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Using Observational Learning Theory to Interpret How Engineering and Computer Science Faculty Learn to Mentor Postdoctoral Scholars

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Using Observational Learning Theory to Interpret How Engineering and Computer Science Faculty Learn to Mentor Postdoctoral Scholars

Abstract: In this research paper, we describe faculty development as mentors to postdoctoral fellows (postdocs). Postdoctoral fellowships have become a significant step in academic and industry positions, while little research investigates the purpose of a postdoc position, the experiences of postdocs, and how faculty develop as postdoc advisors. As part of a larger project investigating postdoc mentorship, nineteen semi-structured qualitative interviews with faculty advisors uncovered themes about how postdoc advisors learn to mentor and advise postdocs. Faculty from U.S. and Canadian universities completed 60-minute online interviews. Participants had varying experience and expertise in advising postdocs. Observational learning theory provides a framework for identifying the process of learning from observation and the replication of mentors' past experiences. Open and axial coding was used to identify faculty experiences that informed how they mentored their postdoctoral fellows. Faculty who had completed a postdoc as part of their training reflected on their experiences, often identifying positive and negative experiences they used to guide, mentor, and plan the development of the postdocs they advise. Faculty who did not complete a postdoc used doctoral and industry experiences to inform their decisions. This work provides a unique window into postdoctoral training and mentorship, highlighting the need for more explicit expectations and plans for postdoc advisors.

Keywords: Postdoctoral studies, Mentoring, Qualitative Thematic Analysis

I. Introduction and review of relevant research

The postdoctoral position in engineering and computer science is fascinating, given that candidates pursuing both academic and specialized industry career trajectories often are expected to undertake some postdoctoral training [1]. Postdoctoral positions across disciplines are intended to help scholars develop deeper methodological and subject content competency, management, and other professional skills like grant writing and leadership that require significant mentorship to accomplish [2 - 4], but literature documents postdoctoral scholars often feeling "trapped" or on a "postdoctoral treadmill" [5] governed by the whims of faculty mentors and going seemingly nowhere as they aim for very competitive faculty positions. Literature in engineering and computer science education has not yet turned a focused eye to the stage of education represented by postdoctoral positions after earning the Ph.D. but before full training is completed. While completion of postdoctoral positions (and sometimes two or three) are nearly a requirement to be competitive for faculty positions in biological and biomedical fields, the nature of engineering and computer science disciplines yields different expectations. While it is not out of the norm for incoming faculty to have postdoctoral research experience, it is not the accepted "requirement" the same way it is in other fields. As a comparison, as of 2019, there were 8,266 postdoctoral researchers in computer science and engineering, compared with 21,847 in biological sciences, 7,159 in physical sciences, and 1,762 in social sciences [6], perhaps due to the wide range of lucrative industry careers for Ph.D. holders in engineering and computer science fields. Though these numbers are lower in engineering than in other fields, it is essential to turn empirical attention to the postdoctoral stage of education with a disciplinary focus, understanding that the expectations for computer science and engineering disciplines reflect different landscapes from other fields. To

date, there have been very few studies of postdoctoral engineering scholars, and those that do study postdocs often aim at investigating their mentorship styles toward undergraduates [7, 8], merging postdocs in all STEM disciplines together [4, 9], or merge graduate students in with postdoctoral scholars in investigating their (negative) experiences [10].

The unstructured nature of most postdoc positions and adherence to a highly individualized relationship that defines the historical "apprenticeship" model for advanced education can lead to irregular access to mentors; potentially incomplete mentorship experiences [11, 12]; insufficient resources essential to successful postdoc development [1, 13, 14]; and bias or discrimination [9]. In engineering, like most disciplines, the postdoc mentorship relationship involves a private, individual relationship that is not accessible or visible to outsiders [15]. Although postdoctoral scholars hold Ph.Ds., there is still a power dynamic: Postdocs rely on advisors by trainees for future research training, guidance, and career opportunities, rendering any meaningful accountability nearly impossible [16 - 18]. Even if faculty desire to improve their mentoring relationships, there are few structures in place at most universities to translate postdoctoral concerns to their supervisors in a meaningful way [19]. To this end, most articles on postdoctoral mentorship conclude with calls for more robust mentorship, closer advisor relationships, focused career development, and professional skills training (e.g., 15, 19, 20]. Considering that implementing these recommendations or other improvements must either be provided by the mentor or have the mentor's support in the undertaking, without supervisors' intentional efforts to improve their mentoring, these calls are moot.

