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Toward a Theory of Engineering Professorial Intentions: The Role of Research Group Experiences

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Keywords

learning, faculty, graduate education, ethnography, grounded theory

Disciplines

Educational Assessment, Evaluation, and Research | Engineering Education | Higher Education | Higher Education and Teaching | Other Teacher Education and Professional Development

Comments

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Biographical Sketch

Brian A. Burt, Ph.D., Assistant Professor of Higher Education in the School of Education at Iowa State University, a National Academy of Education/Spencer Postdoctoral Fellow, and a National Science Foundation Early CAREER Award recipient. He studies the experiences of graduate students in STEM, and the institutional policies and practices that influence students' educational and workforce pathways. He also investigates participation in research experiences (i.e., the science of team science).

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**Towards a theory of engineering professorial intentions:
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Much research has been conducted on preparation for the professoriate, including how graduate students and postdoctoral researchers are socialized for faculty careers. Most common in this corpus is the acknowledgement that students come to learn about faculty careers through intensive interactions with professors (Antony & Taylor, 2001; Austin, 2002; Austin & McDaniels, 2006; Lindholm, 2004; Nyquist, et al., 1999). Through these interactions, students witness both rewarded and unrewarded behaviors and norms of the faculty role. Based on their observations and experiences, students make determinations regarding their interest in and likelihood of succeeding in the professoriate. Professorial intentions, then, tend to be conceptualized as resulting from an individual's interactions with current professors. However, this does not fully account for the wide range of discipline-specific practices, identity factors, and individual experiences that may also shape one's consideration of a faculty career.

Different disciplines have different socializing practices that may encourage or discourage interest in the professoriate (Gibbs & Griffin, 2013; Lindholm, 2004; (Baker) Sweitzer, 2009). For example, Golde (2007) finds that some disciplines have signature pedagogies that socialize graduate students to the norms and behaviors of their field. She reports that it is common for neuroscience departments to have journal clubs where participants (faculty, post-doctoral researchers, and graduate students) discuss articles' strengths and shortcomings. In English departments, she reports the development of a list (i.e., canon) of foundational works of the discipline. She suggests that graduate students become well-versed in common readings of their field and gain practice discussing the highlights of the literature. In science and engineering fields, however, a dominant socializing practice is participation in research group experiences

(Burt, 2017; Burt, Williams, & Smith, 2018; Campbell, Dortch, & Burt, 2018; Crede & Borrego, 2012; Newstetter, Kurz-Milcke, & Nersessian, 2004; Villa et al., 2013). In these fields, graduate students and postdoctoral researchers often “live” in the lab because their research is tied to the lab and to the lab supervisor’s work. In research group experiences, members interact not only with a professor but often with peers (e.g., postdoctoral researchers, doctoral and master’s graduate students, undergraduates). Through these interactions and engagement in research, members develop perceptions of what faculty careers may entail. In all of these examples, the goals of these practices include preparing students to become full members of their disciplinary communities and establishing their expertise, both necessary for faculty careers.

Despite the predominance of research groups in certain fields, there is a lack of knowledge regarding research group experiences as sites for teaching and learning. The engineering education literature base, for example, has virtually no scholarship related to research group participation of graduate students and postdoctoral researchers. There are key exceptions, however. In Crede and Borrego’s (2012) study of doctoral students in engineering research groups, the authors identified three mechanisms that influence student learning, productivity and intention to complete one’s graduate degree: interactions and communication (mentoring and space), resources (equipment and funding), and supervisor role. Central to their findings, however, was the premise that those mechanisms differed based on the size of one’s research group. For example, in large groups, supervisors were characterized as managerial and running the group like a business, fostering more student independence. In medium-sized groups, supervisors were described as fostering community and helping members identify their own research interests. In small groups, supervisors were described as being highly interactive with individual members, and group-related research was dependent on the direction and time of the

supervisor. Newstetter, Kurz-Milcke, and Nersessian's (2004) study aimed to better understand the roles that agency, lab membership and identity formation, and interactive relationships play in rapid learning of group members. They found that "agentive environments" included distributed and shared responsibilities for learning; non-hierarchical lab structures, and shared expertise; intentional interactive practices to encourage rapid participation and learning; and, the presence of support systems to help reduce the impact of research-related failures. The constellation of these characteristics, according to the authors, encourages faster and deeper development of science identities than classroom experiences. Villa et al. (2013) explored how participation in a research group prepared 100 current and previous historically underrepresented undergraduates and master's and doctoral students for graduate study and research careers. They studied a particular type of research group that deliberately develops students' disciplinary learning, research skills, and capacity to work in teams, an affinity research group (ARG). Faculty members of ARGs dedicate ample time during group meetings to help teach students disciplinary and research-related skills. They found that participation in an ARG helped explain how students learned collaboratively, engaged with professional communities, and identified as researchers. According to the authors, participation in ARGs helped socialize students into academic and professional communities.

The scholarship described above is helpful in explaining how research groups serve as sites for teaching and learning at the graduate level. However, as previously expressed, these articles are exceptions; there is not an overwhelming volume of scholarship on research groups. Further, despite the small but growing corpus of scholarship on research groups at the graduate level, less is known about how these experiences shape members' professional intentions (e.g., the professoriate). Without a larger corpus of empirical studies on research group experiences, a

host of questions remain unanswered and undertheorized: How are research groups organized? What practices and activities guide their operation? How is the membership of such groups composed? And most germane to this study, how does group participation influence professorial intentions?

This article, based on a thirteen-month ethnographic study of graduate student and post-doctoral members of a chemical engineering research group, investigated the role of research groups in the development of identification with and intention to pursue a faculty career. Ethnographic observations and interviews were used to gain a deep understanding of the practices and activities, interactions, and outcomes associated with participation. Resulting from this study is the Theoretical Model of Engineering Professorial Intentions (TMEPI). The model posits relationships between six emergent components: 1) social identities and personal factors; 2) sociocultural factors; 3) participation, interactions, and learning in research group experiences; 4) faculty prototype; 5) social comparisons; and, 6) individual and institutional experiences. The TMEPI illustrates how the research group serves as a socializing site where students refine their understandings of the roles and expectations of the faculty career, and evaluate their interest in and likelihood of succeeding in such a career. This study seeks to contribute to an understanding of how these factors influence learning, participation, and identification with the professoriate. The article concludes with implications for future research, and reflections on how the TMEPI might provide insights that will aid in mentoring and preparing students for faculty careers in fields that typically involve research groups as well as in fields that do not use research groups.

Prior Research: Preparation for and Interest in Faculty Careers

Preparation for faculty careers is often conceptualized as taking place through socialization in graduate school. In the context of this article, “socialization” refers to how

graduate students come to adapt to academic and institutional norms and behaviors, and to the graduate student role (Antony & Taylor, 2001; Austin, 2002; Austin & McDaniels, 2006; Gardner, 2008a & 2008b; Nyquist, et al., 1999; Weidman & Stein, 2003; Weidman, Twale, & Stein, 2001). Through various socializing relationships and practices, students start as newcomers to an institution, academic department, or program, and learn how to negotiate and navigate their academic and disciplinary communities (Baker, Pifer, & Flemion, 2013; Gardner, 2008b; Golde, 2005; Lovitts, 2005; Sallee, 2011). Based on this conceptualization of preparation for faculty careers, the people and practices that help to socialize individuals are discussed below. Also discussed are individual factors and experiences that influence individuals' professorial intentions. Although these often operate together, they are discussed separately to avoid conflating the mechanisms that influence socialization for and interest in faculty careers.

Socializing Relationships that Influence Intentions for Faculty Careers

Socializing relationships are interactions with people who help students learn about faculty careers. Existing research often regards a student's connection to a faculty advisor as the predominant socializing relationship (Austin, 2002; Saddler, 2009). In some fields, one's advisor is also the research supervisor (Pearson & Brew, 2002); the terms "advisor" and "research supervisor" are used interchangeably in this article. Pearson and Brew (2002) argued that student learning is largely related to the "responsibility of the supervisor to provide the intellectual and professional leadership and facilitation of research students' learning within the workplace..." (p. 140). Although the roles of advisors are extensive and vary by department and discipline (Barnes, 2009-2010; Nettles & Millett, 2006), existing scholarship has suggested that advisors should serve as sources of information, liaisons to the department, dissertation supervisors, role models, mentors, and career coaches (Antony & Taylor, 2001; Austin & McDaniels, 2006;

Barnes, Williams, & Archer, 2010), and that all of those components contribute to learning and identity development. Bluntly put, the advisor “can make or break a Ph.D. student” (Lee, 2008, p. 1), and nurture a student’s potential for a faculty career or not.

Interactions with peers also mediate graduate students’ learning and conceptualizations of faculty work (Sallee, 2011). For instance, newcomers preparing to present at their first conference often turn to their peers for help (Baker & Pifer, 2011). Advanced students help novices prepare to navigate expectations such as how to present research, or offer practice questions that might arise from the audience (Burt, 2014). These socializing relationships with peers are important because students often serve as next-in-line experts when the advisor is not present (Crede & Borrego, 2012). In addition, some students feel less shame asking questions of peers than of advisors when they do not know something the advisor thinks they should know (Fries-Britt, Burt, & Franklin, 2012). The growing line of research on peers has extended previous conceptions that positioned advisors as the sole link to learning about research.

