Exploring Early Exits: Doctoral Attrition in the Biomedical Sciences

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Abstract

High attrition rates have been a defining characteristic of doctoral education for decades, representing a loss of time, talent, and effort for departing students and their faculty. This qualitative study uses a biomedical science doctoral student sample to collect "real time" data on attrition within the first 2 years of doctoral training. Eighteen students, who represented 16 distinct universities, were interviewed as they engaged in the withdrawal process. Using the conceptual frames of socialization and social cognitive career theory, we explored experiences that preceded these students' doctoral program withdrawals. Furthermore, we examined how expressed roles of students' self-efficacy, outcome expectations, and professional goals contributed to the withdrawal process. Findings indicate that faculty advising (both positive and negative), laboratory rotation experiences, self-efficacy components, and changing professional goals all play a role in the early doctoral program attrition process.

Keywords

doctoral students, doctorate, doctoral attrition, biomedical sciences

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High attrition rates have been a defining characteristic of doctoral education for decades (Berelson, 1960; Bowen & Rudenstine, 1992; Council of Graduate Schools, 2008). These notably high rates represent a loss of time, talent, and effort for departing students and their faculty (Golde, 2000; Hawley, 2010). External university stakeholders often view such departures as a sign of institutional waste and inefficiency (Nerad & Miller, 1996). Across academic disciplines, doctoral education has been the subject of numerous investigations (Bair & Haworth, 2005). The literature reviewed indicates that prominent attrition factors include a poor advisor relationship (Bair & Haworth, 2005; Barnes, 2009; Ruud, Saclarides, George-Jackson, & Lubienski, 2016), an unsupportive departmental culture (Golde, 2005; Lovitts, 2001), unstable funding sources (Pauley, Cunningham, & Toth, 1999; Strayhorn, 2010; Zhou & Okahana, in press), stress and emotional exhaustion (Ali & Kohen, 2007; Hunter & Devine, 2016), and lack of prospective career opportunities (Cyranoski, Gilbert, Ledford, Nayar, & Yahiam, 2011; Golde, 1998; Herzig, 2004).

While these investigations into doctoral attrition have provided significant insight, they are limited in several notable respects. Attrition studies often rely upon data from a single or limited number of institutional samples (Golde, 2005; Lott, Gardner, & Powers, 2009) and use retrospective data (Lovitts, 2001) that can be subject to hindsight bias (Palmeira, Spassova, & Keh, 2015). Although the highest attrition rates fall within the first 2 years of doctoral training (Council of Graduate Schools, 2008; Lott et al., 2009; Nerad & Miller, 1996), attrition studies often include students at various points in their graduate careers (Girves & Wemmerus, 1988; Pyke & Sheridan, 1993). Finally, it is important to recognize that the experiences shaping departure are strongly influenced by the discipline within which the departure occurs (Benkin, 1984; Golde, 2005).

Addressing these concerns, this qualitative study uses a multi-institution, biomedical science doctoral student sample to collect "real time" data on attrition within the first 2 years of doctoral training by interviewing students as they are engaging in the withdrawal process. We explore experiences that precede these students' doctoral program withdrawals. Further, we examine how expressed roles of students' self-efficacy, outcome expectations, and professional goals (collectively referred to as "self-direction"; Lent & Brown, 1996, p. 310) contribute to the withdrawal process.

Doctoral Training in the Sciences

Student attrition rates from doctoral programs in the sciences are estimated to be between 25% and 40% (Council of Graduate Schools, 2008; Nettles & Millett, 2006). To better contextualize why students leave these doctoral programs, it is important to consider these programs' prominent features. Sauer (1986) noted the "exacting structure imposed on students by the laboratory

sciences and by the financial support of [these] students'' (p. 3). This structure includes laboratory rotation participation early in doctoral training (Golde, 1998) and early engagement in laboratory research (Fuhrmann, Halme, O'Sullivan, & Lindstaedt, 2011). While the use of rotations is relatively rare in most of doctoral education (Barker, 1998), student rotation through multiple laboratories to determine best fit is common in many doctoral programs in the sciences (Hall, 2004; Holley, 2009). Rotations occur early in doctoral training and are thought to lower attrition, as students are, theoretically, more likely to find an advisor with whom they would be well paired (Golde, 1998). Given its widespread use within the biomedical sciences, surprisingly little scholarship exists on the rotation process, particularly how it intersects with doctoral attrition.

University research laboratories are situated within several overlapping contexts that inform and influence the day-to-day work demands and the experiences of graduate students. Institutional incentive systems for faculty promotion and tenure emphasize the production of scholarly publications (typically journal articles in the biomedical sciences), the procurement of external grants to fund research, and productive interactions with industry in the forms of contracts and patents (Alberts, Kirschner, Tilghman, &Varmus, 2014; Kleinman, 1998). As research funding offered by the U.S. National Institutes of Health increased rapidly in the 1980s, universities grew to rely on the facilities and administrative cost revenues and salary support that accompanied federal grants to offset operational expenses. However, when funding plateaued in the 1990s, competition for limited research funds became increasingly fierce, with both faculty and institutions dedicating heightened attention to procuring grants to sustain expensive research infrastructures (Stephan, 2012).

