

Abstract

A descriptive phenomenological research design using a socialization theoretical framework is employed to describe the lived experience of socialization and its influence in the career pathways of 16 engineering postdoctoral scholars. Descriptive phenomenological data analysis strategies resulted in four constituents regarding effective postdoctoral socialization: (1) academic identity is nurtured, (2) disciplinary belonging is reinforced, (3) scholarly performance is strengthened, and (4) career development is essential for pursuing the professoriate. The essential structure was conceptualized as follows: Effective socialization of engineering postdoctoral scholars includes the enhancement of their academic identity, disciplinary belonging, and scholarly performance, as well as attention to the career development needs of those aspiring to be a professor. These findings shed light on the importance of the supervisor-supervisee relationship in the socialization process and the role of supervisors in shaping postdoctoral scholars' career trajectories.

Keywords: descriptive phenomenology, engineering, postdoctoral socialization

Introduction

The socialization experiences of postdoctoral scholars have a profound influence on their career pathway (Andalib et al., 2018; Pyhältö, 2018; Scaffidi & Berman, 2011; Shin et al., 2019; Silva et al., 2016; Van Benthem et al., 2020; Yadav et al., 2020). Postdoctoral appointments involve advanced apprenticeships in which doctoral recipients are further socialized into their academic field by learning the values, culture, and expected knowledge and skills of their discipline. While pursuing a career as a professor often is identified as the single most valued career option among science, technology, engineering, and mathematics (STEM) postdoctoral scholars (van der Weijden et al., 2016; Yadav et al., 2020), the path to the professoriate can be quite daunting without proper socialization. The postdoctoral socialization process is driven largely by the supervisor and often includes the enhancement of technical and research skills, effective lab management practices, teaching and mentoring, and strengthening academic writing as scholars navigate the publishing and grant-writing process (Chen et al., 2015). Although the development of these skills is critical to successfully transition to the professoriate, the socialization process has received little attention in the literature (Andalib et al., 2018; Van Benthem et al., 2020).

A descriptive phenomenology design (Giorgi, 2009) is employed to explore the lived experience of 16 engineering postdoctoral scholars to understand their socialization experiences and its influence on their desire to become a professor or seek an alternate career path. The postdoctoral socialization model of Shin et al. (2019) grounds the study, as it brings attention to academic identity, disciplinary belonging, and scholarly performance in the socialization process. This research is sponsored by the National Science Foundation (NSF) Alliances for Graduate Education and the Professoriate (AGEP; award number 1821008), project title

Collaborative Research: The AGEP Engineering Alliance: A Model to Advance Historically Underrepresented Minority Postdoctoral Scholars and Early Career Faculty in Engineering.

Literature Review

Since a career in the professoriate is the single most desired career option for STEM postdoctoral scholars (van der Weijden et al., 2016; Yadav et al., 2020), it is logical to assume the ascent into the professoriate follows a postdoctoral appointment. However, this is not the case because only 16% of engineering postdoctoral scholars secure a tenure-track faculty line upon completion of their appointment (Andalib et al., 2018). While much of the scholar's time and energy is devoted to cultivating their scholarly presence in the field and learning the performance metrics necessary to succeed in the professoriate, appointments tend to be unstructured in their socialization expectations which often hinders academic career aspirations (Åkerlind, 2005). Additionally, appointment duration is quite varied and temporary (Powell, 2015). Nonetheless, the postdoctoral socialization process is credited with forming individuals' research identities and shaping their career aspirations in academia and beyond (Andalib et al., 2018; Burt, 2019; Clement et al., 2020; Pyhältö, 2018; Scaffidi & Berman, 2011; Shin et al., 2019; Silva et al., 2016; Van Benthem et al., 2020; Yadav et al., 2020).

Postdoctoral appointments are designed to provide apprentice-type training and advance a scholar's disciplinary knowledge and technical skills, which boosts their confidence and efficacy as a researcher (Burt, 2019; Chen et al., 2015; Leshner, 2012; Scaffidi & Berman, 2011; Shin et al., 2019; Van Benthem et al., 2020). Studies have found confidence and efficacy are significant predictors of one's desire to remain in academia (van der Weijden et al., 2016). Thus, postdoctoral supervisors are poised to guide the goal-setting process and further a scholar's growth potential and career trajectory, as active mentorship plays a key role in their success in

the academic job market while also bolstering the supervisor's scholarly output (Burt, 2019; Clement et al., 2020; Levy, 2014; Pyhältö, 2018; Scaffidi & Berman, 2011; Van Benthem et al., 2020; van der Weijden et al., 2016). Mentoring significantly influences scholar's satisfaction with their work environment due to increased research productivity, decreased attrition rates, and deepened resilience (Burt, 2019; Pyhältö, 2018; Scaffidi & Berman, 2011; Van Benthem et al., 2020). Furthermore, Van Benthem et al. (2020) noted three contributing factors relate to overall postdoctoral satisfaction: quality of technical training received, encouragement from supervisors, and prior knowledge of career prospects.