In addition to socializing relationships, various socializing practices also inform students’ academic career preparation and choice.

Socializing Practices that Influence Intentions for Faculty Careers

Socializing practices are intentional activities that aid in students’ learning and adoption of faculty career norms. The process of becoming an independent scholar has received much attention in the literature because research suggests that the transition to “independent scholar” is a pivotal point when graduate students must demonstrate their “creativity” (Lovitts, 2008) and “innovation” (Burt, 2014). The degree to which a graduate student demonstrates the ability to be an independent scholar is viewed as a marker of the capacity for success as a faculty member (Bieber & Worley, 2006) because the faculty career is considered an independent and

entrepreneurial enterprise. In many science and engineering fields, research group experiences are the locations of teaching and learning where students become independent scholars (Newstetter, Kurz-Milcke, & Nersessian, 2004; Saddler & Creamer, 2009; Stubb, Pyhalto, & Lonka, 2012; Villa et al., 2013). “Research group experiences” refers to any experience where students engage in generating scientific knowledge (e.g., participating in research groups to conduct experiments, learning through group meetings, contributing to publications, presenting at conferences). Thus, research group experiences create a social context for students’ learning and a location where students’ learning and identities (scholarly and professional) merge.

In addition to research group experiences, in some academic programs (e.g., English), graduate teaching assistantships serve as not only a source of financial assistance, but also the primary form of socialization for faculty careers (Nettles & Millett, 2006). Teaching assistantships provide students with a partial view of what academic careers entail, including the time and effort needed to provide students with classroom instruction and office hours, as well as the need to balance teaching responsibilities with research and service (Austin, 2002; Kinoshita, Amelink, & Knight, 2016; Mena, Diefes-Dux, & Capobianco, 2013).

Additional socializing practices prepare graduate students for faculty careers and increase the pool of candidates for faculty positions. For example, “Preparing Future Faculty” (PFF) and “Alliance for Graduate Education and the Professoriate” expose upper-level graduate students to different institutional types (Lynch & Sears, 2011), provide opportunities for students to develop their teaching skills (Purdy et al., 2003), and provide supportive networks of faculty and peers (Carter-Veale et al., 2016). Through these programs, students “try on” the roles of faculty (McCord et al., 2014), and learn about the range of faculty responsibilities (teaching, research, and service).

After completing a Ph.D., some individuals obtain postdoctoral positions to gain further preparation for academic or research jobs. Postdoctoral positions often (though not always) provide opportunities to strengthen one's independent research. Through the assistance of an established faculty mentor, postdoctoral researchers revise and publish work from their dissertation, establish new lines of research, and practice the behaviors and activities of faculty (e.g., present at conferences, write grant proposals, network and collaborate with scholars, engage in service at the association level) (Mena, 2015; Palmer & Ohland, 2005). These practices can make postdoctoral researchers more competitive on the academic job market, and/or help them determine whether careers in academe are of interest (Akerlind, 2009).

Individualized Factors and Experiences that Shape Intentions for Faculty Careers

Despite the growing body of scholarship on socialization to graduate school, and for faculty careers more specifically, less consideration has been paid to the roles that individual factors and experiences play in individuals' professorial intentions. Such inquiry is clearly necessary, as it is often cited as a limitation in these bodies of work (Crede & Borrego, 2012; Gardner, 2008a, 2008b; Lindholm, 2004). It is possible that who individuals are (e.g., gender, race, marital status), their parents' educational backgrounds and occupations, and their individual experiences (e.g., financial debt, co-curricular involvement) also inform their professorial intentions. For example, Gibbs and Griffin's (2013) mixed methods study of 38 recent biomedical doctoral degree holders found key differences by gender and race/ethnicity in participants' learning and personal values. Female participants described gendered challenges to participating in the biomedical field (e.g., sexual harassment at conferences and with advisors, pressure against having children, comments related to the intellectual inferiority of women). Regarding personal values, Gibbs and Griffin found that while majority participants (i.e., White

and Asian) were interested in faculty careers based on the ability to have autonomy through research, women and those from underrepresented racial and ethnic backgrounds were drawn to the professoriate as a platform to help others (e.g., researching health disparities in their communities).

Considering the body of scholarship discussed above, this study offers a more holistic, and thus, more nuanced, exploration of the ways individuals, practices, and individual factors and experiences shape the professorial intentions of those in a chemical engineering research group, and in doing so, addresses the following research question: What factors influence learning, participation, and identification with the professoriate? Further, the ethnographic methodology – characterized by its extended time in the field, and multiple methods of data collection – offers a more situated understanding of how various factors come to shape professorial intentions among engineering graduate students.

Methods of Data Collection and Data Analysis

Data Collection

This study was conducted to understand the experiences and factors that influence engineering research group members' knowledge of and intentions to pursue the professoriate. Data collection included 13 months of fieldwork (September 2012 to October 2013) exploring the interactions and activities of a research group in chemical engineering at one institution, "Model University" (pseudonym). Model University (MU) was selected in part because it is a large public university where engaging in research at the faculty and student levels is a top priority. MU was home to more than 38,000 students (undergraduate and graduate), 52% of whom were male. White students were the largest racial group (55%), followed by Asian (11%), Black (5%), and Latinx (4%) students. International students made up approximately 19% of the

student population. MU's highly ranked engineering college had over 3,500 graduate students. The chemical engineering department had approximately 150 graduate students (approximately 60% male and 40% female). *Specific enrollment numbers are not provided in order to maintain the anonymity of the research site and this study's participants.* Of those, after graduation, approximately 46% entered corporate/government; 36% entered post-doctoral positions; 6% entered academia; 12% of graduates' post-graduate occupations are unknown.

To select a research group for this study, an expert informant (Spradley, 1979), a full professor who had been at MU for more than 20 years and held an administrative position within the engineering college, was consulted. The informant offered several key recommendations. First, a larger group would provide more participants to observe, more group practices to investigate, and more participants from diverse backgrounds. Diversity was important because of the principal investigator (PI)'s interest in broadening participation in engineering, particularly among those from underrepresented backgrounds. Second, the practices and activities that postdoctoral researchers engaged in, and thus their learning and professional identity development, would be qualitatively different than those of doctoral students; a group where doctoral students outnumbered postdoctoral researchers would allow the primary focus to be on doctoral students. Third, because the nature of the research practiced would lend itself to certain kinds of learning experiences, a group that engaged in experimental research would likely provide observations of hands-on and collaborative work (Traweek, 1992), while this might not be the case for types of research that promoted more independent work (e.g., computational, simulation, or theoretical research). Finally, a supervisor who was a tenured (or full) professor with a record of exceptional teaching, scholarship, and mentoring might be more engaged in managing the group's activities versus exclusively working towards publications and grant

applications like faculty at lower ranks, and a supervisor from an underrepresented background might be more likely to have a research group that included more racially and ethnically underrepresented members. The chemical engineering research group, from this point forward referred to as the “Houston Group” (a pseudonym), met all of the above criteria (e.g., group size; racial, ethnic, and gender diversity; experimental research; collaborative research environment). Further, the group’s faculty supervisor is a full professor, holds MU’s most esteemed teaching, research, and mentoring awards, is a member of an underrepresented racial and ethnic group, and was receptive to allowing a social scientist to observe his group for an extended period.

The Houston Research Group comprised research supervisors (faculty members and a lab manager), postdoctoral researchers, student members (i.e., advanced and novice doctoral students, a master’s student, and undergraduates), professional staff, and visiting scholars. The core participants for this study’s theoretical model (i.e., 12 core group members) were ten graduate students and two postdoctoral researchers who were all fully funded by external research grants secured by the group’s supervisor. See Table 1 for a profile of participants (*professional staff, visiting scholars, and undergraduate researchers are not included in the table because they were transient rather than consistent, and their responsibilities differed from those of “core” members of the group*).

- Table 1 HERE -

Ethnographic methodology guided data collection. Ethnographies aim to uncover the culture embedded within a human activity (Emerson, Fretz, & Shaw, 1995; Spradley, 1979; Van Maanen, 1988). Van Maanen (1988) defines “culture” as “the knowledge members (‘natives’) of a given group are thought to more or less share; knowledge of the sort that is said to inform, embed, shape, and account for the routine and not-so-routine activities of the members of the

culture” (pg. 3). Fieldwork in the present study involved observations and formal and informal interviews to understand the culture of the Houston Research Group and its influence on members’ professorial intentions.

In ethnographic work, observations afford the opportunity to “notice things that have become routine to the participants themselves, things that may lead to understanding the context,” and help to “triangulate emerging findings,” (Merriam & Tisdell, 2016, pp. 139). Additionally, sustained engagement in a research site over extended periods can promote greater rapport with participants, resulting in more authentic insights as well as richer and thicker descriptions of the cultural phenomena of interest (Emerson, Fretz, & Shaw, 1995; Spradley, 1979; Van Maanen, 1988). In the present study, observations of research group practices (e.g., group meetings, subgroup meetings, laboratory work, dissertation defenses, group celebrations, conference attendance) were conducted (41 in total, approximately 120 hours). Observations provided a holistic understanding of participants’ research, and of group members’ roles, interactions, relationships, and rituals.

