addition, I completed analytical memos for each participant at the end of each initial read through to record key thematic reflections and facilitate consistent analysis across the transcripts. To strengthen trustworthiness and credibility throughout the study (Carspecken, 1996), I engaged in multiple peer briefing sessions structured around discussions of initial codes, emerging themes, and theoretical frameworks.

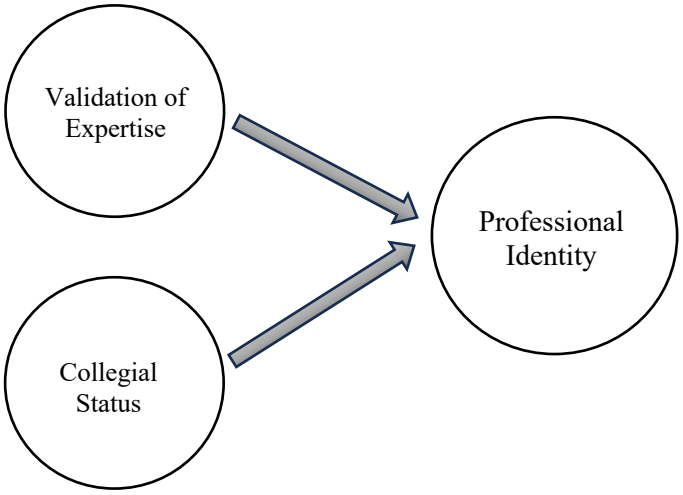
Positionality

It is important to acknowledge the role of the researcher and reflexivity in knowledge production. As researchers, it is critical to engage the implicit subjectivity of our preconceptions shaped by lived experiences. It is especially important to reflect on my own journey and current positionality as a doctoral candidate approaching the career transition. As someone unsure of what the future will hold in my own post graduate career path, I bring a personal lens that may be particularly responsive to the assets of diverse career destinations. The narrative about the potential merits of non-academic careers has emerged from the data and provides an important contribution to the higher education discourse.

Findings

Drawing on interviews with doctoral graduates in biological sciences who recently entered the labor market, I explored differences in perceived professional identity development across academic and non-academic career paths. Examining how doctoral graduates make sense of their professional identity when entering diverse work contexts is critical to supporting successful career trajectories – and understanding the relationship between graduate education and work. Results reveal very different experiences in academic and non-academic roles. Graduates in non-academic careers describe social validation of expertise and shared status with colleagues that cultivate professional identity. In contrast, doctoral graduates who remain in academia may note greater independence as postdocs, but they perceive little change in their status and experience identity stagnation that mirrors the graduate student experience. Figure 1 depicts the two critical elements – validation of expertise and collegial status – that contribute to development of professional identity.

Figure 1. Social Dynamics of Professional Identity



Cultivating professional identity in the non-academic workplace

Despite the potential challenges of pivoting from academic training contexts to non-academic work contexts noted in the previous literature (Guerin, 2020; Skakni et al., 2022), doctoral graduates who entered non-academic workplaces experienced a profound shift in perceived status and expertise – social mechanisms that together galvanized professional identity. In non-academic roles, doctoral graduates felt more like experts who were valued for their knowledge and worthy of equal status among their colleagues. When talking about her transition to a non-academic job, Natalie focused on the contrast in status between graduate student and professional roles. Colleagues in the non-academic social context sought out her expertise and these interactions cultivated professional identity:

> Kind of like the disrespect and the lack of value that I feel from my boss just totally disappear in terms of those company meetings. People would just turn to me and ask me stuff because they truly wanted to know what I thought or what my experiences were. It's like, oh, I'm like the scientist to ask about this. That's pretty cool. It's like, oh, okay, hold onto that feeling when you feel like you're being

> undermined and you're a nothing grad student. There is that, that feeling that will be more pervasive someday, where you're just looked to and valued as being a professional.