In their efforts to secure research funding, many institutions have also encouraged cooperative relationships with private companies from industry that can provide revenues in exchange for the development of intellectual property with commercial value. Alberts et al. (1998) argue that this environment has contributed to several challenges for both faculty and their graduate students: increasing demands on time allocated to pursuing funding, producing research outcomes, and rapid publication. Further, reliance on graduate students as a source of labor to sustain laboratory productivity has created an incentive to admit many more PhD students than can be employed by the academy upon graduation. In the biomedical sciences, this labor supply issue has prompted the National Institutes of Health (2012) to offer funding to prepare PhD recipients in the biomedical sciences to enter fields unrelated to research (e.g., law, business, etc.).

For doctoral students, this internecine environment has translated into long hours in the laboratory (~45 hours per week, on average; Ferreira, 2003) in addition to coursework and time allocated to academic writing, uncertain job prospects, and occasionally fierce competition for recognition and authorship

opportunities within the laboratory. Stephan (2012) reports that only 14% of PhD students in the biomedical sciences attain tenure-line faculty positions. Reflecting this reality, recent survey data from a leading biomedical research campus found that 29% of their doctoral students identified a nonresearch career as their top choice for postdegree employment, and an additional 63% were strongly considering such options (Fuhrmann et al., 2011). Further, disaggregation of the data yielded a significant decrease in interest in pursuing a research career as students progressed in their degree programs.

The above suggests that the biomedical sciences doctoral training environment is dynamic, complex, and competitive, especially within the first 2 years of training. It can be surmised that students selected to join this competitive training environment have devoted extensive time, talent, and effort to prepare themselves for this experience. Why they then leave relatively soon after program entry is the broad question this study intends to answer.

Conceptual Framing

Studies of doctoral education are often situated within a socialization framework (Gardner, 2009a; Holley, 2009). As applied to doctoral training, socialization is defined as ''a process of internalizing the expectations, standards, and norms of a given society, which includes learning the relevant skills, knowledge, habits, attitudes, and values of the group that one is joining'' (Austin & McDaniels, 2006, p. 400). For doctoral students in the sciences, the ''given society'' extends across multiple communities, including the research team, laboratory group, department, institution, and discipline (Flores-Scott & Nerad, 2012). However, as Golde (2005) observed, it is those communities closest to the student, including the research team, laboratory group, and department that are the locus of doctoral training.

Socialization models of doctoral training (Gardner, 2009a; Weidman, Twale, & Stein, 2001) emphasize the criticality of the time spanning from program entry through course completion. In the biomedical sciences, this period equates to the first 2 years of doctoral training. During these years, students learn the tacit and explicit knowledge and skills fundamental to their subsequent development into an autonomous disciplinary researcher. Doctoral faculty and peers are thought to be the key agents of socialization (Parry, 2007), facilitating students' academic and social integration (Tinto, 1993). Early socialization experiences, such as those encountered within the first years of doctoral training, are significant, as they ''affect the course of long-term adjustment, triggering either a success cycle or a failure cycle'' (Ashforth, Sluss, & Harrison, 2007, p. 2).

The socialization framework has provided a unifying lens through which to consider doctoral students' experiences in the United States and how these experiences are shaped by the structures (i.e., teams, laboratories, departments, and disciplines) within which they occur. Critics of the socialization framework

have challenged the assumption of a unidirectional and essentially replicative model (master creates apprentice who in turn becomes master to create apprentice; Flores, 2011; Tierney, 1997) situated within a doctoral faculty mentor-doctoral student mentee cognitive apprenticeship (Walker, Golde, Jones, Bueschel, & Hutchings, 2008). The power relationship inherent in this approach is problematic (Walker et al., 2008). In short, students are not, "... passive recipients of socialization, but active players who ... socially construct their environment, and who attempt to alter that environment" (Ashforth et al., 2007, p. 5). Such construction occurs through the development and negotiation of relationships (i.e., "professional working alliances"; Torka, 2016, p. 145) that result in the coproduction of knowledge through supervised research and scholarly writing.