Fieldnotes were taken during observations to capture the cultural tools (e.g., acronyms, engineering-specific vernacular, symbols of praise and correction, rituals) used in the research group. The majority of the leadership team and core group members were formally interviewed twice, through one-on-one, semi-structured interviews (16 first-round and 15 second-round interviews); an exception was Brielle, an Asian international fifth-year doctoral candidate at the beginning of the study who graduated and took an industry job before a second interview could be conducted. Formal interview questions focused on members’ individual research projects, how their projects were situated within the group’s work, and their interpretations of group practices, activities, and interactions. Additionally, members were asked about their career

intentions throughout the study (i.e., first interview, during informal interviews/conversations, and during the second interview) to capture any change over time. Interviews ranged from forty-five minutes to approximately two hours. The rapport developed through extensive fieldwork afforded the PI opportunities to hold informal interviews (i.e., conversations in the field) about members' interpretations of activities and interactions, and the nature of their research skills, aspirations, and scholarly and professional identities.

Data Analysis

This study's analysis uses grounded theory tools (Corbin & Strauss, 2008; Merriam & Tisdell, 2016; Strauss & Corbin, 1990) and a constructivist paradigm that acknowledges that individuals inhabit multiple realities. In the case of this study, while members participated in the same group and practices, what they learned, how they made sense of their learning, and how their experiences influenced their professorial intentions, differed.

Data were analyzed relative to waves of data collection (i.e., after the Fall 2012 and Winter semesters 2013 (pilot); Spring/Summer 2014; and Fall 2014). This approach helped manage the volume of data and develop preliminary understandings of what group members were learning about research and about the engineering professoriate that evolved as the iterative processes of data collection and analysis progressed. In each wave, analysis began with open coding, labeling initial data chunks from transcripts and fieldnotes that captured important information about members' experiences with research and career intentions.

Initial examples of codes included educational background, engineering identity, family background, gender, race, and science identity. It was hypothesized that these codes offered possible theoretical explanations for how members experienced their research group and career intentions. Next, through the process of axial coding, the most salient codes were combined

when they shared similar properties. For example, “identity characteristics” was initially used to label the salient open codes “educational background, engineering identity, family background, gender, race, and science identity.” Through further analysis, however, it was determined that “identity characteristics” was too broad and needed to be further refined. By constantly comparing codes to determine their unique properties, the codes “gender,” “race,” and “citizenship” became categorized as “social identities,” whereas the codes “educational background,” “family background,” “parent occupation,” became categorized as “personal factors.” The process of grouping the most salient codes resulted in six core categories (i.e., “social identities and personal factors”; “sociocultural factors”; “participation, interactions, and learning in research group experiences”; “faculty prototype”; “social comparisons”; and, “individual and institutional experiences”). These core categories formed elements of a theoretical narrative, or hypothesis. For instance, once it was clear that a set of salient codes formed the core category “social identities and personal factors,” it was necessary to understand how this core category related to members’ learning of research and their professorial intentions. The same was necessary for all six core categories, to determine the influence of each on members’ learning of research and professorial intentions, as well as relationships between core categories. To interrogate the working hypothesis, the PI performed selective coding by revisiting the coded data to gain a deeper understanding of how each core category related to the others, and how each related specifically to members’ learning and professorial intentions.

Of importance, analytic and theoretical memos were written throughout the data collection and analysis (Emerson, Fretz, & Shaw, 1995; Strauss & Corbin, 1990). In these memos, preliminary and evolving hypotheses were explored regarding the research competencies students were learning, how they perceived the professoriate, and the identity characteristics and

personal factors contributing to their intentions to pursue faculty careers. Through the process of memoing, the PI also considered the codes that did not frequently appear and were not intensely referenced (e.g., teaching, service, funding/financial aid), and how these might still relate to members' learning of research and professorial intentions. The record of analytic and theoretical memos spanning back to the first day of data collection became extremely important during the selective coding – hypothesis testing – stage. The early memos provided reminders of what the PI thought before he became thoroughly immersed in fieldwork. Further, early and ongoing memos, when considered together, created linkages between the core categories and provided critical prompts to further scrutinize relationships between the core categories and the theoretical hypothesis. Additionally, because data analysis and data collection occurred simultaneously, the PI used informal interviews with group members to test early theoretical hypotheses. As a whole, these grounded theory techniques assisted the PI in building a cohesive story to explain why members of the Houston Group chose to pursue faculty careers (or not).

To enhance the validity and reliability of the findings, data were collected over an extended period (13 months), providing time to build rapport with participants, make sense of the research group's culture, and observe patterns among the group's interactions, practices and activities. Second, the findings were triangulated through multiple methods of fieldwork (formal interviews, informal interviews, and observation). As suggested earlier, routine informal interviews allowed the PI to ask impromptu questions for clarifying purposes. The second formal interview was informed by the first and by emerging themes, and served as an opportunity to check understandings of patterns and hypotheses related to students' perceptions within the research group and their ideas about professorial intentions. Finally, the PI drafted reflective memos after each observation and interview, and periodically wrote analytic memos

documenting early hypotheses, assumptions, and connections between the study's findings and existing literature and theory (Emerson, Fretz, & Shaw, 1995). This process helped the PI discern the evolution of findings from early stages through the data collection and analysis.

Limitations

There are several limitations worthy of note. First, this study is based on work at one prestigious institution. The institution's prestige guides the direction of its colleges, departments and faculty activities, and thus the types of experiences students have. Students whose interests do not align with those of a prestigious research institution may not strongly consider academic careers, especially if they have not been exposed to a wide range of institutional types. Second, research groups differ on a number of dimensions: size and composition (Crede & Borrego, 2012; Louis et al., 2007), faculty leadership styles (Pearson & Brew, 2002), and advisors' orientation and approach to research (Anderson & Louis, 1994; Reskin, 1979). Third, the group's orientation to research (i.e., experimental) may prime members toward particular kinds of careers, for example, research-related careers emphasizing hands-on and collaborative research. Members in groups that engage in other forms of research (e.g., computational, simulation, theoretical) may be primed for other careers. In addition, the Houston Group's work was mainly funded by external research grants. It is possible that funding from other sources (e.g., industry) could also dictate the nature of a group's research, students' learning experiences, and students' post-graduate career intentions. Fourth, doctoral students outnumbered post-docs in the group. Because learning in research experiences differs by level of study and previous experiences with research (i.e., undergraduate, master's, doctoral, post-doctoral students) (Ahn, 2016; Akerlind, 2009), and the majority of the participants were doctoral students, the components contributing to the TMEPI primarily reflect the experiences of doctoral students. An investigation of a

research group comprising more post-docs is likely to yield different results. Fifth, there are likely other experiences or aspects of faculty careers that students in this study were not exposed to, and were not prompted to respond to based on the interview protocol that centered on research and professorial experiences. Thus, those experiences may not be robustly accounted for. For instance, faculty careers also include service – to the department, institution, profession, and community – and expectations of service vary by institutional type. Participants in this study were not asked about service, and thus, did not explicitly discuss it during interviews. Therefore, it is not clear how other aspects of a faculty career, like “service,” contribute to participants’ professorial intentions. Finally, the study’s ethnographic research design could have influenced students’ sense-making of their professorial intentions. Specifically, it is possible that the extended presence of the PI could have shaped how participants responded and behaved. For example, Professor Houston might have altered group practices and activities due to having the PI observe and interview group members. Similarly, other members could have “performed” during interviews, group and subgroup meetings, and out-of-lab gatherings in efforts to paint themselves in a positive light. That is, participants negotiate issues of trust and presentation of their authentic selves when determining what information to share with an interviewer (Small, 2009). There is no way to fully determine how the PI may have influenced participants. However, the two interviews, informal questions asked in passing, and long period of observation provide the PI with confidence that the patterns identified by participants over time were authentic.

Findings: New Theoretical Model

Findings from the study led to the construction of a “substantive theory,” defined by Merriam and Tisdell (2016) as a theory based on a limited number of observations that generally

informs practice. The “Theoretical Model of Engineering Professorial Intentions” (see Figure 1) holistically explains how members of an engineering research group learn about and come to identify with faculty careers (or not). It accounts for and explains relationships between six emergent components: 1) social identities and personal factors; 2) sociocultural factors; 3) participation, interactions, and learning in research group experiences; 4) faculty prototype; 5) social comparisons; and, 6) individual and institutional experiences. In whole, engineering research group members make determinations about the (mis)alignment of their identities, skills, values, and interests in pursuing the professoriate. Components of the model and the relationships between them are detailed below. While they are presented individually for the purposes of clarity, the model is not intended to be linear.