Literature is clear that postdocs benefit from high-quality advising and mentorship [6, 21 – 25] and suffer without "good mentorship," demonstrated by the fact that "good" advising and mentorship are rarely characterized in literature, especially characterized separately from that expected for mentoring graduate students. High-quality and effective mentorship has long been recognized as essential for graduate and postdoctoral training [26, 27], resulting in mutually positive outcomes like research productivity as measured by journal publications. However, the vast majority of faculty have received little or no training in effective mentorship [19], despite the availability of evidenced-based mentorship training [28-30], with some studies highlighting that faculty are abrasive toward and unwilling to engage and learn evidence-based teaching, training, or mentorship practices [31]. These issues, combined with the extensive time pressures on faculty, leave many advisors to draw upon their own experiences to inform their research team management and mentorships styles [19, 27, 32]. The 'trial by fire' nature of doctoral and postdoctoral mentorship subjects trainees to a haphazard system of academic heritage and privilege that only works well when faculty themselves experienced high-quality and effective mentorship experiences [32 - 35], and even then is sometimes not able to be replicated. Indeed, faculty mentoring postdocs may not have undergone postdoctoral training themselves, indicating that aptitude as a postdoctoral mentor remains dependent on instinct, translation of a mentor's own doctoral experiences, and doctoral mentoring philosophies into the postdoctoral mentorship space, and trial and error in mentoring postdocs successfully [15]. Given that the future trajectory of a postdoctoral scholar is contingent on the quality of the mentorship and postdoctoral experience, the research community needs to understand how—if not through formal means—faculty come to envision and enact their ideas on postdoctoral mentorship. Therefore, the specific research questions for this study are as follows:

1. How do postdoc mentors learn to be mentors?

2. What experiences do postdoctoral mentors draw on to inform their mentorship of postdocs?

Theoretical Framework: Observational Learning

Observational learning theory provides a framework for identifying the process of learning from observation and the repetition of advisors' past experiences. Observational learning theory demonstrates the learning process outside of traditional academic learning, which helps investigate learning through apprenticeship [36] – we posit, following literature, that advisors do not receive specific or intentional training to advise or mentor postdoc trainees. As such, any strategies for postdoc mentorship are derived from observations of experience and the replication of these experiences. Figure 1 displays the theoretical process for observational learning.

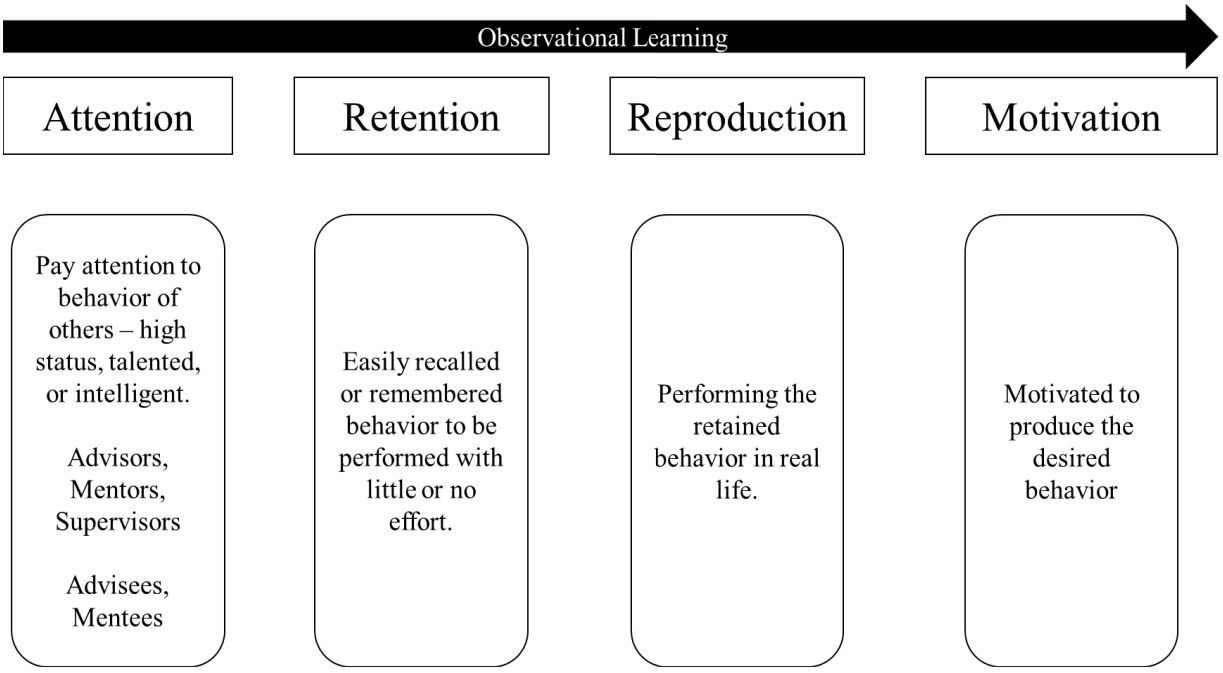

Figure 1. Observational Learning Theory

Observational Learning Theory proposes four stages to learning based on observed behavior: attention, retention, reproduction, and motivation [37]. First, learning requires attention to the specific observable behavior of another. The learner must observe behavior and pay attention to that behavior. Most effective learning happens when learners observe high status, talented, and intelligent others' behavior, implying that the observed behaviors should be emulated [38]. Importantly, behavior emulation leads to the replication of positive and negative behaviors by the observer. Second, in retention, the behavior must be easily recalled to be performed at a later time. Easily retained and remembered behaviors may be automatic or unintentional – these behaviors may be considered but may be performed as an assumed normal behavior. Third, the reproduction of the behavior by performing it in real-life interactions represents the learners' repeated, observed behavior. Finally, observers must have the motivation to perform the behavior. A similar situation may generate motivation to reproduce observed behavior without consciously considering alternative behavioral responses. Conversely, motivation may be derived from a desire to reproduce observed behavior, leading to a specific, desired outcome.