While we ground this study within the socialization framework of academic and social integration, we also highlight the sometimes overlooked reality that the student is an active agent within the doctoral training process. Thus, we pair the socialization framework with the social cognitive career theory (SCCT), a theory useful in understanding how people make academic choices (Lent, Brown, & Hackett, 1994). To explore the agentic nature of students' roles in the attrition process, we consider three key SCCT self-direction factors: self-efficacy, outcome expectations, and professional goals. Lent et al. (1994) observed that self-efficacy, defined as individuals' beliefs in their ability to effectively carry out an action to reach a desired goal, "is not a passive, static trait, but rather is a dynamic set of self-beliefs ... specific to [a] particular performance domain ... " (p. 83). These self-beliefs are informed by "four primary informational sources (or types of learning experiences)" (Lent, 2012, p. 118): personal performance, observing similar others (i.e., doctoral peers), social persuasion (e.g., reinforcing messages within and beyond the doctoral training environment), and psychological states (e.g., stress) experienced while engaging in domain-specific tasks (e.g., tasks associated with doctoral training).

Outcome expectations, or personal beliefs about probable outcomes, involve imagined consequences of performing specific behaviors (Lent et al., 1994). They are closely linked to goals, or one's intention to produce a particular outcome (Lent, 2012). For many who begin a doctoral program, the answer to the question, "What will happen if I earn this doctorate?" at least in terms of anticipated outcomes, is unclear. For example, in a study of recent biomedical science doctoral recipients, Gibbs and Griffin (2013) found that most recipients had no clear career goal when they began their doctoral training. Instead, they were motivated to pursue a doctorate by a love of science and a broad goal of career mobility. Fuhrmann et al. (2011) found that many biomedical doctoral students in their study became significantly more uncertain about their previously selected career path between the first and second year of doctoral training. Thus, it is not entirely surprising that some students begin doctoral studies only to find that their developing scholarly or professional interests are or

have become incompatible with the program in which they are enrolled (Gardner, 2009b). In these cases, their commitment to degree completion wavers, and, as Tinto (1993) observed in his theoretical musings on doctoral student attrition, as with undergraduate attrition, lowered commitment to the goal of degree completion is a crucial precursor to the departure decision.

Method

Participants

Our participants, who were initially part of a larger, longitudinal study ($n = 336$ students) to explore doctoral experiences in the biomedical sciences, began their doctoral programs in Fall 2014. Between the beginning of fall semester 2014 and the beginning of fall semester 2016, 28 students in the larger longitudinal study officially withdrew from their doctoral programs. Of these 28, 18 (64%) agreed to be interviewed about their attrition experiences. These 18 students represent 16 distinct and geographically dispersed biomedical PhD programs, 15 of which, based on Carnegie classification, are R1 (highest research activity), and one of which is R2 (higher research activity).

Of the 18 students, 5 had the withdrawal decision made for them because of comprehensive exam failure ($n = 1$) or failure to be retained in a permanent lab ($n = 4$). Involuntary withdrawal students were retained for analysis because of the insight they can provide into early doctoral attrition as a whole. In the interview sample, 11 students (61%) were female, 16 (89%) identified as White, 2 (11%) identified as Asian or Asian American, 8 (44%) were first-generation students (meaning that neither of their parents completed a 4-year college degree), 2 (11%) were international students, and 3 (17%) had earned a master's degree before entering doctoral training. We note that our attrition interview sample includes no students from underrepresented racial or ethnic minority groups, reflective of the fact that none of the 50 students from these groups within the larger study of 336 had left their program within the first 2 years.

Data Collection and Analysis

We used in-depth interviews, a "construction site of knowledge" (Weiss, 1994, p. 29), to elicit students' perceptions and interpretations of their lived experiences (Merriam, 2009) as they engaged in the doctoral attrition process. Students were assured of confidentiality, an important consideration for many given the sensitive subject of attrition. All student interviews were conducted by the first or second author at a time convenient to the student. To accommodate students' geographic dispersion, all student exit interviews were conducted by telephone, with the exception of one student who preferred to respond to questions via e-mail. With student permission, all interviews conducted by telephone were audiotaped.

The student exit interview protocol (see Appendix) received institutional review board approval and, upon request, was shared with the student in advance of the interview. Protocol questions were developed through an ongoing review of literature relevant to doctoral student attrition (e.g., Gardner, 2009b; Ruud et al., 2016) and authors' experiences in working with doctoral students. Protocol questions asked students to describe when they began considering withdrawal, identify, and discuss in detail the factors they associated with withdrawal consideration, who and what was involved in their deliberations to withdraw, and their postdeparture plans. Most interviews lasted approximately 25 minutes, although some lasted 40 to 45 minutes. The interviewers (the first and second author) reminded students that they need not respond to any questions that made them uncomfortable.

At the initiation of the larger, longitudinal study, students were asked if research team members could collect interview data from their faculty advisors as the study progressed; 11 of the 18 student interviewees had provided this consent. All 11 faculty advisors were contacted with the following request, "I understand that [student name] has left his/her doctoral program, and we are contacting you to ask if you would be willing to participate in a brief phone interview about this student's doctoral student experiences." Five faculty advisors responded; one was unwilling to be interviewed, while four agreed to be interviewed. During interviews, it was discovered that each of these four had been assigned by the program to assist the student in "mastering out" (a process described in the findings) and were not the faculty advisor in whose research laboratory the student had been working. Analysis of their interview transcripts suggested that little relevant information was shared by "mastering out" advisors besides program policies and procedures associated with student attrition; thus, these transcripts were not included in study analysis.