Chloe expressed a similar sentiment, emphasizing the developmental impact of being seen and treated as a professional in the non-academic workplace – an experience that rarely occurred in graduate school:

> Now it's funny because you have parents who themselves are biologists deferring to you and your teaching knowledge and you're like, "Okay, that's a nice sentiment." We know I've only taught for a year, but yes, let's pretend I'm an expert teacher after one year. I definitely, I feel much more in charge. It is crazy, basically, everything is under my prerogative…I would say I definitely feel I'm treated as a professional every day in my teaching career whereas I was treated as a professional a couple times a year in graduate school, which I think was, that's fair. I was primarily a student then, so yeah. I'd say a major shift.

In discussing his career transition, David shared a similar perspective, making a direct connection between social validation of expertise and identity transformation, “I think being in a professional environment now—the moment I got hired, people looked at me as a peer and that I had stuff to offer and bring to the table, and I had an expertise. I think that’s impacted how I view myself as well.” David’s description vividly captures how professional identity is socially activated and internalized through interactions with colleagues in the workplace. Recognition of expertise was a new, and very meaningful, experience for many of the graduates in this study. Victoria talked in length about differences in how her expertise was perceived in the non-academic workplace, highlighting the unique value of her doctoral education in a new social

context. In contrast to the culture of criticism and doubt fostered in graduate school, Victoria's social location in the non-academic community inspired confidence in her expertise and status among professional peers:

> So, among my team, you know, I am the one with the highest degree, so I feel like I am able to dive into the literature and give them the full picture, usually in a few short summaries. And that is taken at face value. It is not questioned and poked and prodded, which is exactly the process when you go through grad school.

Graduates in non-academic positions often focused on the role of colleague perceptions and expectations in cultivating professional identity. When discussing why he felt more like a like a professional in the non-academic workplace, Adam highlighted the meaning of relationships with equal status. While graduate school's structure centered on performing tasks in social isolation, the workplace fostered opportunities to feel valued by colleagues:

> That'd probably be the biggest thing is just how do my peers treat me? Graduate school indicators of success were basically papers and graduating because it was a very solo type of activity. It's not like you would have a PI from a neighboring lab be like, 'Here's the experiment I want done. Who in the department can get this done? Let's get them to do it.' That's not the way it works."

In a similar fashion, Ophelia noted the difference in perceived status among her colleagues, which had a direct impact on her development. For Ophelia, the non-academic workplace cultivated professional identity because colleagues treated her not as a student in training, but as a professional equal:

> Then as a professional, all of my colleagues—even though I am a contract employee—treat me as an equal. They don't ever think, 'Oh well. You don't need

> to come to this, you don't need to do this because you're not actually a [company redacted] employee,' and so that makes me feel like a professional individual who works. I work every day, I am not in school anymore. People see me as their equal even though when I look at them, I'm like, Wow. You've been in industry for 30 years. You're so much better than me, and they don't see it like that.

The social foundations of identity formation also included interactions that at times spanned beyond colleagues. Julia's description of client relationships illustrates how professional identity is a socially situated experience shaped by perceived membership in a community of professionals, "Well, I think it's because the clients view me as a professional that I feel more that I am a professional. It's just I feel like I need to rise to where the clients view me as professional…that I adjust more to what they expect." As a whole, graduates in the non-academic workplace entered new social contexts that validated their expertise, fostered shared status as colleagues, and as a result, triggered transformational changes in professional identity.

Identity stagnation of postdocs in the academic workplace

While doctoral graduates in the non-academic workplace encountered new social contexts that validated expertise and a sense of equal status among colleagues, graduates who continued in academic roles as postdoctoral scholars did not share those experiences. For many graduates, postdoc positions were often more independent but felt developmentally static – more like a continuation of graduate training with limited validation of expertise, lack of equal status among colleagues (maintenance of relationships with advisors), and unclear professional identity. As postdocs in the academic workplace, doctoral graduates entered a sort of developmental purgatory that felt more like an extension of their doctoral programs. When talking about her experience transitioning into a postdoc position, Lauren talked in length about the lack of

perceived changes in professional identity in the new role. In many ways, her language reflects little awareness of any developmental transition in the workplace, and instead focuses on experiencing continued confusion around her identity as a professional:

> Oh, I don't. Not at all. Yeah. No. I don't know what else to say. I don't. I don't feel like I'm a professional anything. Not to say that I don't feel like I have skills or I'm good at anything or whatever, but I don't know. Yes, it feels different to be a grad student than a postdoc, I guess, yeah, mostly in the way that I—to me the biggest difference is just that relationship with my bosses is really different, but as far as—I don't feel like any sort of professional. I don't know if I'll ever feel like a professional. [Laughter] I don't know. I don't know. What does a professional feel like?