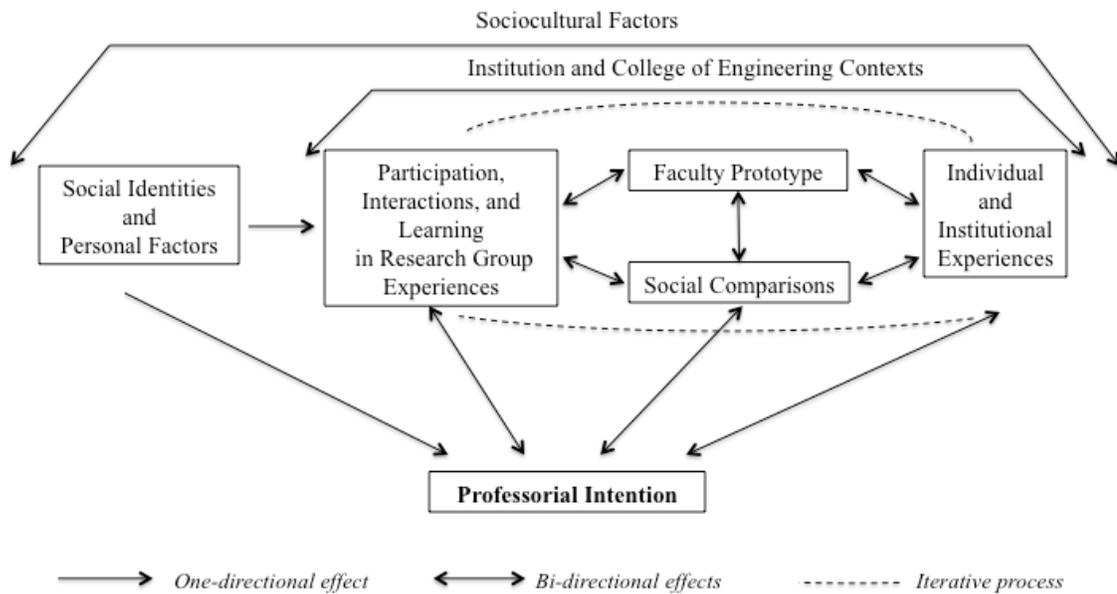


Figure 1: A Theoretical Model of Engineering Professorial Intentions

Social Identities and Personal Factors

The theory starts with “social identities and individual experiences” to acknowledge that who individuals are before they participate in the research group can generate predispositions regarding career intentions. In addition, some members’ social identities can *at all times*

influence their perceptions of academic work. The diversity of participants in this study helps illuminate the complex relationship between members' identity and individual experiences with career intentions. Specifically, some members' social identities (e.g., race and ethnicity, gender, citizenship status) and personal factors (e.g. marital status, parents' educational background and occupation) influenced how they experienced research, perceived faculty roles, and developed intentions to pursue the professoriate. This is consistent with Lindholm's (2004) finding that early experiences and family influences shaped faculty members' interests in becoming professors. In the present study, Ralph, an Asian international first-year doctoral student, described how schooling and the images of professors differed between his home country and the United States. Ralph indicated what "an American professor" looks like: "tall with beard... have you ever seen [engineering professor] before?...So, big and tall, and kind of like the white beard, and have a thick accent or deep voice." Although Ralph was only a first-year student at the start of data collection, his candid description based on his international perspective included a gendered and racialized image of the typical engineering professor at MU's engineering college, a tall White man, with a beard, and deep voice. However, as will be discussed later in the findings, this perception of what "American" engineering professors are like may have mattered less to his professorial intentions than his past perceptions of professors (including his own father) from his home country. In another example, Allen, a Black second-year doctoral candidate who was also an international student said having Professor Houston as his supervisor (and advisor) helped him navigate some challenges and pressures of being racially underrepresented in the academy:

It feels good [to have a faculty advisor of color] in the sense that at least that part of racism is out of your mind. I don't think about racism when I work with people with different race[s]...But at least having [an] advisor who's [also from an underrepresented racial group], you don't have to deal with that and that takes off a lot of pressure.

Because Professor Houston comes from a historically underrepresented group (his specific race and ethnicity is protected for confidentiality purposes), Allen often attributed his growing interest in becoming a professor to his admiration of Professor Houston. For Allen, Houston was both a model of scholarly success and a prototype for Allen's future possibilities. Allen's race/ethnicity played an explicit role in his connection with Professor Houston. Such findings related to social identities suggest that race and gender – and other social identities – contribute to the images individuals form of what an engineering professor looks like.

Some women members rejected the possibility of becoming faculty. Their decisions were at least partly based on misalignments between their perceptions of academic norms and expectations and their values of becoming a mother and/or wife. For example, Gloria, a White third-year doctoral candidate from the U.S., was married at the time of data collection. Although she “love[d] teaching,” she shared how her relationship in large part influenced her thinking around her future career choices: “Yes, my family is all there [her hometown in the Midwest]. [My husband's] family is all there, too. So a lot of this depends on location. If we find the perfect location and everything else and the only job I can find is something in industry, I would maybe adapt.” Gloria describes the role of a “trailing spouse,” one who follows a partner to another city because of work. It is apparent that Gloria felt she had to weigh her interest in teaching against doing what she felt was best for her family. Although it appeared she preferred to teach, her perception was that industry jobs would allow her to follow her husband back to their home state.

In another example, Emma, an Asian international fifth-year doctoral candidate, saw the professoriate as her least likely option, partly because she was considering “raising a child or [becoming a] full-time mother.” Likewise, Brielle, who was publicly praised within the group as

being “the one who could make it in a faculty career,” mentioned that she had “responsibilities” and that a faculty career would get in the way. She said, “I am happy teaching people or doing stuff for people, but right now I also... have some other responsibilities... that I need to take care of and I can't devote as much time [to teaching].” Her comment about the time needed to be a professor was in direct comparison to what she observed in Professor Houston. Further, after the interview, Brielle informally elaborated that her “responsibilities” referred to cultural pressures to eventually marry and raise children. This sense of cultural pressures was also informally shared by Emma. This finding related to the intersections of gender roles and cultural expectations around marriage and children suggests the possibility that individuals’ identities (related to ethnicity and culture) may influence how they think about and make decisions related to faculty careers.

In another example of the role gender plays in individuals’ considerations of faculty careers, Gloria expressed a concern about balance: “I want to start a family someday; I don't want to be the mom that's working odd hours, all hours, and everything like that. So, I want something that has better predictability.” Gloria recounted an instance in her department where a female assistant professor worked until giving birth and returned to campus a few days later. Gloria described this as “ridiculous,” though she said the professor had since earned tenure and “everyone respects her.” She proclaimed: “Obviously, I am going to work hard, but I don't want to have to make sacrifices like that just to get to that position.” For Gloria, the expectations of professors who are also mothers conflicted with her view of motherhood.

These data illustrate some women’s concerns about the demands a faculty career would make on their personal time, especially if they wanted to have families. This finding connects to work by Williams (2000), who describes the changing expectations of workers in the work place.

The “ideal worker,” as explained by Williams, was a man who took no time off, and had a stay-at-home wife who could tend to the needs of the family. Not specific to engineering education, but rather, to employment more broadly, today, the concept of the “ideal worker” continues to evolve as both women and men take time off for vacations and breaks. But complexity remains for women balancing work with raising children. Because of what she witnessed within her own department, Gloria believed that an industry career (or non-tenure-track teaching position) might better suit her needs and interests.

It is important to note that gender inequities were not reported as a conflict perpetuated by the research group, but by the broader science community in which women remain underrepresented. This finding, which contributes to a broader conversation about what it means to be, look like, and do the work of scientists and engineers, relates to scholarship on doctoral socialization and academic professional identity development (Pifer & Baker, 2014; Sallee, 2011), and confirms the importance of mentors in the persistence of women and underrepresented faculty of color in engineering (Dutta, 2015; Foor, Walden, & Trytten, 2007). This suggests that the role of gender in the Houston Research Group – by itself – did not fully explain female participants’ professorial intentions. Rather, the interplay among multiple TMEPI components may more holistically explain some female participants’ professorial intentions (e.g., sociocultural factors and conceptualizations of the faculty prototype, both of which will be explained in the sections to come).

The desire to raise a family was not exclusively expressed by women; two male doctoral students also mentioned wanting to maintain balance in their marriages and eventually raise children. Sherman, a White second-year doctoral student from the U.S., described how a faculty career would impede his ability to balance family life with work: “The few professors that I've

gotten to know really well are some of the busiest people I've ever met. And I am married, I want to start having kids relatively soon and I don't want work to be my life and I feel like if you're a professor that's exactly what's going to happen.” Sherman’s consideration of how faculty balanced – or did not – work and life relates to the work of Levin, Jaeger, and Haley (2013) and Quinn and Litzler (2009). In particular, Quinn and Litzler (2009) found that work-life balance may be a generational priority rather than a “gender-specific phenomenon” (p. 86). Added to considerations of work-life balance were discussions about the realities of geographical constraints, dual-career couple issues, and pressures imposed on faculty relative to institutional type, which could also complicate intentions to pursue the professoriate. Tensions between members’ cultural contexts, gender, and perceptions of the intensive nature of the professoriate in part negatively shaped their intentions regarding faculty careers.