Audiotaped student interviews were equally distributed among the first and second author for transcription, as transcribing "is not an antecedent to analysis, but it is a central aspect of the ways that researchers analytically orientate to data" (Gibson & Brown, 2009, p. 125). During the transcription process, these authors met regularly to identify and document emergent themes from recently transcribed interviews. They also individually and then collectively coded interview text line-by-line to develop raw data themes in the form of quotations from the participants (Cousin, 2009). SCCT self-direction concepts (self-efficacy, outcomes expectations, and goals) served as an analytic framework for coding internal and contextual information sources students reported using to make the decision to withdraw. This material was developed into a code list and applied by the first author to all transcripts using the constant comparative method (Glesne & Peshkin, 1992), constantly comparing and contrasting emergent themes both within and across transcripts. As a measure of trustworthiness, findings emergent from codes and code relationships identified by the first author were scrutinized by the second author and also reviewed by all other authors.

Findings

Advisor Relationships and Roles

A common finding in the doctoral education literature is that several factors jointly contribute to a student's decision to withdraw (Gardner, 2009b; Ruud et al., 2016). In particular, studies have indicated that a negative advising relationship is a key component of the withdrawal process (Bair & Haworth, 2005; Barnes & Austin, 2009; Golde, 2005). Corroborating this research, we found that problematic advising relationships drove attrition decisions for more than half of our sample. Ten students reported that the negative nature of the advising they received from faculty in whose laboratories they worked was a key withdrawal factor. In instances when advising was not the only factor mentioned, it was either the underlying factor from which other factors emerged or the "straw that broke the camel's back," pushing students toward final withdrawal decisions.

At the same time, eight other students in our sample reported positive, even *highly supportive*, advising experiences from faculty in whose laboratories they worked, which were sustained even after advisors knew these students were withdrawing. This finding suggests that doctoral advising relationships and roles during doctoral attrition may be more complex and nuanced than previously thought. Given the bifurcated nature of our sample in terms of reported advisor relationships and roles, we first report data associated with negative advising relationships and then identify overarching factors that prompted withdrawal even in light of positive advising relationships.

The nature of negative advising relationships. For the 10 students who reported poor advising experiences, these experiences were a key factor prompting withdrawal thoughts. Of these, one male participant had a successful year in a permanent laboratory, only to make an off-hand comment to a peer about the heavy workload. The comment was repeated to the female faculty advisor and was poorly received; the situation escalated until the student felt he had to withdraw. This student stated, "For me, it was very black and white; it was the conflict in the relationship between me and my advisor. Had that not occurred, I would have happily continued and finished."

For six other students, a distinct advising pattern emerged. Each reported joining a permanent laboratory with positive feelings and prematriculation or rotation interactions, only to experience what one student called "a complete 180." Descriptions included the following:

> One major reason [I left] was the lab environment. When I rotated in my lab, it was a great lab . . . friendly people and everything. But when I started working in the lab, it was just too competitive, which was something the [male] PI bred in the lab. [female doctoral student]

> She [advisor] was wonderful during my rotation period . . . she was available for questions I might have about experiments or literature . . . As soon as I signed the paper that said I would be in her lab, there was a complete 180. Whenever I asked questions, she was like, 'You should already know this.' She just completely 180'd on her attitude on learning and teaching and it was bizarre. [female doctoral student]
> I originally had a sense of belonging in the lab I joined, and I really liked the project and the people. But once I officially joined the lab, it felt to me like the [male] PI was playing favorites. If I wasn't making progress, it was because I was a bad scientist. If he [a lab mate] wasn't making progress, it was because nothing was working for him – not his fault. If I did something good, I got lucky. If he did something good, he was really good . . . I felt like I didn't belong after officially joining the lab. [male doctoral student]

The changeable context applied not only to personalities but also to projects. As one female student noted, "The project I had been forced to take [in my permanent lab] was not what I was told I was going to get as a rotation student . . . they [faculty] just kept forcing it on me." Another stated:

> Before I came [to this university], I spoke to one [female advisor] who was taking graduate students [in my specialty]. But she took someone over the summer, and I didn't know that, so I came here without a place to go. [female doctoral student]

The remaining three students each described a sense of isolation from their advisor and laboratory at the time of their departures. One failed his comprehensive examination at the end of his second year. He simply stated, "My [male] PI would not give me the chance to redo my comps, so that was the end of it . . . I gave him a handshake and a hug and said, 'Thanks for the experience' . . . I didn't fit in." The remaining two never found a niche within their laboratories:

> My research focus was different from the rest of the lab, and so I was always on the outside . . . My [male] advisor told me, 'Come back when you have some data, and then we can talk.' For me, it [withdrawal] was a matter of how closely aligned my research was with that lab and how supportive my advisor was on top of that. [female doctoral student]
> All joking aside, it [my withdrawal] was basically when my PI told me that she would no longer invite me . . . I don't know if I wasn't living up to her expectations . . . it was kind of hard to follow what was really happening . . . I've always felt like an outsider [in my lab], probably because of the generation gap – I'm 55 now . . . [male doctoral student].