II. Methods

Participants, Recruitment, and Data Collection

As part of a larger, IRB-approved and NSF-funded study on postdoctoral mentorship, potential engineering and computer science advisor participants were identified from recent National Science Foundation (NSF) awardees in the engineering (ENG) and computer science (CISE) directorates and were supplemented with snowball sampling. A recruitment email sent to potential participants requested recipients complete a short survey on mentorship of postdocs and demographics. Participants with postdoc mentorship experience were asked to volunteer for individual qualitative interviews about their postdoc mentoring experiences. Based on the survey responses, participants were selected to represent the broadest range of engineering and computer science departments, women and men, and race or ethnicity identities.

Participant perspectives reflect a wide range of experience as faculty member, number of postdocs, and disciplines. Participants had held faculty appointments for a range of years: 0 to 5 years (n =3), 5 to 10 years (n = 6), 10 to 15 years (n = 4), 15 to 20 years (n = 2), or more than 20 years (n = 4). Similarly, participants had advised at least 1 postdoc during their fauclty career: 1 to 2 postdocs (n = 9), 3 to 5 postdocs (n = 7) or 5 to 10 postdocs (n = 3). Faculty represented multiple engineering disciplines: aerospace (n = 1), chemical (n = 2), civil and environmental (n = 5), computer science (n = 4), electrical (n = 3), engineering education (n = 3), and mechanical (n = 1). Self-identified demographic representation included women (n = 3) and men (n = 16); U.S. born participants (n = 13) and faculty born outside of the U.S. (n = 6). The majority of faculty were white (n = 15), with some Asian (n = 2), Middle Eastern (n = 1), and African American or Black (n = 1) participants.

The selected faculty volunteers received an invitation to schedule a 60-minute semi-interviews via Zoom videoconferencing software. The second and third authors, faculty in engineering and computer science, conducted the interviews. The interview focused on mentor relationships and expectations, engaging participants in discussing their expectations and relationships with current and past postdocs. The semi-structured interview allowed the interviewers to follow up or probe deeper on answers to elicit a deeper understanding [39]. The interview included prompts that asked participants about their views on postdoc mentorship and their own experience as a postdoc. Participants received a $25 amazon gift card after completing the interview.

Data Analysis

Recorded interviews were professionally transcribed for analysis and manually cleaned to check accuracy. The interview transcripts were coded with open or axial methods using NVIVO qualitative data analysis software to develop a codebook of themes [40, 41]. The first author, a postdoc, coded the interviews for advisors with attention to how the faculty participant learned to become a postdoc mentor. Open and axial coding was used to identify faculty experiences that informed how they learned to mentor their postdoctoral fellows. Open coding allowed for new and unexpected codes to come from the data [40, 41], while axial coding engaged observational learning concepts to identify how advisors learned to be postdoc advisors and included codes for attention, retention, reproduction, and motivation to map the emergent themes and experiences onto the tenets of Observational Learning Theory that serves as the theoretical framework for this study.

Positionality

The research team represents both sides of the postdoc position in academia with a postdoc in engineering education and two faculty members in engineering education with technical departments in mechanical engineering and computer science. Combining the perspectives of the research team brings a more nuanced view of the postdoc fellowship position. As the primary analyst, the first author, a postdoc in engineering education, holds assumptions and expectations based on his own experience as a postdoc. Similarly, as the interviewers and primary investigators, the faculty team members bring expectations based on their own experiences with postdocs and faculty in engineering. As a team with distinct perspectives and experiences, we approached the data with a well-rounded view of postdoc mentorship. As qualitative researchers, we hold a few key tenants that influence our data analysis. We hold self-evident the gendered and raced history of engineering and computer science while recognizing the continued and persistent influence this has on the experiences of historically oppressed and currently marginalized trainees within these fields. We are dedicated to the diversity, equity, and inclusion of engineering and computer science disciplines through our research and practice. However, we remain within the academic system and are products of that system. Our experiences as individuals reflect the institutional contexts that have shaped our approach to these issues. However, we remain committed to high-quality qualitative work and the necessity of trustworthiness in qualitative research [42]. The work presented here provides valuable knowledge in improving the mentorship experiences of postdoctoral training in engineering and computer science.

Limitations

As with all studies, we acknowledge some limitations. While our participants represent a variety of experiences mentoring postdoctoral trainees, they are a limited set of engineering and computer science postdoctoral mentors. Within the range of experience, some participants had mentored only one postdoc or had not directly mentored a postdoc for several years. However, the narratives provide a rich and robust source of material to add to postdoc research literature. Our use of axial coding provides strengths and weaknesses: axial coding allows for adherence to a specific theoretical framework while it may also limit the analysis of data that poorly fits that framework. However, the data provides ample evidence to support the utility of observational learning as a framework to investigate engineering and computer science mentors learning to mentor postdocs.