Adrian described a similar sense of stasis, highlighting the developmental stagnation of his postdoc experience, which mirrored the day to day routines of his graduate school career. His words reveal a critical tension for doctoral students in postdoc positions who struggle to comprehend their identity beyond the student trainee role. For graduates who took postdocs in the academic workplace, the new position was supposed to be a professional point of transition that ushered in a new stage of their careers. Yet when on the job, graduates recognized that the structural realities of graduate student life were generally unchanged. In contrast to peers in non-academic settings who were perceived as experts with equal status, postdoctoral scholars remained in a social context that reinforced existing status roles and responsibilities in the academic hierarchy:

> I don’t know. I realized the other day that I’ve been at the bench for over a decade now. Like, ten years at a bench, moving small volumes of liquid around. It really

> hasn't changed from day one. The only thing that's changed is my basal knowledge. The day to day is more or less identical still, for the most part. Every once in a while, you'll do some weird experiment that's different. By and large, it's the same…the actual what I do every day, is the same thing I was doing back in 2010 learning all this stuff for the first time. It's the same.

Claire echoed this perspective when discussing her experience as a postdoc. In her view, the role was more like an extension of graduate school than any kind of professional transition, "I mean, in terms of being a professional, it doesn't necessarily really feel that different from graduate school."

Graduates working as postdocs in the academic workplace often noted the lack of significant differences in their new role, though some also described novel aspects of the postdoc position. This included Stephanie, who reflected on both core similarities and some unique distinctions. While she admitted the position felt largely the same as her graduate school experience, she also emphasized an increased sense of independence with higher expectations:

> In many aspects, it remains the same. What I would say is a little bit different is the fact that you have a little bit more not responsibilities because I would say in my past lab, the responsibilities were pretty much the same. I would say that the difference is that you're expected a higher—maybe a more mature approach, so you're kind of in a different level of—it's hard to explain, I guess.

Other graduates highlighted more specific points of comparison between graduate school and the postdoctoral role – parallels that stifled opportunities for validation of expertise and equal status among colleagues that ignited professional identity development in the non-academic workplace. John's experience reveals how structural similarities between graduate

student and postdoc roles can mask the perceived transition between education and work, producing developmental stagnation in a social context that mirrored graduate training. For John, transitioning between his doctoral program and job was almost indistinguishable:

> I don't think I really had that big of a transition. The graduate school lab that I was in was very laissez faire. It was pretty much hands off. A lot of the things that I was doing were self-directed. There wasn't—even the hours, it wasn't really monitored, but it was never a concern because I would work a lot more than would have been required, so I don't think anyone ever really checked up on it. It doesn't feel a whole lot different, to be honest, especially with the later years of graduate school. I am doing the project I want to do. I'm going in the hours that I want to go in, and it's a lot so no-one gets mad. I'm kind of figuring a lot of things out for myself…I guess I really don't see it as that different. Maybe I haven't had a very big transition.

Many graduates in the academic workplace noted the lack of developmental change in transitioning to the postdoctoral role. While recent graduates had completed doctoral training and began their careers, the lived reality of the postdoctoral experience continued to reinforce their identities as graduate students. This was the case for Julie, who described identifying 'perpetually' with the student role regardless of starting her career. Julie's depiction illustrates how postdocs who remain in the academic workplace may struggle to build identities beyond the student trainee role. Rather than feeling like perceived experts with equal status among colleagues, postdoctoral scholars confronted largely the same social context, one that constrained their professional identity to that of the graduate student in training: "I don't know if I've ever really had that big transition period. For me, it's always

just been that I feel like I'm perpetually a student, and there are things that I know how to do, but I still learn how to improve my techniques all the time."