Sociocultural Factors

Sociocultural factors are the larger *contextual* structures that influence members’ experiences, who members *interact* with, what they learn from their interactions and *participation in research group practices and activities*, and how these interactions and group practices and activities shape their *professional identities* (e.g., intentions to pursue a faculty career) (Baker & Lattuca, 2010; John-Steiner & Mahn, 1996; Lave & Wenger, 1991; Wenger, 2010; Wertsch, del Rio, & Alvarez, 1995).

“Contexts” are embedded within structures (e.g., historical, political, economic, cultural, and institutional environments) that contribute to shaping individuals’ learning and professional identity (Lindholm, 2004; Rogoff, 1990; Wertsch, del Rio, & Alvarez, 1995). Two overarching structures most visibly influenced members’ research experiences: institutional priorities and economic factors. At MU, research productivity at the faculty and student levels is an

institutional priority. Faculty are incentivized to pursue and win external grants. This is especially true in engineering and science, where extramural grant funding is required to rent laboratory space, purchase cutting-edge equipment, and fund a research group, and where research assistantships are the primary source of financial support for doctoral students (National Center for Science and Engineering Statistics, 2014). As members of the Houston Group, all graduate students in this study received full funding, supported through extramural grants won by Professor Houston. This highlights a contextual priority of the research-intensive institution: to train and prepare researchers who engage in high levels of research activity. The institutional climate in which the Houston Group is situated is important because it rewards certain kinds of research activities and behaviors more than it rewards teaching. Members' experiences with research are greatly influenced by institutional expectations, and the practices and activities of the group are directly related to the priorities of the institution, college, and department.

Contexts extend beyond institutions to the larger economic and political worlds in which actors operate. Existing higher education scholarship also acknowledges that opportunity structures, or the availability and/or likelihood of gaining one's preferred option of employment, are of concern to graduate students, especially during times of economic uncertainty (Lindholm, 2004; McAlpine, 2015). In the current study, the economy provided both a direct (dis)incentive to pursue faculty careers and an indirect influence through members' models of success. First, some members acknowledged that there were fewer faculty than industry positions available in chemical engineering, which would result in greater competition. Even when confident about their research competence, some felt less confident about their competitiveness on the academic job market. One even acknowledged that it was easier to consider industry positions because most of their research group's alumni chose industry positions. This reified the assumption for

some that they were being prepared for industry. Tiffany, an Asian international third-year doctoral candidate, explained how interactions with group members and alumni influenced her career intentions:

You are always affected by the people around [you]...[I]n our group I would say most people go to industry, and if I see them go to industry I see them leave very happily....we don't have so many group members in our group that do faculty positions.

Tiffany suggested that it is easier for members to make linkages between the work they do in the Houston Group and potential careers in industry. Although there are many reasons a member might choose an industry position, it is possible that former members did so because of the lack of faculty positions available during the recession. As a result, current members were thinking about their career options based partly on models of recent alums whose career decisions may have been shaped by the economic downturn during the study period.

Similarly, in response to the prompt, "Are there other people in the group that you know of that are interested in becoming professors," Gloria replied: "No. Sometimes we don't talk about that because it's just depressing that we still have three or two years. And a lot of people change their minds. Within my friends, some people have completely flip-flopped and said "I don't want to do that anymore, I have no idea what I want to do." Not only does Gloria's quotation highlight some graduate students' thinking around when to begin focusing on a career path (i.e., immediately prior to graduation), it also illustrates the influence that social interactions play in members' thinking about careers and career options.

As representative examples from the group, Tiffany and Gloria provide illustrations of how the research group serves as a vibrant community of practice (Burt, Lundren, & Schroetter, 2017; Crede & Borrego, 2012). From a sociocultural perspective, learning occurs through the co-construction of knowledge and interactions with others within a given community of practice

(Baker & Lattuca, 2010; Wortham, 2004). Within communities of practice, community members share “words, tools, concepts, methods, stories, documents, links to resources...” (Wenger, 2010, p. 1), and resources may include former members of the community (i.e., alumni members of the research group). It is through the community of practice that members form understandings of the group’s practices, and members view themselves (e.g., professional identities) through the context of the community) (Lave & Wenger, 1991). Tiffany and Gloria both described their thinking around the professoriate specifically, and engineering career options more broadly, based on interactions within their community of practice. Further, although they both shared some interest in faculty careers, because “flip-flopping” career intentions was a common community practice, they both were undecided about pursuing faculty careers at the start (their third-year) and conclusion (their fourth-year) of this study’s data collection.

Participation, Interactions, and Learning in Research Group Experiences

Learning was observed in three main contexts: individual research in the laboratory, full group meetings, and subgroup meetings. These settings cultivated specific types of learning and interactions. Group members pursued individual projects in a fairly independent manner, but these projects were linked to a larger research agenda, set forth by Professor Houston, that the group jointly pursued. Members assisted one another on different projects where they shared research methods and equipment. In this sense, members were interdependently collaborative; while they independently worked on their projects, they still relied on one another to accomplish their work on a day-to-day basis, and importantly, to accomplish the team’s overall goals. The practices and activities of the group created the cultural understanding that the group would not succeed (i.e., acceptance of conference presentations; publications; grant-getting) if individual projects did not succeed. This sentiment is best captured through Professor Houston’s comments

about teamwork:

It's [the Houston Research Group] a team, and like any team...you have all these components that you have to have on a winning team, and that is basically what we are trying to build. I don't have to have one student trying to do all of those things... [Building a team] is going to take some time, but mostly it's for the good of the group.

Because Professor Houston wanted a “winning team,” he often explained how important individual members were to the larger group's goals. From his perspective, an individual does not win, an individual contributes to a team's win. Based on this orientation, he intentionally designed the group to foster learning and interactions: “You sort of look for what the anticipated or desired outcome is and then structure things accordingly.” For example, he intentionally implemented “peer-to-peer learning because you are working alongside other students and postdocs.”

In contrast to laboratory work, weekly group and subgroup meetings appeared to be social forums where the advisor could not only monitor members' research, but also shape their performance. In particular, during full group meetings, select members gave conference-like presentations to practice justifying the significance of their work, defending the accuracy of their findings, and substantiating the work's applicability to broader contexts. During these meetings, Professor Houston provided constructive criticism. Feedback ranged from light-hearted and affirming to stern and critical, as needed. Brielle characterized how participation, interactions, and learning took place through the practice of presentations within group meetings:

He [Professor Houston]... just managed to push me enough that I got sufficiently good enough results to graduate...And it's not just him. If you look at the group as well, you will get commented on the way your slides look, the way things are presented, the color, the font, every single thing...And if a student is a second-year giving his first presentation, you make them acquainted with the presentation styles that are out there...Four practices, the group mates will be there. Practice five times, the group mates will be there. And it's amazing.

Because group presentations dominated the group meeting time, it is not surprising that members described the benefits, yet anxiety, of receiving feedback during the meetings. Brielle's quotation highlights the expectation of active engagement (i.e., providing feedback and critique). She also explains the social learning that takes place through presenting one's work; for example, first-year members learn from the work of more senior members in the group.

Unlike the group meetings, which emphasized oral presentation skills, the weekly subgroup meetings provided feedback on their work-in-progress. At these smaller meetings, members were grouped by their research projects, sat at the conference table, and individually described their activities and progress. Danny, a Black international fourth-year doctoral candidate, characterized how participation, interactions, and learning within subgroup meetings worked:

Well...there are different projects divided into smaller subgroups, and then people within the same subgroup interact a lot, but there's no hierarchy within the students. Even though some students are like fourth-year or first-year, there is really no hierarchy...if someone hears something that they can help with, they can always help [even if that person is in a different subgroup].... But mostly you interact with people within your own subgroup and ask "what do you think about my presentation, and what do you think I could change?"

The subgroup design was implemented to help organize members around common projects dictated by different grant funding. While Professor Houston explained the design as a function of efficiency, it was also designed to help increase interaction among members. Danny's quotation above highlights how the subgroup design shrinks the larger group into smaller, expertise-focused units. The subgroups and their respective meetings then offer additional feedback loops and provide opportunities to troubleshoot specific research problems (Burt, 2017).

Brielle and Danny's explanations of participation and learning experiences in both full

and subgroup meetings are representative of how other members described their participation and learning. Also important to address is how members made explicit connections between what they were incrementally and cumulatively learning through group meeting practices and succeeding in research in the future. This perhaps is best captured by Allen, who, when describing the group's meetings, where members asked tough questions of presenters, stated, "If you can make it here, you can make it anywhere...The goal of that [asking tough questions of presenters] is to make you a better candidate, a better Ph.D. student, a better person, you know?" This sentiment appeared to be shared by other members who also articulated how participation in group meetings was preparing them to be thoughtful and innovative contributors to research, whether or not they chose faculty careers in the future. Thus, most members (with the exception of newer members) felt comfortable with presenting their research, one component of the faculty role.

In the early months of data collection, it became clear that members were also performing what was initially described in fieldnotes as "non-research related tasks." Further observation revealed that all members were responsible for tasks related to making the group function (e.g., maintaining the lab schedule, refilling the gases, placing orders for materials, cleaning the lab, lab safety, planning celebrations). But it was unclear why members held these tasks. Professor Houston explained his intention:

[Y]ou have all these components that you have to have on a winning team and that is basically what we are trying to build...So and so takes responsibility for the gases for everyone. We have dry boxes and we will get one of them refurbished, and somebody is going to do that...Because you did that [task] you can take advantage of something somebody else did for you!