III. Findings

Faculty draw on their experiences as trainees and mentees to advise and mentor postdocs, including mentorship experiences as doctoral students, postdocs, industry training, and experiences as doctoral and postdoc advisors. Figure 2 shows the layering of mentorship experiences in the attention phase of observational learning. Faculty who had completed a postdoc as part of their training reflected on their experiences, often identifying positive and negative experiences they used to guide, mentor, and plan the development of the postdocs they advise. Faculty who did not complete a postdoc relied on doctoral and industry mentorship experiences to inform their decisions. In addition, the faculty drew on observations of past doctoral students and postdoc trainees in their interactions with current postdoc trainees. Following attention, retention illustrates recollected experiences and the desire to reproduce or not reproduce a set of mentorship experiences. Figure 2 displays the ways in which assumptions and desires to mentor may be

misaligned between postdoc mentor and mentee, particularly in the reproduction and motivation stages of observational learning.

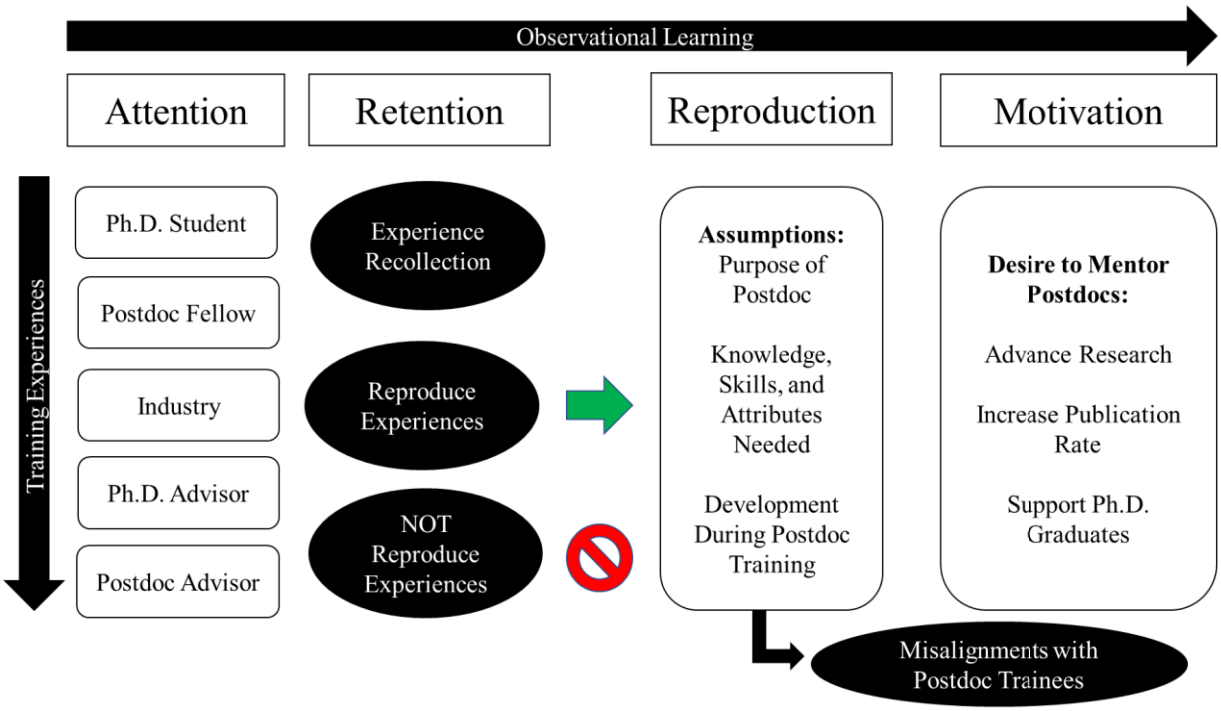

Figure 2. Observational Learning and Training Experiences of Postdoc Advisors.

A. Attention

Faculty demonstrated attention in narratives about their own experiences with mentorship as trainees by discussing their observations and how those observations influenced their current behavior as faculty members. Edwin, a computer science professor, spent his time as a postdoc learning skills necessary for his current faculty role as researcher, advisor, and mentor. His experiences as a postdoc mentee helped develop and refine skills he would need to be a productive faculty member, and he has purposively aimed for a postdoctoral position at a high-ranking institution to overcome what he perceived as weaknesses from attending a lower-ranking program for his doctoral research.