When discussing her experience as a postdoc in the academic workplace, Michelle talked in length about academic culture. Her perspective emphasizes the culture of criticism in the academic work environment, which poses critical challenges to building confidence in expertise and cultivating professional identity:

> I think I just have to—I think it's one of those things where you just have to be okay with not feeling that confident. Yeah, cause they beat you down…I think it's just because people don't really build you up in grad school. It's not really the culture. It's kind of just like, you should know this. Oh, you didn't do this right. Then you always feel like you're not enough or you feel like you should know more, or you should be doing more.

Doctoral graduates who took postdoctoral positions rarely experienced validation of expertise or a sense of professional identity. While the new role sometimes afforded increased responsibility and independence, graduates consistently described an experience that felt more like a continuation of graduate school. This had important implications for their identity development during the job transition, which remained stagnated within the structures and social context of the academic workplace.

Discussion

This study explored changes in professional identity experienced by recent doctoral graduates making the transition to both academic and non-academic workplaces. While an emerging body of literature has begun to examine relationships between doctoral education and work including employment aspirations, identity development, and the transition to work (Bloch et al., 2015;

Guerin, 2020; Hayter & Parker, 2019; McAlpine & Amundsen, 2018), little is known about how diverse work pathways shape professional identity. Interviews with 53 doctoral students who recently transitioned to jobs in academic and non-academic workplaces reveal critical differences in identity development that vary by career trajectory. PhD holders who took non-academic roles encountered new social contexts that validated their expertise and affirmed equal status with colleagues, structural characteristics that cultivated professional identity in the workplace. In contrast, graduates who stayed on academic pathways as postdocs experienced a sense of identity stagnation. While the postdoctoral role sometimes involved more responsibility and independence, as a whole PhD holders continued to feel like graduate students stuck in the trainee cycle – carrying out similar activities within a social structure with little perceived expertise or collegial status.

The presented findings extend previous work by exploring how doctoral students experience the transition to different types of careers (Guerin, 2020) by illuminating positive growth in professional identity in non-academic spaces. Despite the potential challenges encountered by PhD holders entering non-academic work cultures (Skakni et al., 2022), many of the graduates in this study who were employed in non-academic contexts reported meaningful shifts in their professional identities that empowered agency in the workplace. Although the job titles varied, the social structure of teamwork among colleagues in professional settings, provided the context for significant changes in perceived status and expertise, and consequently professional identity. This finding is significant, given the increasing number of doctoral graduates opting out of academic career pathways. By revealing some of the developmental assets that non-academic work cultures can foster for new professionals, this study provides a

lens for re-framing the value of diverse career destinations for doctoral students struggling for professional validation in the academic workplace.

This study also makes an important theoretical contribution to understanding social processes of professional identity development in doctoral education, including the role of work-related relationships beyond the university (Baker & Lattuca, 2010; Sweitzer, 2009). For the doctoral graduates in this study, continued academic socialization in postdoctoral roles was not a source of professional identity progression, and instead maintained the tightly bound social structure and relational hierarchies of graduate training. While models of doctoral student socialization have noted the potential role of work-related communities in student development for the career (Weidman & DeAngelo, 2020), little has been done to investigate the specific social mechanisms of diverse career trajectories. The presented findings draw attention to the developmental force of the career transition stage as a multifaceted site of identity transformation or identity stagnation. As doctoral students cross the bridge from education to the workplace and career, they must navigate a social context with sets of relationships that shape perceived expertise, shared status among colleagues, and ultimately, identity as professionals. Depending on the chosen career path, these social environments may reinforce identification with the graduate student role or cultivate new possibilities for how doctoral students understand their professional selves post-graduation. Thus, doctoral socialization for the career is primed by academic experiences but extends beyond graduate training and into the point of job entrance. The specific pathways out of doctoral education, and into the cultural context of the workplace, are key inflection points that shape continued career development.