However, the socialization process and subsequent relationship with the postdoctoral supervisor may result in disparities in training because the supervisor is primarily responsible for individual experiences, workplace culture, and overall job satisfaction (Burt, 2019; Clement et al., 2020; Pyhältö, 2018; Scaffidi & Berman, 2011; Van Benthem et al., 2020; van der Weijden et al., 2016; Yadav et al., 2020). When expectations and guidance are lacking, postdoctoral scholars tend to revert to graduate students and wait for direction rather than take ownership of their development (Burke et al., 2019). These experiences can manifest into depression and anxiety (Gloria & Steinhardt, 2016) and feeling as though one does not belong or is even an imposter (Chakraverty, 2020). Outcomes related to the imposter phenomenon include feelings of isolation, self-doubt, and low self-efficacy. Each construct works against a scholar's career goals and may contribute to their departure from academia (Chakraverty, 2020), which is compounded by a decline in tenure-track positions for engineering doctoral recipients (Silva et al., 2016).

Research indicates postdoctoral scholars are exposed to high levels of stress due to high scholarly output expectations coupled with limited supervisory support and low institutional oversight which thwarts successful socialization (Burke et al., 2019; Leshner, 2012; Small,

2012). Ålund et al. (2020) found that effective socialization most likely occurs when institutions enact policies aimed at supporting the career advancement, wellness, and mentorship of postdoctoral scholars. Yet, instances of negative postdoctoral supervisor-supervisee relationships permeate the literature (Burt, 2019; Van Benthem et al., 2020). Since supervisors are directly responsible for much of the satisfaction derived from a postdoctoral scholar's appointment, the academy must consider the role of supervisors in socialization and its influence in postdoctoral career paths (Burt, 2019; Clement et al., 2020; Levy, 2014; Pyhältö, 2018; Scaffidi & Berman, 2011; Van Benthem et al., 2020; van der Weijden et al., 2016; Yadav et al., 2020).

Theoretical Framework

The postdoctoral socialization model of Shin et al. (2019) served as the theoretical framework of the study. The model is based on the Academic Profession in the Knowledge Society (APIKS) survey which is dedicated to the study of changes in academic work, such as research, teaching, and working conditions in over 30 countries (Center for International Studies, 2021). Through a descriptive and multivariate analysis of Korean academics, Shin et al. (2019) determined postdoctoral socialization includes the development of an academic identity, a sense of disciplinary belonging, and heightened scholarly performance. The researchers found these components influence career motivations and competitive positioning in the faculty job market:

1. Academic identity: how an individual self-identifies in a professional setting.
2. Disciplinary belonging: the extent to which an individual feels like a valued member of their academic community.
3. Scholarly performance: an individual's technical skills and academic record.

The postdoctoral socialization model informed the study through the concepts being embedded in the interview protocol, which included questions about experiences that defined their graduate

work, reasons for choosing a postdoctoral opportunity, satisfaction with their postdoctoral appointment, long-term career goals, and professional development opportunities. The model also was integrated in the data analysis process and considered in the implications of the study.

Methodology

Research Design

A descriptive phenomenological research design (Giorgi, 2009) was utilized to describe the lived experience of socialization among 16 engineering postdoctoral scholars. The methodology was based on the philosophy of Edward Husserl: “from a Husserlian point of view, phenomenological research is the explication of the essential structures of phenomena as they present themselves to consciousness” (van Manen, 2017, p. 2). Thus, the lived experience must be captured pre-reflectively as it reaches consciousness. Interviews, grounded by the postdoctoral socialization model of Shin et al. (2019), provided an in-depth account of postdoctoral socialization and how socialization influenced their career path, particularly their desire to enter the professoriate. Due to the scope of this NSF sponsored project, the research questions guiding this study are:

1. How do engineering postdoctoral scholars describe their lived experience of socialization?
2. How does socialization influence postdoctoral scholars’ desires to become a professor?

Participants

The National Postdoctoral Association was utilized to recruit an original sample of 50 STEM postdoctoral scholars through a dedicated email-alert. Participation was incentivized with a \$25 Amazon gift card. Over 300 individuals responded indicating their eagerness to participate,

and the final sample was based on self-reported field of study, race/ethnicity, and gender. The findings report specifically on the socialization experiences of the 16 engineering postdoctoral scholars within the original sample. The focus of the study was on engineers since the goal of the NSF AGEP Alliance is to support the transition of racialized engineering postdoctoral scholars to the professoriate. All participants had been in their postdoctoral position for at least one year and held appointments at R1: Doctoral Universities with Very High Research Activity. The sample was comprised of two African Americans, four Asian Americans, seven Caucasians, and three Latinx individuals who were all US citizens. Seven identified as female and nine as male, and ages ranged from 29 to 43. Engineering fields represented in the sample included aerospace, biomedical, chemical, civil, computer, electrical, environmental, and nuclear.