> *So for me, the postdoc has been a vital part of work-life balance, as well as enriching my training, [since Doctoral Institution] isn't an R1 in engineering. And so being able to take a little bit more time to polish and mature my research skills was really vital to, I think my career success in the academic track. And then I actually got another postdoc by helping write a proposal.* - Edwin, Computer Science

The attention given to his own development reflects the importance of his mentorship experiences and a desire to replicate these experiences for his own mentees. Similarly, Chris, a mechanical engineering faculty member, held a postdoc appointment that was not directly tied to one faculty member's research or funding. In Chris' words, his formal postdoc supervisor *"was just there to sign on approved expenses."* Although this was a detriment in some cases, Chris reflected a commitment and appreciation to being "forged in the fire," insisting that the independence of the

position helped him develop research skills and prepare to be an independent researcher in mechanical engineering. However, independence also limited Chris' access to high-quality mentorship, thereby limiting his experience as a mentee. Chris passed down this tension in his perspectives in mentorship, reinforcing the independence aspects as he supervises his own postdocs now.

Faculty also discussed considering close attention to the research group climate in retrospect. For example, a chemical engineering professor, Josiah, looked back at his experience as a chemical engineering Ph.D. student. *When I was a Ph.D. student, my advisor had a postdoc who was female. … We were a friendly group of Ph.D. students, but I felt that she kind of felt that we're targeting her even if we are not."* As a Ph.D. student, he did not grasp the reasons and importance of the postdoc's isolation, but now, as a postdoc mentor, could he see how important belonging and inclusion can be for trainees. He attended to the female postdoc's feelings, recognizing them as important even though he did not fully understand the importance of isolation as a postdoc. He learned from this experience about the potential isolation postdocs feel, even within a friendly lab group, and this reflection formed his philosophy on the need for supportive mentorship to combat isolation.

Within the "attention" theme, faculty participants spent a great deal of time paying attention to the differences between Ph.D. students and postdoctoral scholars. As a note, if they did not specifically call out the differences, the interviewers prompted them to discuss how they thought differently about these populations, though many faculty often defaulted to discussing their postdocs as "students" grouped in with their doctoral students. Arran, a civil and environmental engineering professor, attended to the difference between postdocs and other categories of trainees, informs Arran's expectations for postdoc productivity and performance based on his experiences.

> *So once [the postdocs are] getting paid, you [the postdocs] are becoming more serious. The postdocs, they are not working from nine to five. They can come earlier than nine and they can stay later than seven, eight, it depends on the work. This is the beauty of having a postdoc, rather than having a graduate student or having even an undergraduate student. They are giving you even beyond your expectation.* - Arran, Civil and Environmental Engineering

Though this quote reinforces harmful assumptions about expectations, overwork, and lack of work-life balance well-documented in the literature, but also reflects a dominant assumption on the differences between a postdoctoral scholar and a graduate student that then influences mentoring philosophies. Hugo, also in civil and environmental engineering, compared doctoral students and postdocs in their ability to conduct research and the amount of supervision required of them. Hugo feels more comfortable in giving postdocs freedom in their work when compared to doctoral students who still require careful supervision. The level of contribution from a postdoc reflects this expectation to be more independent and self-sufficient in the research process from concept to publication. The attention to the differences between doctoral and postdoc needs helps inform Hugo's expectations for trainees.

> *For grad students, being able to wrap up their research project, be able to think through a problem, design an experiment, things like that. Postdoc, I want them to see... How they can formulate a problem, how they can move toward development of proposals, because paper writing and all of those things. They are more responsible compared to a graduate*

student. I will be more hands-off dealing with postdoc when it comes to writing a paper, so they will be responsible for more of its components. But one thing that's fundamentally different is I expect them contribute to development of research ideas and get involved in development of proposals. - Hugo, Civil and Environmental Engineering

B. Retention

Participants' narratives necessarily represent retention – they were events attended to by participants that they were then able to recall and share in the interview. Here, we share specific narratives about participants' retention and recollection of postdoc-related events and mentorship. Thomas, faculty in an engineering education program, recalled the importance of his postdoc mentorship in preparing him for his current faculty position and transitioning from graduate student to a faculty role. Here he describes the importance of the postdoc position as the transition from doctoral mentee to a faculty mentor. Thomas needed the time, perspective, and guidance he gained from his postdoc training to become an effective faculty member.

For me, it would have been extremely hard to jump from graduate student to faculty, because as a graduate student, I did not have nearly the kind of broad perspective that I later learned, and going through a postdoc helped me on that, at least realized that that was important and start along that path of broadening my outlook, and I think that was extremely valuable. – Thomas, Engineering Education

Participants shared experiences they retained specifically as examples of mentorship experiences they wanted to reproduce for their postdocs. Sean, in engineering education, had positive experiences with his postdoc mentor that he wanted his postdoc trainees to experience. He recalled the interactions with his mentor that empowered him to explore new interests. The retention and recognition of the importance of flexibility in a postdoc position informed his mentoring strategies.

I had a great supervisor. Her project that we worked on was a new space for me, so it allowed me to explore a new area of interest, it was something I was interested in, but just didn't relate to my dissertation, she provided me with... Like, tell me what you wanna do and gave me flexibility. – Sean, Engineering Education

Sean recalled learning about the necessity of journal articles and grants as part of his postdoc training in engineering education. He learned the importance of publications and grants, and the academic job-hunting process to successfully transition from mentee to mentor.