The nonprotective factor of positive advising. Despite the finding that negative advising is an important factor linked to doctoral attrition (Bair & Haworth, 2005),

a sizable number of departing students in our sample reported positive advising experiences. Eight students (of the 18 interviewed) reported supportive advising, even when the advisor knew the student was withdrawing. Representative comments included "I felt a lot of support from my advisor"(female advisor, female doctoral student), "I had two bosses [advisors] and I loved them both" (male advisors, female doctoral student), "I actually got two letters of recommendation from my faculty for pharmaceutical schools [when I decided to leave], so they were very, very, very good, very kind" (male advisors, male doctoral student), and "We [my advisor and I] definitely maintained a decent relationship [male advisor, male doctoral student]."

What factors led to these students' withdrawals? As one stated, "Graduate school is a huge opportunity; I am not unaware of that. I wasn't doing poorly or had a bad PI. None of the reasons that students traditionally leave were any of my reasons for leaving" (female advisor, female doctoral student). All eight students withdrew for reasons well aligned with the self-direction factors of self-efficacy, outcome expectations, and professional goals during the attrition process. Their experiences, as well as the 10 students who reported poor advisor relationships, are next examined in light of these self-direction factors.

Self-Direction Factors Informing the Withdrawal Process

In this section, we explore the SCCT self-direction factors of self-efficacy, outcome expectations, and professional goals in students' attrition narratives. While we consider data associated with each factor independently, we acknowledge that they interact extensively in students' withdrawal experiences. We also note that departure is a longitudinal process (Tinto, 1993), and during this process, most students engaged multiple self-direction factors over several months or longer. As one student observed, "I took my time thinking about it [withdrawing] and I talked to a lot of people. It wasn't just a rash decision."

Self-efficacy. As noted earlier, self-efficacy refers to an individual's belief in his or her ability to carry out an action to reach a desired goal within a specific domain (Lent, 2012). In this case, the domain is early doctoral training, and the domain-specific tasks are those undertaken to learn the tacit and explicit knowledge and skills fundamental to their subsequent development into an autonomous disciplinary researcher. Doctoral faculty and peers are essential to this learning process. A student's self-efficacy is informed by academic performance, observing peers and role models, social persuasion, and psychological states experienced while engaging in domain-specific tasks (Lent, 2012). This self-efficacy underpins a student's response to the question, "Can I do this [earn this doctorate]?" (Golde, 1998).

Academic performance. Only two cases arose in which academic performance was noted within the interview transcripts, the first of which was the student who

failed his comprehensive examination. What is interesting in this case is that this student stated he had been admitted to medical school before ultimately deciding to pursue a doctorate in biomedical science. This suggests that he did not lack academic ability but rather was unable to appropriately assimilate discipline-specific information and display knowledge of it in the way dictated by admission of a comprehensive exam. In the second case, the student who withdrew to pursue an MBA stated, "I was on probation in the first year [of doctoral training], and that was when I was like, 'OK, I cannot do biochemistry'...that contributed a lot to my decision [to leave]." Similar to findings from prior studies (Council of Graduate Schools, 2008; Girves & Wemmerus, 1988; Pyke & Sheridan, 1993), academic performance, in and of itself, was not a factor in students' decisions to withdraw.

To leverage academic performance in their programs, seven students in our sample "mastered out" of their doctoral programs. Some did so to have a credential that accounted for their time in the program. For example, one student stated, "People don't just leave, they usually leave with at least a master's...something to show for the time you've spent here" while another said, "I think it is for me to have something to show, although I don't think it will do a whole lot of good." Pursing a master's degree allowed students to enroll in classes outside their department that were previously off limits to them, such as marketing and entrepreneurship courses. Two students indicated a stigma attached to mastering out, with one describing it as a "process of coming out" as a master's student. Finally, the process of mastering out varied widely across programs in terms of what was expected from students and from faculty. As one student explained:

> I left that lab [after getting kicked out] and started meeting with my program coordinator who suggested I just write up the work that I had done in the lab and defend it as a thesis defense – and then take the master's and leave. But basically I ended up writing a thesis with no advisor because I was out of the lab. When it came time for the defense, the defense didn't go very well. So I am actually in purgatory now waiting to see what happens next. But no matter what, I am not going back to the program.