For Professor Houston, participation in the "non-research related tasks" was equally as critical to the group as experimental research. In addition to completing these tasks, members learned

valuable lessons about gas replacement, ordering supplies, lab safety, the importance of building community and celebrating the community of practice. Finally, he made it clear that performing these tasks maintained a cycle of service to the group. When he said, “You can take advantage of something somebody else did for you,” he was describing how new members had less service as they became acclimated to the group, whereas more senior members took on heavier tasks. This is another example demonstrating the social learning that takes place within the group. To be clear, members did not draw explicit connections between their non-research related tasks and professorial intentions. However, when describing the tasks that they – or their fellow members – engaged in, they displayed the knowledge that such tasks would need to be completed if supervising a research group.

Through these practices and interactions with fellow group members, students developed research competencies such as communicating results and proper use of lab equipment. Further, they learned about local (i.e., university, department, group) expectations related to conducting engineering research. (See Burt, 2017 and 2014 for more on research competencies developed and their associated group practices). Through participation in the group’s independent and collaborative research-related practices, members learned more about faculty work (e.g., designing and conducting experiments, supervising undergraduate researchers, presenting at conferences, and writing journal articles).

Development of a “Faculty Prototype”

The intense participation, interactions with, and observations of group members doing the work of engineers and scientists influenced the identification of a “faculty prototype,” or the maintenance of an existing one. The concept of a “faculty prototype” is drawn from Blackburn and Lawrence (1995). In their study of more than 4,000 faculty across ranks, disciplines,

institution types, age, gender, and ethnicity, they argued that faculty learn about expectations for academic careers through social knowledge, which they defined as “[faculty members’] perceptions of various aspects of the work environment. Faculty form beliefs from experiences with colleagues, administrators, committee decisions, faculty meetings, institutional rules and norms, and professional association practices” (p. 99). According to Blackburn and Lawrence, faculty are socialized to a “faculty prototype” based on their perceptions of the expectations and values of their environments, and of others in those environments. They suggest that to succeed in the academy (e.g., receive institutional recognition for publishing, grant work, high ratings on teaching evaluations), faculty adapt their behaviors to their perceptions of prototypes they cognitively construct through observing and interacting with successful colleagues.

While Blackburn and Lawrence (1995) offered the concept of a “faculty prototype” as a key variable in explaining faculty members’ motivations, they concluded by suggesting the need for longitudinal research on graduate students to learn how they are socialized to the expectations of faculty work. Such an approach would account for an “ongoing cycle of interactions and altered cognitions, values, beliefs, preferences, and behaviors” (p. 289). The group members in the present study also constructed a faculty prototype. Before fully applying Blackburn and Lawrence’s conceptualization of a “faculty prototype,” a general caution is offered. From an engineering perspective, a “prototype” is often considered a “rough draft” (i.e., not a finished product), whereas “prototype” in this article aligns with Blackburn and Lawrence’s usage to refer to an idealized model, with characteristics to be emulated.

In the current study, Professor Houston was not just a researcher and lab manager, but also a well-respected teacher who had won several teaching and service awards. Additionally, he was an entrepreneur (founder of an engineering-based company), was married, and had children.

These additional characteristics were important because members' views of him – while dominated by his role as a scholar, advisor, and lab supervisor – included a broader, more holistic picture of what a successful faculty member is. One example best captures this finding. During the third month of data collection (December 2013), the PI attended the group's annual holiday party at Professor Houston's house. While sitting at the kitchen's bistro table, Allen passionately described how being in Professor Houston's "beautiful house" and meeting his "beautiful family," and seeing the group brought together in the informal setting, was inspiration and motivation for him to pursue the professoriate. Recall how Allen described his appreciation of having Professor Houston as an advisor because of their shared person of color status: "It feels good [to have a faculty advisor of color]..." Thus, in this example, Allen was talking about the "beautiful house" and "beautiful family" in the context of an "underrepresented person of color" with a beautiful home and beautiful family. He envisioned himself in Professor Houston's role, in large part because of their shared status as people of color. His passionate reflections during the party related to previously discussed social identities and the interplay between components of the TMEPI (in this case, social identities and the faculty prototype).

Members often described Professor Houston's hands-off approach and tended to link that to a trusting and student-focused demeanor. They marveled at his ability to oversee projects and supervise members but still allow members to learn through making mistakes. Comments from Gloria, a third-year doctoral candidate, exemplified this sentiment:

I have heard from others about how their group works. I really like Dr. Houston's, ...because he guides you, and you can talk to him, and he knows "this may not work"... And he gives you enough room to even sometimes make your own mistakes on your own and then come back...So he guides you, but he also gives you room to do your independent thing.

Gloria's observations foreshadowed comments from her second interview about whether or not

she fit her own description of the ideal professor; she described her ability to potentially lead a research group of her own:

I hate to be all cocky and what not, but yeah, I think I do [fit the description of an ideal professor]. As you get older you get more responsibilities, you're the go-to person on equipment, and you're doing more logistic stuff for the group. So I think just being a part of the group and progressing through it. And then like I've said, I've watched them [her co-advisors; one being Professor Houston]...for the past three years kind of day in and day out, so I know a little bit more of what that [being a professor] entails.

Because Gloria participated in two research groups, she juggled responsibilities to two teams, in addition to her coursework. While she offered descriptions of both teams (e.g., size of the groups, composition and diversity of the groups, nature of member collaboration, her responsibilities in both groups), she did not compare her advisors. Additionally, she focused more exclusively on her experiences in the Houston Research Group (perhaps because that was the focus of this study). Given her extensive experiences with research, she believed that she fit the mold of an engineering faculty member because of her competencies in managing research projects and supervising students. Her consideration of the professoriate included weighing her understanding of the job (based on her faculty prototype) with her current knowledge, skills, and attributes. Yet, as noted earlier Gloria remained undecided about pursuing the professoriate because of her perceptions of academic norms related to gender and parenting (social identities) and potential misalignment with her faculty prototype on that dimension. Similarly, Allen's observations of Professor Houston provided indications of what a faculty prototype meant to him:

[The emails at 4am] just means he's still working, that's it. Because he came to work during daytime, takes off around 5/6p, and you think that he is off. He is off with his family and is going to come back tomorrow. But...he is actually still working at home.

As his faculty prototype, Allen believed that a professor works long hours, and that work does not stop after one leaves the lab on campus.

It is important to note that one member acknowledged that his prototype was based on a faculty member other than Professor Houston. Specifically, Ralph (who, as noted above, perceived “American” engineering professors as tall white men with beards) indicated that his father – an Asian professor – was the reason he wanted to become a professor. However, joining the Houston Research Group served to extend his existing interest in a faculty role. This finding relates to previous work that one’s conceptualization of what it means to be and do the work of faculty may be cultivated prior to graduate school (Anderson & Louis, 1994; Beiber & Worley, 2006; Lindholm, 2004). Other members in the group also acknowledged that their perceptions of the professoriate were shaped by encounters with other faculty – in some cases, professors they had as undergraduates. However, the majority compared and contrasted their understandings of faculty and faculty work to their encounters with Professor Houston. This may be because during undergraduate studies, students may not have a deep understanding of what professors actually do. In contrast, graduate students and postdocs gain a closer view (Berdanier, et al., 2016; Burt, 2014), and have opportunities to mentor other students (Ahn, 2016).

Social Comparisons

The power of the faculty prototype is that it motivates individuals to adjust their behaviors (Blackburn and Lawrence, 1995; Phillips & Russell, 1994). In the current study, it influenced members to self-assess their research competencies by comparing themselves to the prototype and to other group members. This finding is similar to that of Phillips and Russell (1994) who found that advanced graduate students in counseling psychology were more productive than novices because they modeled their research behaviors on faculty and peers. According to social comparison theory, individuals require self-assessment, and in the absence of objective measures, compare themselves to others (Festinger, 1954).

Social comparison theory provides a lens to understand how members made sense of their chances of becoming a professor relative to their group's members and faculty prototype.

Recall that part of Allen's understanding of faculty careers related to his observations of Professor Houston working late and sending email at 4am.

The pressure—most people don't like that, but I don't mind. Obviously, I stay in the lab 11pm or 12am in the night, I don't mind. But again I mean—it could be maybe because I am just single I just don't care...I come into the lab on the weekend, I don't sleep, I have nothing else to worry about, I have nowhere else to go.

Based on his perceptions, Allen suggests that he is already participating in the practices needed to succeed in a faculty role. His quotation also illustrates a recognition of his social identities as a non-married individual with no children. In those comparisons, he suggests that his ability to work long hours and exclusively focus on research in the lab might be connected to his marital and family statuses. Using himself as the baseline, he compared his perceptions of the professoriate to other group members, starting with Brielle:

[Brielle] saw Professor Houston working hard, not sleeping, sending emails 2-4am in the morning that scared the hell out of her. She just could go take a job in industry, take a job from 8am-5pm or 9am-6pm and that's it. She doesn't have to worry about anything when she's off, just enjoy the rest of the day and come back in the morning. But the academy is not like that.