I learned a lot from [MentorName] during this period of time about applying for faculty positions and preparing myself for those types of positions, included in that was really focusing on writing journal articles published, while also making sure that I check the box of "I'm getting paid off a grant." – Sean, Engineering Education

He identifies these experiences as essential for preparing for the next steps in applying for faculty positions and being a successful faculty member with a sustainable research group. These experiences prepared him for mentoring his postdoc trainees.

C. Reproduction

Reproduction of observed mentorship represents participants' ideas about the purpose of the postdoc; the knowledge, skills, and attributes of a postdoc; and the development of postdocs during training. Josiah demonstrated reproduction when he described his experiences with mentorship and how the differences between Ph.D. and postdoc mentorship informed his mentorship style in supporting postdocs in their research.

> *[My postdoc experience] was great. It was quite different from how my Ph.D. advisor ran his lab. So, when I was in my Ph.D. program, at that time, my Ph.D. advisor would not require us to meet every week. … When I joined as a postdoc, my [postdoc] advisor would meet me weekly. In general, it helps me in getting more mentorship. It's like, I'm not making a decision whether it is the right time to meet my advisor or not.* – Josiah, Chemical Engineering

Josiah benefitted from increased individual meeting time in his postdoc compared to his Ph.D. The increased time allowed him to gain more mentorship, improving his performance as a postdoc, and the exposure to this new style of mentorship meant that then Josiah replicated this new, "great" mentorship model in how he sets up the mentoring of his current postdoctoral scholars and graduate students to afford them the same mentorship.

Faculty also reflected on how their philosophies of the postdoctoral position are replicated in how they structure their postdoctoral positions. For example, Thomas, an engineering education faculty member, described the purpose of the postdoc as broadening the knowledge base of postdocs beyond their dissertation focus. As faculty, researchers need to hold broader knowledge of their topics to be open to innovation and progress. As doctoral students, the narrow focus on a dissertation project does not prepare them for the faculty role. Thomas seeks to reproduce his experience of broadening perspectives during the postdoc as preparation for the demands on faculty research.

> *I think a postdoctoral position is extremely useful because as a graduate student, you learn an awful lot about your particular little bin, and you don't tend to look outside that bin very much. As a postdoc, you tend to be forced to look at it either at the same bin from a different angle or an entirely different bin, which is a broadening experience that is I think very valuable. You get different perspectives because you're in a different place, different ways of thinking about things, interacting with different people and having different kinds of conversations*. - Thomas, Engineering Education

Similarly, Eva in civil and environmental engineering described the postdoc as a transitional period for postdocs to prepare to become assistant professors. She sees various ways in which a postdoc position may improve students' preparation for faculty positions both in publications and in practice leading and mentoring others. This expectation then informs how she defines her successful postdoc trainees.

> *In some ways, it's a transitional period for people. They have their Ph.D., but they're not quite in that academic role as an assistant professor. Ideally, they are... Of course, they all wanna get out papers, so they wanna improve their CV. Oftentimes, they are taking much more of a leadership role. And I think that where I look at the students [postdocs] who've*

> *been really successful with me, they have been able to lead a team with graduate students and undergraduates and really take that leadership role in my research group, being able to make decisions and play a large role in mentoring.* – Eva, Civil and Environmental Engineering

These perspectives on the purpose of the postdoc and what a successful postdoctoral position looks like then inform faculty expectations for what postdocs should experience, especially as these may look differently from graduate training.

Participants also shared mentorship experiences they did *not* want to reproduce for their postdocs. Phillip, an electrical engineering professor, reflected on how as a postdoc, he set himself up for disappointment by focusing on a high-impact journal publication at the expense of making other progress, in his words, "dying on the altar" of the high-impact paper. He observed other postdocs publishing more and being involved in broader research projects, being highly productive in research even if they resulted in slightly lower-impact publications, a strategy that, in retrospect, that could have benefited him. Phillip notes how this realization has served to frame the way he develops his own postdocs now:

> *I promised myself I would not put my postdocs through. … here is something that's very tempting to do, and that is to chase the super high-impact Science paper or Cell paper or Nature paper. And I think that's well and good, but I had the opportunity to see a lot of graduate students and postdocs die on that altar. And so I always wanted to make sure that anybody I'm advising is moving forward, even if they've got some high-impact thing on the backburner, that they're moving forward and they have something to show for it that doesn't require that, that doesn't require that high-impact paper.* – Phillip, Electrical Engineering

In the same vein, Hugo, now a computer science professor, observed a peer postdoc's experiences with publication rejection. The repeated rejection affected his peer's productivity and attitude in conducting research and pursuing other projects. In his current role as a faculty member and postdoc mentor, he is attentive to the need for "early wins" for postdoc trainees.