Observing similar others. Early doctoral training in the sciences involves extensive interaction within classrooms, research teams and laboratories, and departments (Weidman, 2010). As such, doctoral students spend extended time periods with peers and other researchers, their "similar others." We found evidence that those who withdrew were keenly aware of others in their lab or program who had left before them or had experienced difficulties. Some appeared to use this information to feel better about their own situation. For example, one said, "We were a cohort of ten, and I was the second one to leave, but then there have been a few

others, so I am in good company." For some students, this information influenced their decision to withdraw: "I have seen a lot of other people struggling with it [not sure about earning a PhD] and not enjoying their time, and I am like, 'I don't want that to be me'," "The guy in lab – he is in his fifth year, and he is still taking classes. I mean, in the fifth year, you want to focus on your writing and research, and he is still taking electives, so it is very discouraging to me," and "One post-doc in our lab was struggling to find a job and basically told me I made the right decision." Thus, although the influence of observing similar others was not a driving factor of withdrawal, it was present among students' descriptions of their experiences.

Social persuasion. In general, most students did not discuss their withdrawal deliberations with their peers. When they did, peer responses were polite and non-committal: "If that's what you want to do, that's what you want to do. It's totally up to you": "You have to do what is right for you – good luck in the future." However, almost all reported discussing their situation with family or significant others. Students' descriptions of interacting with their families (including significant others) evidenced notable variations. Students reported that those who were very close to them on a daily basis were highly supportive of the withdrawal decision: "I discussed withdrawing with family and my significant other; they just wanted me to be happy and, given the treatment that I received [from my advisor] for months, it seemed like the clear choice" and "My significant other was fine with it [withdrawing] because she saw me every day and saw that I was basically a miserable person. A miserable, anxious mess." In other cases, family members were surprised but eventually supportive: "They [family] said, 'Let's talk this through . . . ' but once we finished our conversations, the consensus was that it was the right thing to do," "I think there was a general, 'How will your life go on if you don't finish your Ph.D.?' maybe a little bit of disappointment . . . but overall it was pretty supportive." Thus, most students involved family members or significant others in their withdrawal deliberations. Further, these interactions did appear to influence and validate withdrawal decisions, although there was substantial variation in how families reacted to students' decisions (as well as how or when students decided to inform family members).

Psychological states. Students in our sample experienced a range of emotions during their tenure in the doctoral program. With the exception of relief that their time in the program was ending, none were positive. Stress and anxiety were expressed by most students in this sample: "It dawned on me that I was really stressed out going home for Thanksgiving [in] just thinking about coming back to school," "My mental health was taking a big toll in graduate school and it was actually weighing on my physical health too . . . it was just a result of the stress and anxiety." Several students reported seeking counseling: "The stress of

school and [a new] marriage triggered flashbacks which worsened throughout the semester . . . I sought counseling . . .,'' "I went to the counselor the summer after my first year, and I saw her for eight sessions. I was obviously stressed. . .,'' and "I had to start seeing a therapist because the decision to leave caused me quite a bit of anxiety.'' Students reported being "worn out'' and "burned out'' from long hours in the lab contributing to the desire to leave: "I was completely worn out and couldn't do it for the next five years,'' "At this job, there was no balance – I was putting in 12 to 16 hour days during the week and one 8 hour day and one 5 hour day on the weekends,'' "70-80 hour work weeks . . . I was burnt out,'' and "My PI just had a child and is exhausted every single day and can barely stay awake while she is at work – Holy cow! Is this what I want?''

Outcome expectations. Outcome expectations, or personal beliefs about probable outcomes, involve imagined consequences of performing specific behaviors (Lent et al., 1994). Most students in this sample imagined the consequences of earning their doctorate and found them to be unattractive. Three areas of concern emerged in these expectations. First, some students rejected program-specific obligations, such as the amount of time they realized it would likely take them to earn their degree in their chosen program or the research area they would be forced to accept. For example, after learning that the previous PhD recipient in her lab had taken 7 years to earn this degree, a student flatly stated, "There is no way I am going to stay here for seven years.'' Other students who felt forced to take a project or accept an area of specialization simply rejected them, preferring to withdraw than to earn a degree with an undesired area of expertise. Second, a few students identified anticipated post-PhD lifestyle changes that they found unappealing, such as the need to relocate away from family or the likelihood of their job extending the 40-hour work week. As one student commented:

> We [my fiancé and I] are planning on having children, and if we are both working full-time, and if I have job in which I am working fifty to sixty hours and she is working forty to fifty hours, how do you have children and do that?

Finally, several students described their realization that earning a PhD in their field would, in their mind, provide them no professional advantages compared with those without a PhD. Representative comments included:

> Once I got to a new mentorship environment, I realized that what I liked about academics and science were things I could make a career of without a Ph.D. And when I was researching those careers, there were people with Ph.D.'s in those careers but they weren't making any more money or doing better than people who didn't have a Ph.D.