Data Collection

Interviews are the primary form of data collection in phenomenological studies because they allow for a dialectical relationship between participants and researchers (Giorgi, 2009). Following Institutional Review Board approval, all participants were provided with a consent form detailing the purpose of the study, the interview procedures, and the safeguards in place to protect their anonymity. Each interview averaged 60 minutes in length and was conducted one-on-one via web conferencing or telephone. The interviews were administered by multiple individuals and digitally recorded. The model of postdoctoral socialization (Shin et al., 2019) was embedded in a semi-structured interview protocol. Queries focused on career interests and goals, professional activities undertaken during postdoctoral training, and capacity for career success. The interview questions encouraged participants to adopt a pre-reflective stance towards their socialization experiences rather than simply relaying them (van Manen, 2017). A natural, free-flowing dialogue was cultivated where researchers were active listeners and participants in

the interview to develop the dialectical relationship espoused by phenomenological researchers (Giorgi, 2009). While the interview protocol was carefully worded and questions were specified in a particular order, the interviews were conducted in an unstructured manner to create a comfortable, genuine dialogue. Upon completion of all 50 interviews, the recordings were transcribed by a third-party service and permanently deleted after the transcripts were reviewed and cleaned for any errors.

Data Analysis

Descriptive phenomenological data analysis strategies of Giorgi (2009) were utilized to describe the lived experience of socialization among the participants. Giorgi (2012) delineated his analysis process in five steps: (1) sense of the whole, (2) meaning units, (3) transformation, (4) structure, and (5) essential structure. To effectively employ a phenomenological research design, researchers must first adopt the attitude of the phenomenological reduction by bracketing out prior knowledge of the phenomenon and setting aside one's thoughts, feelings, and experiences to minimize research bias in the data analysis process (Giorgi, 2008). To accomplish this, the researchers collectively discussed their academic socialization experiences and their scholarly perceptions of socialization. Through this process, an understanding was reached relative to the importance of caring and supportive mentors in socialization and the value of developing independence as a researcher. Adopting the attitude of the phenomenological reduction also includes refraining from theorizing or conceptualizing that which is "given" during the interviews, while understanding information presented is not necessarily accurate as participants are sharing what is in their consciousness (Giorgi, 2012). Last, special sensitivity must be given to the lived experience being shared in order to engage in the experiential, discovery-driven analysis process required in phenomenology (Giorgi, 2008).

In applying the first step, researchers read the interview transcripts several times to obtain a *sense of the whole* of the interviews by engaging in phenomenological reduction (Giorgi, 2009). This occurred through immersion in the data, resisting judgment or interpreting meaning of the data, and developing a closeness with the participants through the attitude of special sensitivity. Bracketing also was reintroduced to consider new and multiple ways of approaching the data. In the second step, *meaning units* were developed separately by each researcher because units are subjective, intuitive, and correlated with individual researchers (Giorgi, 2009). Meaning units were revealed as the researchers re-read the transcripts and began to define meaningful parts of the whole. *Transformation* in step three occurred by converting the participants' words and expressions into higher levels of meaning through free imaginative variation in which contextual factors and conditions were considered to gain a closeness to the data. The theoretical framework of postdoctoral socialization (Shin et al., 2019) was used in this step as an analytical lens to develop further meaning of the participants' voices.

In the fourth step, the *structure* was illuminated through consideration of the shared constituents of socialization while attending to variations of the engineering postdoctoral scholar experiences. Four constituents emerged from the data regarding effective postdoctoral socialization: (1) academic identity is nurtured, (2) disciplinary belonging is reinforced, (3) scholarly performance is strengthened, and (4) career development is essential for pursuing the professoriate. The fifth step involved a discovery of the *essential structure*, which entailed generalization and clarification of the inter- and intra-relationships among the constituents (Giorgi, 2012). The essential structure was conceptualized as follows: Effective socialization of engineering postdoctoral scholars includes the enhancement of their academic identity,

disciplinary belonging, and scholarly performance, as well as attention to the career development needs of those aspiring to the professoriate (see Figure 1).