> *In the beginning he [postdoc] was good, but after one year, he did not have one publication, so he had, he submitted the paper, first to a very good conference, rejected. Then, to still a good conference, rejected. Again, to some lower-level conference, rejected. I could see at the end; he was so frustrated, and my advisor did not extend his contract. The expectation from a postdoc is much more and when you don't fulfill that, it's more embarrassing, so I guess an early win is important but for postdoc.* – Hugo, Computer Science

Faculty also discussed continuously evolving strategies for postdoctoral mentorship through adverse or unproductive experiences with postdocs, working to make sense of what went wrong to not replicate those experiences in the future. Josiah, a chemical engineering professor, described comparisons between Ph.D. students and postdocs as informative to his perspectives on postdoc training. Josiah had concerns about postdoc productivity and their motivation in taking a postdoc position. The attention to these experiences informed what he assumed postdocs' goals and motivations when choosing postdoc training.

> *[W]hen they're working towards their Ph.D. […] there's a big drive for [making publication progress]. And at the same time, they have a longer period in which they get trained. Whereas sometimes we get a postdoc who is in your lab because they did not find an industry position and so they're using this time to basically find another job. And in that case, maybe they are not super inclined to perform wonderfully well in your lab, and so that's why maybe there's a bigger failure rate. I think unless you are one of the top persons in your field and if you are not in Harvard or MIT, you may have that kind of experience.* - Josiah, Chemical Engineering

Faculty often discussed how the needs of the postdoc related to their future career goals were sometimes misaligned with the goals of the project or the faculty member, specifically with attention to the amount of publication expected or necessary for a specific project. In general, though, attention to and retention of their own and others' past experience, the experience provided faculty with the knowledge they used to inform what mentorship decisions they would reproduce in the mentorship of their postdocs. Unsatisfying or unproductive mentorship experiences, whether they be past (as mentees) or current (as mentors), also framed how the faculty participants in this study.

D. Motivation

Participants' motivation to mentor postdocs varied based on their needs as researchers and faculty, as well as their expectations for postdoc trainee performance. The faculty discussed the need for postdocs to advance faculty research programs by bringing unique skill sets into the lab. Amir, a structural engineering faculty member, Zachary in chemical engineering faculty member, discussed their preference for postdocs with skills different from their own. Amir and Zachary demonstrated motivation to bring new skills to their research and lab groups. New skills brought by postdocs expanded the opportunities for faculty research as well as the training of doctoral students.

> *You get to work with people with different skills that I don't even have. I have some postdocs that they literally know more than me in software development. So I'm being very honest, so I literally don't have time to go and learn all the techniques and tricks of software development, that's why I'm working with them.* – Amir, Structural Engineering

> *I always say the best postdocs are the ones where you bring in a skill set that helps the group, and then you learn about something that helps you progress your career, so it's more about a skill set.* – Zachary, Chemical Engineering

In addition to advancing a research program, faculty desired to increase publications for the lab and advisor represents a mutual benefit for postdoc and advisor, but have an underlying assumption that the postdoctoral scholar wants to obtain a future academic position and so is also motivated to "churn more stuff out" (as noted by Phillip, below).

> *In practice, I'd say it's to... You're more productive as a postdoc than as a graduate student generally. Well, because you don't... You can write your own papers, you can churn more*

> *stuff out, you're kind of at that peak of when you're a grad student.* - Phillip, Electrical Engineering

Hugo, a civil and environmental professor, discussed how his own positionality had influenced the emphasis he placed on certain parts of the postdoctoral mentorship, noting that when he was early in this career, he was more selfish and focused on the publication of articles as the main focus of a postdoc, whereas now, as an established and tenured faculty member, he has the affordance or "luxury" of being able to tailor postdoctoral experiences more closely with the specific goals of the postdoctoral scholars.

> *So maybe early on, it was very important for me that the postdoc publishes as many papers as possible because we are all in desperate need of publications, so yes, it has evolved. I'm more secure in my approach. I think I have the luxury of revisiting the expectations, I would say. So it is more aligned with what they wanna get out of this.* - Hugo, Civil and Environmental Engineering

An alternative motivation for advisors to engage postdoc trainees was to support recently graduated Ph.D. students. Zachary and Eva discussed keeping their recent graduates on as postdocs as they transitioned to permanent positions. Some doctoral students officially finish training without a position to go to after graduating. Some faculty see the temporary retention of high-quality graduated Ph.D. students as postdocs as a benefit for both the student and the lab: the postdocs can earn a salary while searching for positions, and advisors continue to benefit from the expertise of fully trained researchers familiar with the topics and processes of the lab without extra hiring, onboarding, or other distractions. Another motivation for mentoring postdocs was to assist them (the postdocs) in pivoting to another field or area of research. Sean shared his mentorship experience with a doctoral trainee-turned-postdoc as she moved into engineering education.

> *She [a current postdoc] had reached out […] I ended up sitting on her dissertation committee, really, we only were really working together for maybe a year, but we had a pretty good relationship, and so as she was graduating, I was like, "Hey, I've got this project and I need a postdoc, would you be interested?" And so she was excited.* - Sean, Engineering Education

In sum, our participants illustrated their experiences with the apprenticeship model of postdoc training in alignment with observational learning theory. Participants' experiences with mentorship throughout their training contributed to their concepts of appropriate postdoc mentorship. While these narratives only report consciously remembered experiences, other experiences likely contributed to their development as postdoc mentors.