Allen continued his social comparisons to Erik (a White U.S.-born second-year doctoral student at the beginning of data collection), Danny, and Professor Houston:

A lot of people normally at this stage don't know what they are going to do. You ask Erik, "what are you going to do?" and he tells you "I don't know." I ask Danny "what are you going to do?" "Oh I don't know, yet, but probably not in the academy." Houston's wife asked me "what are you going to do" and I said "I want to become a professor." She said, "Oh wow, I never hear that from anyone at this stage." When Professor Houston was in grad school he didn't know he was going to become a professor, he didn't know he had to graduate, go off two years and then actually come back.

In the quotations above, Allen makes comparisons first to his research group peers, and then to Professor Houston based on information from Professor Houston's wife, with whom he

interacted with at the bi-annual gatherings hosted at the Houston house. In these comparisons, he was gauging his likelihood of pursuing the professoriate relative to his faculty prototype's journey to the professoriate as well as the journeys of his peers.

Social comparison theory also offers clues to how members made sense of their research competencies, and how these self-assessments also influenced their professorial intentions. For example, there was no rubric for Houston Group research presentations in group meetings. Instead, members prepared their presentations in comparison to feedback received by others. Vince, an Asian international first-year doctoral student, compared his shorter presentations to Allen's lengthy talks: "He [Allen] goes through all his data when he presents in subgroup or group meeting. Other people take 15 minutes, he takes 40 minutes; he wants to point out every observation he has." Vince noted that Allen's presentation skills were representative of one most likely to pursue the professoriate. These comparisons were important to Vince because as a new group member, he was trying to decide whether to pursue a faculty career:

I think one of the things that Allen does is he would always try to have a comeback to every question or every suggestion, while others might just take the suggestion and sit down, and that's why he takes so long in the group meeting because he tries to come back...to critique is something I think I can see a faculty doing.

Vince pondered how Allen exceeded his allotted presentation time, yet still received praise. He assumed that Allen was acting like a faculty member by presenting all of his data, challenging all feedback he received, and being "showy," a word Vince later used. Similarly, Vince used descriptors he perceived to exemplify successful professors, such as "egotistical" and "like to show off how intelligent they are." While these terms had ambiguous connotations (i.e., both positive and negative), he ended by aligning himself with Allen and the characteristics he used to describe faculty members, admitting that he, too, had a bit of an ego, and "would like to be acknowledged as a good grad student or a good researcher, that would be nice."

The social psychological literature provides possible rationales for Vince's self-comparison to Allen. From a social comparison perspective, Vince considered Allen a target to emulate. This literature would consider Vince's desire to adjust his behavior to achieve the same acknowledgement Allen received "upward social comparison," whereby an individual may self-enhance behavior to improve both self-evaluations and others' perceptions (Hackett, Esposito, & O'Halloran, 1989; Lockwood & Kunda, 1997). From an alternative, social-cognitive perspective, it could be speculated that the nature of feedback from Professor Houston and "significant others" primed (i.e., triggered implicit understanding in) members to learn what was acceptable and unacceptable. This priming, whether intentional or not on Dr. Houston's part, could have shaped members' perceptions of what faculty do, perhaps creating in their minds a prototype.

As illustrated by Vince, group communication practices (e.g., giving and receiving constant feedback) triggered reflections on perceptions of faculty, and self-assessments of the alignment of members' current knowledge, skills, and abilities with those perceptions. Members often described skills they had not yet learned or developed well, or faculty characteristics they felt they lacked. Such skills or characteristics appeared to be, in large part, framed by observations of and interactions with Professor Houston. Erik perceived faculty to be "innovative," or have the ability to proactively identify solutions to problems. Erik also suggested that innovation required expertise in what research questions have already been asked, what questions could be answered through research, and how to address these questions. He expressed concerns about his ability to develop an innovative research agenda: "I lack the confidence to pull a completely new innovative novel research idea out of something that I read in the literature. I can't take some things I read in literature and completely spin it into a research project that I could write about or write [a] grant for, as a professor [might]." He further

suggested that because the field champions innovation, and because he was not confident in his ability to create new groundbreaking work, he could not see himself as a professor:

Part of the reason I don't want to pursue the professorship...is because of my worry of that – of finding research areas that I know I can – I don't want to say succeed in, but I know can play a part. Because most of the well-known professors have a research area that at least in [Model University] that they are in the top at...they play a big part in advancing the research in a certain science.

Like other members, Erik benchmarked his skills against those of MU faculty whom he described as “advancing” science. Members like Erik tended to self-assess their research abilities relative to models who routinely received recognition from MU and secured grant and corporate funding based on research innovation. Perceived gaps in members’ skill sets in part influenced how some thought about their chances of succeeding in academia, and whether or not they might pursue faculty jobs.

As with Vince’s observations of Allen above, members’ perceptions were often related to academic status. A first-year doctoral student might not have acquired skills equivalent to those of advanced doctoral students and postdocs. Research suggests that learning during graduate school happens in stages, and varies by field (Baker & Pifer, 2011; Baker, Pifer, & Flemion, 2015; (Baker) Sweitzer, 2009). Although this may seem like common sense to faculty, explicit conversations with students, explaining that they will learn more skills and participate in increasingly complex tasks as they progress, appeared to be lacking. Feelings of inadequacy, promoted through social comparisons, might be exacerbated when newer members observe advanced peers engaging in additional forms of research activity.

Explicit comparisons of other students, shared with the PI, were rare, which made observations of competition within the group even rarer. This might have been because most advanced students viewed their same-class peers as being at the same skill level, thus rendering

no comparisons necessary. This is likely the case because some advanced students in this study did mention others they held in high regard, but those students had graduated before the start of this study. This rationale, while speculative, aligns with that forwarded by scholars who discuss how individuals decide to whom to compare themselves (Anderson & Chen, 2002; Gibbons et al., 2000). Newer students may have been so new that they were still trying to understand what the group's norms and values were before determining who their "target" would be.

At the onset of data collection, the PI was prepared to observe competition within the group, although it was not clear what competition might look like. The PI had a hunch that competition was related to class level (e.g., advanced versus novice members) during group meetings. Specifically, the PI wondered who sat at the conference table (versus the chairs behind the conference table), and why? Was this a social practice learned over time or was there assigned seating? Data analysis revealed that seating during group meetings did promote slight social comparisons. Excerpts from fieldnotes and interview data provide supporting evidence for the initial hunch:

Fieldnotes Excerpt (Week 1)

As I entered the conference room, one student was already in there, it looked like she was rehearsing for something. Sure enough, she tells me that she was preparing for a conference presentation and the team meeting would be focused on her presentation.

I sat at the conference table. Was I supposed to sit here? As others come into the room, I started to wonder who was seated at the table with me, versus who was seated in the chairs arranged behind the conference table. Was the seating based on hierarchy (with the exception of me)?

As the presentation went on, the people taking the most notes were those at the table. Were they more engaged? Were they simply used to these group presentations and knew that you're supposed to take notes? Were they more knowledgeable because they are co-authors on the paper?

Fieldnotes Excerpt (Week 3)

This week...I did not sit at the conference table. Sitting in the back corner of the room now provided me an angle to see everyone in the room. Yet, I was still confused if there was a hierarchy for seats in the group meetings. I informally asked a non-core member of the group about the seating. [H]e confirmed that senior people sit at the conference table, but he said that it just happens like that, that it wasn't based on a "hierarchy" (his word, not a word I prompted him to say).

These two excerpts highlight the glimpses of social comparisons that manifested in terms of seating. To further investigate, the PI formally asked members to explain where they sat during group meetings and why. Allen stated:

No not really [there are not specific seats]—people sit wherever they like, it just depends on—well, some people like to sit at the table and some people don't, including myself; I don't like to sit at the table, I like to sit out and you always see me I am never at the table unless I am presenting. But during group meetings there are other people that just like to sit not at the table but on the side.

Researcher: Do you think you'll always sit on the back row?

No, essentially not. (laughter) Actually, now that I think about it, I think the table is mostly: Professor Houston, Professor Lee, Dr. Randall, and then the fifth-year maybe Emma, Brielle, then Tiffany, and then Gloria. So that's actually a good point, that's actually the way it is right now (laughter). Anytime you go to a group meeting those are the people who are sitting at the table and (laughter) I think it's the way we think of it...we think of it as respect. You will see always Erik and I sitting on the back row, you never see Erik at the table or me.

Brielle and Emma confirmed the PI's hunch about seating. Brielle excitedly explained:

Professor Houston sits here all the time [pointing to a drawn image of the seating in the room], and now I've noticed this—it's becoming more and more hierarchical...Emma likes to sit behind here, or sometimes she comes up [to the conference table] after [someone] told her about how postdocs have to sit in the front.

Emma confirmed: "More senior people sit at the conference table and new people sit on the side...I guess we kind of respect seniors to let them choose first to have better seats." Taking Brielle and Emma's quotations into consideration, it is clearer that the group's more senior members saw seating during the group meetings as a form of social comparison because seating was related to the social order within the group. Further, with the exception of Emma being told

to move up to the conference table because she was a postdoctoral scholar, it appears that seating was a social practice learned as members became more advanced.