I talked to people in industry. Even if you have a Ph.D. or you have a master's, you start with an entry level position . . . the five years you spend in graduate school in a Ph.D., you could spend that in industry and you would be in a higher position in industry as compared to what you would get if you earned a Ph.D. and then joined industry.

I feel like I can do well in the workforce with a master's probably better than with a Ph.D. [which would] limit me tremendously even though I would be a so-called expert at whatever . . .

Professional goals. Almost all students in our sample indicated that they "still loved science" despite withdrawing from their programs. Only a few, however, had definite professional goals guiding their postwithdrawal plans. One stated, "I am not 100% what my future plans are - start a job at the university next week as a lab tech." One planned to attend pharmacy school, a second planned to pursue an MBA, while a third had secured a job as a medical writer. Almost all others, however, had returned to exploring various educational and career options: "I have applied to be a Physician Assistant, but then I withdrew my application and thought I'd better think more about it," "I am volunteering with my spouse in different countries," "I am looking for jobs in all kinds of health-care and pharmaceutical industry," and "I want a standard service job that only forces me to work 40 hours a week rather than 24/7; then I will have time to take internships. I am looking into veterinarian, pathology, or forensic science."

Discussion

This study explored experiences that preceded doctoral students' withdrawals and examined how expressed roles of students' self-efficacy, outcome expectations, and professional goals, (collectively referred to as "self-direction"; Lent & Brown, 1996, p. 310) contributed to the withdrawal process. In this section, we highlight study findings that significantly contribute to and advance current understandings of students' early doctoral program withdrawals, particularly as it occurs within the biomedical sciences.

Typical doctoral programs in the biomedical sciences differ from those in many other disciplines in their reliance on laboratory rotations during the first year as a mechanism of matching new students to permanent advisors and providing access to long-term supervised research opportunities. Being invited to join a permanent laboratory at the end of the first semester or first year marks a major transition for students in terms of both the nature of the advisement they receive and the expectations held of them for labor and performance. The rotation practice can be considered as a "signature pedagogy . . . a type of teaching that organizes the fundamental ways in which future practitioners are educated for their new professions" (Shulman, 2005, p. 52). Therefore, it is

somewhat disconcerting that our findings, while exploratory, reveal a less positive side of this signature pedagogy. In a large proportion of cases from our sample, once a student committed to a permanent laboratory, the expectations created during rotations were far different from the reality encountered.

We acknowledge many reasons may contribute to this expectation mismatch, such as an honest misunderstanding in communication among laboratory constituents or unrealistically high hopes held by the novice student. However, our findings also suggest other explanations. The increased reliance on graduate students as a labor source to sustain laboratory productivity and attract funding to support research agendas and infrastructures (Stephan, 2012) may be implicated. When competition between laboratories to recruit students is high, so too is the likely need for the laboratory to offer a ''friendly façade'' to their rotating student guests. Once the recruitment deal is sealed, a focus on productivity over student learning needs or project preferences may emerge. Because so little is known about students' rotation experiences, and because of the possible link between these experiences and early attrition, further exploration in this area would be beneficial.

On a more positive note, we are encouraged that a portion of our findings offer a counternarrative to the commonly held position that the poor quality of doctoral supervision and doctoral advisor–student relationships continue to be ''exceedingly vexing problems'' (Barnes & Austin, 2009, p. 298). Quite unexpectedly, we found that a relatively large number of study participants reported supportive and caring doctoral advising relationships, even in the face of impending departure. We recognize that not all attrition is considered *bad*, especially attrition occurring early in doctoral training. As has been noted earlier (Council of Graduate Schools, 2004; Nerad & Miller, 1996) and as supported by our findings, some portion of early career doctoral students will realize that the career they had hoped to secure through doctoral training is now undesirable, and their professional goals have changed. Others will quickly realize that the long, often grueling, hours associated with degree acquisition are not for them. What was surprising in these findings is that a notable proportion of faculty, as reported by their student advisees, evidenced a significant level of personal and social skills, or as O'Meara, Knudsen, and Jones (2013) suggested, emotional competence, in their responses to student attrition. Whether these faculty are doing so to ''cut their losses,'' so to speak, from a sense of empathy for their students, or because, as one student noted, ''When I was withdrawing, a new batch [of students] was coming in'' is unknown. However, it is worth noting that all advisors had made a substantive investment in these students by providing them with permanent laboratory placements.

Many of our study participants ''mastered out.'' Some saw this as a worthwhile exit strategy resulting in something tangible to show for their efforts. Others, however, stated that earning a master's degree was of little value, as they perceived that their field valued experience over credentials. Further, we

found no consistency across institutions in regard to "mastering out" policies or procedures. Some institutions offered a structure to guide students to master's degree completion, while others left students within a "no man's land" of absentee advisors. With the exception of student blogs, to our knowledge, the literature base is silent on the "mastering out" phenomenon, despite the likelihood that it is extensively used, given the high doctoral attrition rates we noted at the start of this article. Future research within the area of doctoral education is needed to examine this doctoral program exit strategy.