In addition, this study has important implications for understanding some of the developmental challenges of academic culture. The social structure of relationships in academia

contains many built-in hierarchies, including significant power imbalances between graduate students and faculty members (Friedensen et al., 2023). Postdoctoral scholars are hybrid workers in a space of professional liminality, and must navigate complex issues of agency, unclear expectations, barriers to collegiality, and marginal identities (Burke et al., 2019; Nowell et al., 2021). Identity is a socially situated process, and recognition plays a powerful role in postdocs developing professional identities as scientists (Hudson et al., 2018). Doctoral students who become postdocs remain in a working environment that stresses persistent criticism and an obsession with prestige tightly bound to academic ranks. For those pursuing academic career paths, this means spending an extended, and often unknown, number of years in social contexts that struggle to cultivate confidence and expertise. Academic culture creates a social environment where graduate students – and postdocs – rarely feel like experts with collegial status, hampering their ability to transcend the trainee role and build professional identities.

This study's focus on the first job after the PhD centers the critical moment of transition from education to the labor market. While postdocs contain a training component, they are full-time salaried positions and represent the first job opportunity for many doctoral students post-graduation, and thus represent an appropriate comparison with non-academic positions obtained immediately after the PhD. Despite the notable developmental barriers revealed by the data, postdoctoral roles can serve as valuable stepping stones in continued training towards tenure-track faculty careers. Thus, it would be important for future studies to explore subsequent transitions, and in particular changes in professional identity as postdoctoral students transition to assistant professor roles.

Implications for Practice

These findings also have important implications for practice in higher education, and in particular for supporting successful career transitions in doctoral education. First, graduate programs should think critically about how to disrupt power imbalances that shape student experiences in academic culture. Academia is rife with relational hierarchies that can make it very difficult for doctoral students and postdoctoral scholars to feel like experts with status in the workplace (Burke et al., 2019; Friedensen et al., 2023; Nowell et al., 2021). In many instances in this study, the academic environment seemed to reinforce a lack of confidence in expertise and confusion around professional identity. This is an important tension to address, as one of doctoral education's key purposes is the training of specialized experts with confidence in their abilities who are capable of making substantial contributions to original research. Graduate programs should encourage practices that better enable doctoral students and postdocs to feel valued as experts and equal collaborators in the academic workplace. This could take the form of reimagining advising practices that emphasize scholarly agency and shared collegiality in the production of academic work. Indeed, structures that soften some of the relational inequities between doctoral students and their advisors could go a long way towards counteracting the identity stagnation expressed by graduates in the academic workplace.

In addition, higher education institutions should put greater emphasis on the opportunities, and potential benefits, of career paths outside the academy. It has become increasingly rare for PhD holders to secure tenure track jobs and the majority of doctoral graduates now find themselves navigating the non-academic workplace (McApline & Amundsen, 2016; Vitae, 2016). This study demonstrates that changing PhD career patterns, while often invoked in negative terms, may provide a sense of professional fulfillment and validation for doctoral graduates that is often absent in academic culture. Leaders in graduate

student development and education should put greater emphasis on exploration of non-academic career pathways. This could include explaining differences in social contexts that shape professional work culture such as working in diverse teams with shared status, and the recognized value of doctoral expertise in applications outside of the university environment. Moreover, internship programs for doctoral students could be institutionalized and expansive in showcasing careers beyond higher education. Increased opportunities for structured experiential learning within the non-academic workplace could provide immersive insights that enable doctoral students to practice different kinds of work and experience distinct work environments.

Exploring differences in professional identity development for PhD holders during the job transition, and understanding how graduates adjust to work environments within and beyond the university, is crucial to fulfilling the mission of graduate education. Given the dramatically altered landscape of the academic labor market, doctoral students are increasingly required to navigate and thrive within a variety of work cultures outside of academia. The findings in this study draw attention to the diversity of experiences and needs for doctoral students in an evolving career context. Understanding the social dimensions of career entrance across diverse pathways is vital in ensuring successful preparation for post-graduate careers, and supporting the long term professional success of doctoral students beyond the PhD.

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