Validity and Rigor

Sundler et al. (2018) shared the importance of addressing issues of validity and rigor in descriptive phenomenology studies through upholding reflexivity, credibility, and transferability of the research process. Reflexivity through bracketing and the involvement of several researchers in the data analysis process allowed for continuous, critical reflection of the constituents and the essential structure. Credibility was achieved by following Giorgi's (2009) descriptive phenomenological data analysis steps to ensure the process was transparent and accounted for the whole of the data rather than narrowing in on data that may have resulted from confirmation bias. To ensure transferability, participant quotes were utilized to provide thick, rich descriptions of the phenomenon and to bolster the "relevance, usefulness, and meaningfulness" (Sundler et al., 2018, p. 737) of the essential structure to other contexts. Additionally, the implications of the study speak specifically to interested stakeholders so they can determine whether the findings resonate with their own lived experience and unique setting.

Limitations

This study involved only postdoctoral scholars willing and selected to share their socialization experiences, which suggests bias in the data. Those who desired and were selected may have been substantively different than individuals who chose not to participate or were not selected. Member checks were not conducted due to the extreme difficulty in scheduling and administering the interviews to align with the participants' busy schedules. While Giorgi (2009) questioned the value of member checks because participants lack the training to apply the attitude of phenomenological reduction, member checks are a common qualitative trustworthy

strategy (Lincoln & Guba, 1985). Member checks may have provided a more complex depiction of the lived experience of socialization and its resulting influence on the career intentions of the participants. It is also important to note that all study authors are education academics trained in qualitative research methods and hold professorship, research affiliate, and/or administrative positions; thus, the data were approached largely from an outsider perspective.

Findings

Academic Identity is Nurtured

While a postdoctoral scholar's academic identity is largely shaped through personal conceptualizations of their capabilities, individual strengths, and future aspirations, the socialization experienced during their postdoctoral appointment nurtured their academic identity. Most supervisors intentionally fostered the academic identity of their scholars with a focus on ensuring they not only possessed the skills and knowledge, but also the confidence to be independent researchers who could pursue a variety of career options. Interviewee 1, an Asian American male pursuing a career in industry, shared the positive relationship with his advisor and his subsequent confidence in moving forward in his desire to go to industry, "By the end of the postdoc, I felt that I knew enough to talk to people. I knew enough to be marketed for a job outside academia, and so I felt confident."

Most postdoctoral scholars intended to secure a tenure-track faculty position, but they shared uncertainty on whether they chose this career path by default or were passionate and committed to it. Some supervisors eased into the role of helping the scholars identify their career goals, while others deliberately worked to build this capacity from the start, as evidenced in the following statement from Interviewee 2, a White female:

My primary postdoc supervisor sat all the postdocs down the first semester and said, “What do you want to do after you're done here and what can I do to help you get there?” And so he worked with me through all of my application materials and figured out what questions to ask in interviews to gauge if it was going to be a good fit for me, and so he was really instrumental.

This supervisor clarified he was there to support and guide the individual's journey from postdoctoral scholar to engineer in academia, government, or industry. Interviewee 3, an African American female, noted the genuineness of her postdoctoral supervisor during her interview:

My current mentor for my postdoc, she's been pretty helpful. She was someone that I connected with in the middle of interviewing and she pretty much was like, regardless of whatever you choose, I'd be open to helping you decide your career path and mentor you.

This supervisor's commitment to the development of the scholar's academic identity drove her decision to choose this institution because the supervisor's dedication was a quality she valued and purposely sought out throughout her academic journey.

Postdoctoral supervisors also supported the academic identity of their scholars by encouraging them to network in venues outside academia in order to recognize their ability to make scholarly contributions in diverse settings. Interviewee 1, an Asian American male hoping to become a professor, shared his supervisor suggested he attend a city meeting, which led to his local acclaim and a published paper:

This town hall meeting was about a local issue, some water issue...I just made some notes, and then I shared with my boss and some other colleagues. I wrote a paper that got published...and then a few months later, I find out that...an assembly person, state senator, from that area, and some local activists...used a few extracts from my article and

cited it in a letter to some agency. And so that felt like recognition that somebody found this work interesting, meaningful, and significant...the fact that somebody was able to benefit from my research and scholarship, that was important.

This one suggestion from his supervisor led him to see how his research could be applied to real-world problems, which strengthened his academic identity. He heralded this experience as boosting his confidence as a researcher and building his scholarly capacity.

Although most participants reported positive socialization experiences that fostered their academic identity, some indicated they were “shaken” by aspects they witnessed about the life of a professor. Interviewee 2, a White female who now desires a career in academia in an administrative capacity, conveyed the following:

I observed that a lot of the faculty that I interacted with on the tenure-track were very stressed about finding money and stressed about getting a certain number of publications...and so, it was a lot of adjusting and tweaking the goal [of becoming a professor] that I had laid out for a very long time.

In a related comment, Interviewee 4, an Asian American male interested in pursuing a career as a professor, indicated the pressure on faculty and postdoctoral scholars negatively socialized him to the professoriate:

Even the supervisor has more difficulty than in the past to get grants. And this makes them maybe not the most ideal mentor because they are stressed. They have their own problems. So, this is something which is sometimes disappointing and maybe this is my least favorite component [of the professoriate].