We used the socialization framework as a foundation but sought to extend it by exploring students' active engagement with aspects of self-direction during the attrition process. SCCT theory acknowledges the role of student self-efficacy, outcome expectations, and professional goals within the doctoral journey. In regard to sources informing self-efficacy (academic performance, observing similar others, social persuasion, and psychological states), our findings indicate that students do not choose to leave their doctoral program because they lack intellectual ability or confidence in that ability. A meaningful portion of our sample (over 20%) described the influence of observing similar others (peers), seeing them struggle with indecisiveness about earning a PhD, trying to finish coursework far into their degree programs, or finding a job postgraduation. Although the influence of observing similar others was not a primary withdrawal factor, it was certainly present among students' descriptions of their experiences.

In our review of social persuasion, we found that students were fairly guarded in their interactions with peers while considering withdrawal. A few reported in-depth peer interactions during the withdrawal process but most informed peers of their withdrawal decision only after it was made. Peer responses were usually noncommittally supportive, along the lines of, "You need to do what you need to do." Most students involved family members or significant others in their withdrawal deliberations and these interactions did appear to influence and validate withdrawal decisions. In our review of psychological states, the final self-efficacy component, we note that stress, anxiety, and mental health counseling were frequently relevant to our participants. These findings align closely with emerging literature identifying the critical importance of well-being to doctoral persistence (e.g., Hunter & Devine, 2016; Pyhältö, Toom, Stubb, & Lonka, 2012).

We found that aspects of self-efficacy played a mixed role in attrition. The influence of academic performance and observing similar others (peers) was fairly muted, while interactions with family members and significant others, often coupled with negative psychological states, were relevant attrition influences for our participants. Perhaps self-efficacy, while linked to important outcomes at the undergraduate level (e.g., Chemers, Hu, & Garcia, 2001; Vuong, Brown-Welty, & Tracz, 2010), is either not as potent or as responsive to adverse experiences when the student sample consists of doctoral students, most of whom are attending highly selective doctoral programs at R1 institutions.

In terms of the SCCT factors of outcome expectations and professional goals, we found that in general, these were tightly intertwined within our students' narratives. Regarding outcome expectations, we were disheartened but not surprised to find that a meaningful portion of students in this study indicated their belief that earning a PhD in their field would provide them no professional advantages compared with those without a PhD. A PhD is an important form of currency only in realms that recognize and honor it as a symbol of acquired knowledge and the capacity to create new knowledge. Traditionally, that realm has been academia. However, few students will secure an academic position (Cyranoski et al., 2011; Stephan, 2012) and many who enter a doctoral program will strongly consider nonresearch career options upon graduation (Fuhrmann et al., 2011). The stark reality is, as one of our participants observed, that the time spent earning a PhD could be spent in industry, "and you would be in a higher position in industry as compared with what you would get if you earned a Ph.D. and then joined industry." It is not surprising, then, that in our sample, professional goals, which were often vaguely defined at best, were redirected to professional paths still dedicated to science but searching for more secure footing.

The objective of our study was to discover why students, who have devoted extensive time, talent, and effort to prepare themselves for doctoral training, leave within the first 2 years of their doctoral program. We found that while a small number are forced to leave because of comprehensive exam failure or failure to be retained in a permanent lab, most choose to leave on their own accord. They do so because they find unacceptable the long hours spent within unpredictable lab environments, coupled with highly uncertain job prospects upon degree completion. This raises questions about how realistic their understanding of doctoral student expectations, especially in the biomedical sciences, was when they decided to pursue doctoral program acceptance. Regardless, there is no doubt that these students are exercising their agency and they have determined that leaving is preferable to staying. Their narratives suggest that the experience of the PhD journey as "survival of the fittest" (Hawley, 2010; Kerlin, 1995) remains intact, but the question arises: Who is more "fit"? Those who accept the conditions that often characterize the PhD learning environment and professional outcomes, or those who do not? This is a question that those concerned about the multiple competing priorities involved with doctoral education in the context of the industrial model of R1 Federal Grant Institutions must address.

Appendix

1. When in your doctoral experience did you begin to think about withdrawing from your program?

2. What factors influenced to your decision to withdraw from your program? (Please describe in-depth).
3. Have you discussed this decision with your family and/or significant other? If so, what was their reaction?
4. How did your Primary Investigator (PI) respond to your decision to leave.
5. How did students or others in your lab and/or program respond to your decision?
6. How do you feel about what has happened and your decision to leave your program?
7. What are you planning to do now?
8. Do you anticipate returning to a doctoral program, either this one or another one?

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