V. Discussion

Viewed through observational learning theory, this study showed how engineering and computer science faculty members progress through the stages of attention, retention, reproduction, and motivation with respect to how they learned to mentor postdoctoral scholars. Our findings support previous research that suggests postdocs need high-quality advising and mentorship to thrive in their research careers [5, 21 - 23]. However, postdoc advisors learn to be postdoc advisors through their own experiences, leading them to replicate unhealthy or even abusive relationships with their postdocs [9, 24, 25]. By attending to mentorship, whether good or bad, as an example of how high-powered actors mentor, faculty retain and replicate the behavior in their mentorship practice.

Without training or guidance from institutions, advisors rely on their own experiences, that likely do not reflect best practices or the limited information available on positive mentorship practices. In replicating their own experiences and observations, mentors may perpetuate poor mentorship in several ways. Similar to Chris' experience with a postdoc supervisor who was just there to "sign on approved expenses," mentors may limit their interactions with postdocs to a purely functional role, thereby limiting access to high-quality mentorship [11, 12]. Similarly, replicating experiences with poor mentorship and limited resources, in turn perpetuates a lack of access to professional development and career resources for their trainees [1, 13, 14]. However, mentorship is a skill that can be developed with training and adequate practice [28 - 30].

Misalignment in expectations between postdocs and advisors creates an opportunity for unmet goals, conflict, and missed opportunities for career preparation [10, 43]. Postdoc advisors may perpetuate the misalignment of expectations due to their experiences. Recalling Arran's observation and expectation that postdocs work even more than doctoral students demonstrates a repeated problem of overworking already underpaid and overworked postdocs who have few options. Further, the emphasis in many narratives on research, science, and publications comes at the expense of career development. The imbalance may be due to advisors who learn to mentor without experiencing a postdoc position themselves. The focus of the postdoc can then turn to the advisor's needs, research, and funding, contributing to the imbalance of postdoc development. Priority expectations during the postdoc remain unclear, with a tension between research and career development [5]. As demonstrated in several quotes, advisors held conflicting expectations of postdocs based on their own experiences and observations, and as Hugo noted, faculty members who are more senior and "secure" in their positions can be less focused on publications and more focused on tailoring postdoctoral positions to individual's needs.

Further, reliance on observations of other professional training may not clarify the purpose and expectations of the postdoc position. Several participants had not held a postdoc position and did not receive any training or guidance on postdoc mentoring. These participants based their philosophies of postdoc mentoring on other experiences that lacked sufficient similarity with the purpose of a postdoc traineeship. Some faculty pulled their philosophies from their own experiences as a doctoral student or looked to the adverse experiences they or other students or postdocs experiences to try to make changes so as not to replicate harmful activities. However, without "positive" examples, this approach turns to a guess-and-check methodology. Similarly, comparing and using experiences with graduate students may further muddy the expectations advisors have of postdocs. Some participants emphasized the distinction between doctoral and postdoctoral training, while others replicated mentorship decisions from doctoral students to postdoc trainees without critical reflection on the differences.

In addition, postdocs may have an expectation misalignment for their future careers. In academia, approximately 15% of postdocs across disciplines gain a tenure-track career [44]. An ever-evolving job market and academic research enterprise make assumptions or expectations of postdocs becoming academic researchers unrealistic. Many of our participants assumed or advocated for their postdocs to pursue an academic trajectory based on the advisor's experience of the postdoc as a transition to and preparation for faculty positions. The mentorship and advice provided for postdocs directed postdocs to develop skills necessary for an academic career. However, postdocs may not actively envision or develop transferrable skills or critically evaluate

what competencies they may need in a non-academic environment [45], calling attention to the importance of mentorship.

Future Work

The results reported here come from a general mentorship interview. Future research could more specifically investigate advisor development as postdoc mentors. Research questions could elicit narratives specifically about their own mentorship experiences and how those experiences influence how they think about postdoc mentorship. Similarly, researchers should ask advisors what training or support they have in becoming postdoc mentors for the first time. Future research could explore the needs of postdoc advisors to support their development as postdoc mentors. Additional qualitative and quantitative research could explore advisors' questions and concerns about successfully supporting postdocs. Such research may assist in identifying what funding agencies and universities can do to better support postdoc development through faculty resources.

VI. Conclusions

Advisors learn to mentor postdocs through their own mentorship experiences as graduate students and postdocs and past experiences with their graduate students and postdocs. Observational learning theory provides an explanation for how faculty replicate experiences and mentorship that may not always be the best for the specific expectations and requirements of postdoctoral scholars. Repetition of their own experiences may support postdocs well or perpetuate harmful practices. Postdoc advisors need alternative sources for postdoc mentorship strategies to ensure positive, productive, and educational postdoctoral training and development. Further, critical reflection on their mentorship practices may help postdoc mentors to engage more constructively with postdocs to support successful skill development and career preparation.

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