Stress and pressure often characterized faculty work, suggesting the socialization experienced by the scholars caused them to question their academic identity and resilience for entering the tenure-track job market.

Disciplinary Belonging is Reinforced

Supervisors were pivotal in socializing postdoctoral scholars to the work culture, dynamics, and norms of academia. Supervisors who fostered a positive culture in their workspace, labs, and with their networks reinforced a sense of disciplinary belonging for their scholars. Opportunities to collaborate and network with prominent academics across institutions helped participants see how they could contribute to the field of engineering. Interviewee 5, a White male, shared one of his experiences that exemplifies the importance of disciplinary belonging:

My mentor here has become good friends with famous people in the field and so we've had the honor and privilege to take some visits to meet them and use their machines to image. And that has led to a number of different discoveries and that's been just incredibly insightful and very exciting.

A supervisor who is willing to make connections and introduce their scholar to their academic networks creates opportunities for them to gain recognition and to feel like a valued contributor in research collaborations. The prestige of the university also is important. Interviewee 6, an Asian American female, mentioned she is “at the peak of the mountain...on the top of the whole academic experience and really trying to cherish that.” She keenly understood the reputation of her institution gave her credibility and stature which supported her professor career aspirations.

A White male, Interviewee 7, stated the work environment was his most treasured component of his postdoctoral appointment:

I would say my favorite overall aspect of the postdoc has been the relationships here. I think this place has a knack for recruiting people that have the same infectious passion for helping children and I think that naturally brings out the best in people.

This scholar indicated developing friendships made him feel he belonged; he quickly understood he could easily relate to others and develop personal connections through a shared passion for engineering. Yet, not all participants were socialized to feel as though they belonged in academia, as noted by Interviewee 4:

They [postdoctoral supervisors] are thinking about themselves, they're thinking about their project, and they just want to move on to make progress in that. And sometimes I feel they don't care what you're doing or feeling. I mean, as long as someone is moving on, as long as someone is making progress for research, that is all they're looking for.

This individual failed to feel he was a valued member of his lab team or his team truly cared about him beyond his research contributions. These experiences led him to question his confidence and efficacy for academic work, which diminished his sense of belonging.

Each of the racialized postdoctoral scholars shared at least one occurrence that left them feeling like they did not belong, which they attributed to poor socialization. Interviewee 8, an African American male seeking a tenure-track faculty position, shared a conversation during a lab meeting that led him to question the degree to which he belonged:

There was one moment in the lab where there was a conversation around applying for fellowships...basically, it was a conversation around how there are often quotas...for people from underrepresented backgrounds. I'm the only Black person in my lab, and there was a guy, an undergrad, who was applying for funding for graduate school. People were kind of lamenting about how difficult this was, and there was a comment from my

advisor, "Yeah, it's a shame that you're not from his background, because it would be easier for you," or something along those lines, basically implying that it was easier for me because I was Black...I'd never really experienced that before.

The scholar was stunned by this exchange and felt his supervisor displayed racial bias and ignorance by intimating racialized students are afforded undue advantages, which he believed perpetuated an assumption that he was less qualified than others on the team. This led him to feel he did not belong and drove a wedge between him, his supervisor, and other lab mates. As a result, he questioned his place in the lab and whether his accomplishments as a researcher landed him his postdoctoral position or if it was his "skin color."

Scholarly Performance is Strengthened

Supervisors also are charged with strengthening the scholarly performance of postdoctoral scholars through ensuring they develop into independent researchers. This development includes building individual research capacity, polishing writing skills, and acquiring effective lab management competencies. Adept scholarly performance is necessary for growth in the field as a researcher and as a future professor because researching, writing, and publishing are necessary to ascend the academic ladder. Interviewee 9, a Latino currently contemplating a career in industry, shared his supervisor's socialization influence on his scholarly advancement:

At the beginning, I didn't put too much attention in deeply analyzing the results that I obtained. Then my adviser criticized that. He told me, okay you obtained results, but you didn't pay enough attention to the analysis of why I am obtaining these results? What are the reason for which these differences are large, these differences are small?...This situation allowed me to learn and to improve as a researcher.

His supervisor had cultivated a strong personal and professional relationship with him, which ensured this “difficult conversation” was constructive and an opportunity for growth.

Interviewee 4 revealed his supervisor encouraged him to apply for a second postdoctoral appointment to further extend his research skills and training, rather than remaining on his current project:

My advisor encouraged me to find the chance of working in a second lab to...at that time I had the chance of working at a renowned institution with additional focus on applying my engineering skills into health sciences, and it seemed like the better fit.

He was deeply appreciative of his supervisor ensuring he possessed the necessary competencies and experiences to be competitive for a tenure-track faculty line, an important component of postdoctoral socialization. Additionally, Interviewee 5 shared his excitement on the amount of time and energy his advisor invested in expanding his skill level:

It's a great place for me to learn, especially with [my supervisor]. He's been fantastic and extremely patient, taking me to school, drawing things out on the whiteboard, and spending hours explaining things to me. And I just couldn't thank him enough.

Socialization experiences that heightened individuals' scholarly performance were the most valued, particularly when coupled with genuine passion and enthusiasm for research and new discoveries.

A vital aspect of socialization in terms of scholarly performance for engineering postdoctoral scholars is to successfully secure external funding. Interviewee 5 noted his supervisor nominated him to participate in a grant-writing seminar that was quite valuable because it led him to successfully submit a federal grant with an excellent chance at being funded:

I attended a five-week workshop where every week you're working on a different component of the application so it kind of helped me structurally set my ideas down. It's only available to 15 or so postdocs...the people running the workshop really know what they're doing so it was a great learning experience and looking back I believe that my application would have been very subpar without that opportunity.

This experience fostered confidence in the participant's ability to write grants, and he expressed optimism for future success in this area. Moving forward, he shared he would welcome grant-writing opportunities, as he feels capable in his abilities to tackle the challenge. Women scholars were acutely aware that they would likely face bias in the grant-review process, so they were cognizant of the importance in collaborating with others. Interviewee 10, a White female shared, "There's systematic bias against women...and that's something I hope I don't have to deal with...I sort of combat that fear by just trying to work with the most prestigious mentors I can find and put in my time." She understood that this bias permeated academic performance metrics, from the hiring process to the promotion and tenure process.

Career Development is Essential for Pursuing the Professoriate

In addition to fostering academic identities, disciplinary belonging, and scholarly performance, effective supervisors supported the career development of their postdoctoral scholars through the socialization process. While the first three constituents identified in this section encompassed career development, this constituency is distinguished by the purposefulness and intentionality displayed by supervisors in guiding their scholars toward their next career stage. Interviewee 12, a White male, shared his supervisor provided hands-on support in preparing him for the tenure-track job market:

I give my advisor a lot of credit, he clearly put a lot of effort into helping me, he read through my application materials, gave me advice...He said it's a good idea to go to a lot of conferences, do a lot of presentations to try to get yourself out there, and meet people and network and find opportunities. So, I think for a lot of people, their postdoc advisor and how much effort they made can really make a difference.

This account perfectly illustrates the important role of supervisors in the career development of their scholars. Their support bolsters confidence for entering their next career stage and successfully prepares them for their intended career path.

However, not all participants felt prepared or in a competitive position to vie for a tenure-track faculty position. These postdoctoral scholars often placed blame on their supervisors who they believed held little disciplinary clout to support their career development. Interviewee 13, an Asian American male aspiring to the professoriate, shared his supervisor is not recognized in the field, which hindered his ability to be competitive in the tenure-track faculty job market:

He knows that a lot of hiring takes place in industry and academia by telling people, 'Hey, my postdoc is applying to your university. Could you at least see his CV?'...but he's not very influential...I'm a little bitter, I would say, because I started the postdoc with the goal of becoming faculty later on, but I feel I am not able to...I found it depends on the influence of the advisor.

His disappointment was palpable, as he believes he "wasted his time" working hard during his postdoctoral appointment because his supervisor was unable to provide him with the connections to move forward with his intended career goal.

Interview 13 also intimated frustration and regret at receiving limited to no guidance in the career decision-making process:

There was a lack of support from my advisor...when I asked, what is the career pathway after this? He was like, oh, you need to figure that out for yourself, what you like, what you don't like. This is true, but there was a lack of support. I didn't like that.

He was deeply disappointed and even disenchanting with his postdoctoral position because his supervisor's unwillingness to even have a conversation about career options made him feel he was on his own. Interviewee 14, an Asian American female, shared a similar sentiment:

We have a saying in my culture. If you are on the top of a palm tree, you are neither on the ground nor in the sky. A postdoc is somebody in the middle. They feel like they are way up, really able to see everything, but really, they're not in the sky. They're also not on the ground. They fall into the crack somewhere...so they're completely lost.

While only a few of the postdoctoral scholars shared these types of experiences, the isolation of which they spoke was deafening.

Beyond the efforts of their postdoctoral supervisor, more than half of the scholars identified participation in career development opportunities as beneficial to defining their career plans. These opportunities arose through a suggestion from their supervisor or were hosted by their institution or a professional organization. Each enhanced the socialization process for the individual and brought them closer to the next step in their career. Interviewee 15, a White female, shared:

My department offers some events that are things like career advice or research statement writing advice...we also have a couple of events so that we can talk to the people who have recently got an academic position. So those were all pretty useful. Otherwise, I ask my advisors to involve me in some activity that may be useful in the future. For example, reviewing a manuscript or putting together our small projects for visitors.

Relatedly, departmental financial support to attend conferences was considered critical for those intending to join the professor ranks. Interviewee 11, a Latino remarked, “I enjoy conferences very much because I can do different projects, and present...we have the funding and its rewarding.” These experiences were consistently identified as valuable socialization opportunities.

A few individuals discussed institutional consortia designed to support racialized postdoctoral scholars as they navigated academia and the professoriate ladder. Interviewee 3 shared her experience of having a network of mentors dedicated to her career success: “We're mentored really well between those at the Provost level and Dean level, the hands-on support and their commitment to us...and our potential faculty appointments means a lot.” Interviewee 16, a Latina, also shared the professional development opportunities in which she participated:

We have an office of postdoc studies that puts on a ton of programming around different topics helping people prepare for the job market. They also have a new program called NexGen professors...we would meet about once a month and it would be on different topics and we had access to underrepresented faculty...we would have power mentoring sessions, where we could ask anything of the faculty. We had peer reviewing of our teaching and diversity statements.

Participants appreciated these types of programs because they were created to support the diversification of the professoriate, provide guidance on developing competitive application materials, and offered tailored programming to address the career goals of racialized scholars.

Discussion

Understanding the socialization experiences of postdoctoral scholars is critical to improving the postdoctoral experience and the career pathway to the professoriate. Sharing the

viewpoints and insights of engineering postdoctoral scholars through a descriptive phenomenology research design (Giorgi, 2009), grounded by a postdoctoral socialization model (Shin et al., 2019), illuminated the integral role of postdoctoral supervisors in successfully socializing and aiding scholars in their career pursuits. Descriptions of quality socialization experiences were found to be paired with reports of supervisors who invested a great deal of time and energy in their postdoctoral scholar's career trajectory, suggesting the nature of the personal and professional relationship is a key component of effective socialization. The notion that positive and supportive socialization is a critical component of successful postdoctoral appointments corresponds with the work of other researchers who found successful socialization experiences shape and support scholar career aspirations (Burke et al., 2019; Burt, 2019; Chakraverty, 2020; Clement et al., 2020; Pyhältö, 2018; Scaffidi & Berman, 2011; Silva et al., 2016; Van Benthem et al., 2020; van der Weijden et al., 2016; Yadav et al., 2020).

As postulated by Shin et al. (2019), effective postdoctoral socialization includes supervisors supporting the development of their scholars' academic identity, disciplinary belonging, and scholarly performance, as also noted in the literature (Chakraverty, 2020; Clement et al., 2020; Scaffidi & Berman, 2011; van der Weijden et al., 2016; Yadav et al., 2020). The model provided the components and context with which to recognize how socialization plays out in practice and influences the career pathways of postdoctoral scholars. Yet, a key finding in this study that diverted from the postdoctoral socialization model was the importance of addressing the career development needs of scholars, particularly those aspiring to the professoriate.

This study provides rich insights into the socialization process and the subsequent supervisor-supervisee relationship of engineering postdoctoral scholars and ways in which this

relationship influenced career pathways, as well as awareness of the values, norms, and expected knowledge and skills of aspiring professors. Supervisors who enhanced the academic identity and scholarly performance of their postdoctoral scholars through successful research projects and dissemination efforts led the scholars to feel confident and able to compete for a variety of career options, as has been found by others (Al Qunayeer, 2019; Burke et al., 2019; Burt, 2019; Chakraverty, 2020; Clement et al., 2020; Levy, 2014; Pyhältö, 2018; Scaffidi & Berman, 2011; Silva et al., 2016; Van Benthem et al., 2020; van der Weijden et al., 2016). The time spent by supervisors in reviewing job application materials and flexing their networks and connections in support of their postdoctoral scholars was critical in obtaining the attention of hiring committees and easing career transitions (Burt, 2019; Chen et al., 2015). It is clear supportive supervisors created healthy workplace cultures and team dynamics that positively affected postdoctoral socialization by increasing disciplinary belonging and decreasing stress levels, a finding also supported by others (Clement et al., 2020; Gloria & Steinhardt, 2016; Pyhältö, 2018; Scaffidi & Berman, 2011; Van Benthem et al., 2020; van der Weijden et al., 2016; Yadav et al., 2020).

Conversely, a few of the postdoctoral scholars shared instances of poor socialization and unsupportive supervisors, describing their experiences as “hostile” and a “waste of time,” which led them to reconsider their career goals and desire to be a professor, as also noted by other researchers (Burt, 2019; Leshner, 2012; Small, 2012; Yadav et al., 2020). Some participants shared their supervisors provided little to no support and guidance when considering their next career step, while some supervisors directly told them “they would not cut it in academia” and actively worked against their ascent into the professoriate by diminishing their work contributions, which also is consistent with the literature (Åkerlind, 2005; Scaffidi & Berman, 2011). Several of the postdoctoral scholars believed their supervisors to be poor advocates which

limited the help they could provide them in reaching their career goal (Clement et al., 2020). Scholars also witnessed stressful work environments when interacting with tenured/tenure-track faculty, which led them to consider career paths outside of the professoriate. Regardless of intent, poor socialization experiences and unsupportive supervisors were equally influential in shaping the career pathway of their postdoctoral scholars, which is also noted by other researchers (Burke et al., 2019; Burt, 2019; Chakraverty, 2020; Clement et al., 2020; Pyhältö, 2018; Scaffidi & Berman, 2011; Silva et al., 2016; Van Benthem et al., 2020; van der Weijden et al., 2016; Yadav et al., 2020).

Implications for Practice

The role of postdoctoral scholars in the research enterprise of higher education cannot be overstated; therefore, their socialization must become a high priority. The findings of this study suggest scholars seek supervisors who are not only committed, but also skilled at intentionally enhancing their academic identity, disciplinary belonging, and scholarly performance, as well as meeting their career development needs. Thus, institutions must devote resources to postdoctoral offices and supervisor training to ensure scholars receive the appropriate support to advance in their careers. It is imperative supervisors possess the skills, knowledge, and dispositions to effectively socialize their scholars into their disciplinary field and for the academy to take responsibility for orientating supervisors who do not possess these characteristics. Training must occur in a holistic manner, with attention not only to effective socialization practices, but also to ways in which to develop mentoring relationships and positive work cultures for those under their guidance. It is important for supervisors to understand their critical role in advancing and guiding their postdoctoral scholars' career decision-making process.

Future Research

An important area for future research lies in the need to identify efficacious postdoctoral scholar socialization practices that can be replicated and scaled across programs and institutions. Knowledge of the factors that comprise effective socialization experiences and encourage the pursuit of the professoriate is critical to the future of engineering academia and warrants further study, as little research has been brought to bear on this topic. Examining supervisors and institutions that place value and emphasize the role of mentorship in the postdoctoral scholar experience may contribute to the efficacy and satisfaction of scholars, as well as to their career trajectories. Investigating the training received by supervisors to support postdoctoral socialization also is a rich area for exploration, as advocated by others (Burke et al., 2019; Levy, 2014; Pyhältö, 2018; Scaffidi & Berman, 2011; Yadav et al., 2020).

Additionally, examining the socialization experiences of racialized scholars is vital for those invested in broadening participation in engineering academia (NSF, 2019; Yadav et al., 2020). Presently, just under 10% of engineering postdoctoral scholars (Yadav et al., 2020) and 6% of engineering professors (Roy, 2019) identify as racial/ethnic minorities. The experience shared by Interviewee 8, the African American male scholar, who surprisingly found himself in a hostile work environment requires further study. Unfortunately, this occurrence is similar to the findings of other researchers who have reported racialized postdoctoral scholars experience marginalization, bias, and tokenism which diminishes the desirability of academia (Chakraverty, 2020; Robinson et al., 2016; Yadav et al., 2020). An investigation also is needed on the ways in which supervisors support the intersectionality of racialized postdoctoral scholars because their experiences stand in stark contrast to those of White male scholars. It could also be fruitful to attend to different institutional and cultural contexts, as those interviewed in this investigation

were all cast at US institutions. While none of the scholars spoke of the imposter phenomenon (Chakraverty, 2020), many articulated the associated outcomes such as feelings of isolation, self-doubt, and low resilience, which warrant further study.

Conclusion

This descriptive phenomenological study (Giorgi, 2009) explored the lived experience of 16 engineering postdoctoral scholars who were primarily seeking to enter the professoriate upon completion of their postdoctoral appointment. The socialization model of Shin et al. (2019) provided a deeper understanding of the components of effective socialization and how socialization intersects with postdoctoral career paths. This study answers the call in the literature to better understand the ascent from postdoctoral scholar to professor (Andalib et al., 2018; Burt, 2019; Clement et al., 2020; Pyhältö, 2018; Scaffidi & Berman, 2011; Shin et al., 2019; Silva et al., 2016; Van Benthem et al., 2020; Yadav et al., 2020). It shed light on the importance of the supervisor-supervisee relationship in the socialization process and the supervisors' prime position to shape scholars' career trajectories. Findings highlight that effective socialization of engineering postdoctoral scholars includes the enhancement of their academic identity, disciplinary belonging, and scholarly performance, as well as attention to the career development needs of those aspiring to the professoriate. A greater awareness and appreciation of the socialization experiences of engineering postdoctoral scholars has the potential to positively influence the academy at large, and engineering academia specifically.

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