While competition did not emerge as a major theme across members, the social comparisons mediated by weekly group and subgroup meetings might have influenced a culture of competition whereby students wanted to give the best presentations, show the most impressive data, and receive favorable public reviews from Professor Houston and the leadership team. This conjecture aligns with Allen's statement that "The group is very competitive." He articulated a sentiment expressed by Professor Houston that "everyone in the group wants to be a star." Over time I gathered from other information (like Vince's comparison of himself to Allen) that the superstar(s) in the group were the students who received the most favorable attention and feedback from Professor Houston. If it is the case that explicitly comparing oneself to another team member is an indication of who one's competition is, then it makes sense that more students did not explicitly self-assess their skills relative to their peers. Nonetheless, when students did self-assess their competencies, they did so against the gold standard of research and engineering work, the faculty prototype. They tended to assess their abilities in two domains: competencies practiced within the group, and skills they had not yet learned or developed well.

Individual and Institutional Experiences

While this study broadly focused on members' experiences in a research group, it became obvious that individual and institutional experiences also shaped their views on faculty careers. The number of potential experiences are vast; they are accounted for in the theoretical model because they inform members' career intentions. For example, the amount of financial debt Lloyd, a White U.S.-born post-doctoral group member, accrued in school made lucrative industry careers more appealing than the professoriate. Prior to returning to academia as a

postdoc, he worked a number of years in industry. He shared that industry positions tend to pay more than faculty positions. This was an important consideration as he thought about supporting his family and paying back his student loans: “In terms of [why a career in] industry, obviously the number one thing would be the money. Whatever I am doing I could probably earn 30% more in industry doing the exact same thing.” Lloyd was not an anomaly. In their work on student returners, Peters and Daly (2013) found that loss of earnings was a strong concern for students returning to academia after working in industry positions. Lloyd was concerned not only about his current loss of income, but about a lifetime difference in potential earnings in industry versus academia.

Brielle also discussed an interest in a career outside of the typical jobs of those with engineering doctorate degrees:

Do you know [a university adjunct professor]? He used to work in [a vehicle technology company] as a researcher. He worked there for a good number of years and then he’s here now as an adjunct faculty. That’s sort of a role I would want. Because at some point you want to give back. The knowledge that you’ve gained and everything that you’ve learned you want to give it to people back. It may not be totally faculty, I may teach in a high school or something. But I really want people to be interested in science and interested in problem solving in general. That’s the skill set that I think I should be able to deliver and I have a little bit of it and that’s something that I really want to give to people.

Based on her interactions with and observations of the adjunct, Brielle’s ideas about what was possible in terms of a future career, even if it was a hybrid between research and adjunct teaching (i.e., a form of a-la-carte job creation) (Burt, 2014), had expanded based on his model.

Brielle’s background is important to note because her father is a high school teacher (i.e., personal factor), which may help explain why Brielle was interested in K-12 teaching as well as college teaching. It is possible that because Brielle enjoyed teaching, but was not completely sold on all of the demands of the professoriate, she was able to view herself as a future teacher at the K-12 level. Further, existing research asserts that women and those from underrepresented racial

and ethnic backgrounds often enter STEM fields with the intent of helping their communities. Yet, as they continue through STEM pathways, they are not shown how remaining in STEM will allow them to meet their goals (Carlone & Johnson, 2007; Gibbs & Griffin, 2013). From this perspective, considering their social identities (i.e., gender, race and ethnicity) may offer additional insights into why the altruistic priority of giving back to younger students is of interest.

Not all Houston Group members enjoyed teaching. For some, it was a skill that they had not fully mastered, but perceived to be one that professors need. An important contextual note: at MU, all engineering graduate students (master's and doctoral) were required to serve as a teaching assistant for at least one semester to gain experience of and exposure to the art of teaching, while not necessarily mastering it.

Experiences in the classroom, and/or fear of being an instructor, influenced how some members thought about academic careers. Concerns about leading a class were heightened for members whose first language was not English (similar to findings described by Rosse-Richards, et al., 2013). For instance, two international group members were not as confident in their ability to succeed as faculty given their language skills. Emma shared how teaching undergraduates shaped her professorial intentions: “[I had a] bad experience when I did the [graduate teaching assistantship]...It was very difficult to teach – English is not my first language...I felt [a faculty career] wasn't for me.” Tiffany described her communication skills as a barrier reducing her competitiveness on the job market: “I would have some disadvantage compared to my other competitors, and all of this will make me feel hesitant about it [pursuing a faculty career].” Emma and Tiffany illuminate how some members acknowledged that succeeding in faculty careers requires a menu of skills, including teaching and communication, not just research

competence.

Though teaching was of concern for some, at MU, all graduate student teaching assistants were required to participate in a number of teaching and learning workshops. This means that at some point, all students in the Houston Research Group would have been exposed to conversations and activities to improve their teaching. In addition to the teaching and learning workshops for teaching assistants, MU offered a PFF program. Those who were aware of PFF were more advanced students closer to the job market. This contextual finding makes sense of why the more advanced members were able to discuss institutional types other than MU, their perceived fit at different institutional types, the types of courses they would like to teach, and other faculty career-related ideas. This is in contrast to the novice students, who appeared to be unaware of PFF and other campus resources dedicated to improving teaching and learning. The novice members appeared to be primarily focused on transitioning to MU and the research group, and completing coursework.

Discussion of Results and Implications for Research and Practice

This 13-month ethnographic study, conducted to explore experiences and factors that influence research group members' intentions to pursue faculty careers, provided new understandings of the culture of one research group in chemical engineering, and led to the development of the Theoretical Model of Engineering Professorial Intentions (TMEPI). While centered on chemical engineers in one research group at one research-intensive institution, the TMEPI has immediate implications for research and practice – particularly mentoring practice – for the wide array of fields that use research groups as sites for teaching and learning. The model also offers insights that can be applied in fields that work differently.

The TMEPI suggests that the culture of the group, shaped by its interactions between

members, and practices and activities, influenced members' learning of research and development of professional identities with regard to faculty careers. This overarching principle of the model underscores the significant role that research supervisors and members of research groups – as communities of practice – must be cognizant of when designing and executing research group experiences (Baker & Lattuca, 2010; Burt, Lundgren, & Schroetter, 2017; Crede & Borrego, 2012; Lave & Wenger, 1991; Wenger, 2010). That is, the nature of the group's design, its interactions between group members (both intentional and unintentional interactions), and the kinds of practices and activities within the group ultimately shape the culture of the group, and that culture influences members' professional identities (e.g., to pursue a faculty career or not). This principle of culture may have similar influences in fields that do not use research groups. Individuals engaged in alternative forms of research experiences may be influenced by their interpretations of their departmental interactions, including but not limited to interactions with their faculty advisor/supervisor and peers, and observations of how faculty interact with each other. Perceptions of these interactions, as well as the kinds of research experiences individuals are engaged in, likely provide them with clues as to whether or not a faculty career aligns with their professional goals and values.

Central to the TMEPI is participation in research experiences. However, sociocultural factors (e.g., structures, policies, economic influences) are foregrounded in the model because these factors bear not only on members' social identities (e.g., race/ethnicity, gender, citizenship status) but also on their personal factors (e.g., parents' educational background and occupations, previous work experiences); these identities and factors are part of who members are. Thus, sociocultural factors influence members at every stage. Social identities and personal factors, for example race and gender, can shape how members perceive the norms and values within the

group, and thus how they participate in research practices and activities. Participation in the group influences the identification of – or the maintenance of an existing – “faculty prototype,” the ideal representation of a professor. Simultaneously, members socially compare themselves to the prototype and to anyone else who exhibits characteristics and behaviors of the prototype (e.g., peers, faculty). Over time, they participate in new practices and activities and interact with new members, prompting them to iteratively refine their understandings of research expectations and of the professoriate. This nonlinear, often cyclical process prompts members to self-assess their research competencies relative to the faculty prototype and peers. Other individual and institutional experiences (e.g., financial debt, teaching experiences) also influence considerations regarding faculty careers. While these factors and experiences are not directly related to research group experiences, they shape students’ perceptions and intentions regarding the professoriate.

Implications for Future Research

The Theoretical Model of Engineering Professorial Intentions highlights some of the learning and developmental outcomes associated with participation in a collaborative research group. Members learned which behaviors to emulate through interactions with and observations of already fully engaged members of the community (the advisor and advanced group members). Participation in the group’s practices and activities also afforded members opportunities to “try on” faculty roles. While the six emergent components described in this article are specific to this research group, they provide direction for future investigation.

As members participate in group practices and observe their supervisor in action, they form a faculty prototype that represents their understanding of faculty work; in fields that do not use research groups, individuals engaging in independent or apprentice research experiences likely also form a faculty prototype. More research is needed to understand the range of

prototypes and their characteristics. Further, because prototypes provide cues – both positive and negative – related to faculty careers, which in turn influence interpretations of what faculty careers might entail, a better understanding of the cues members see and hear would provide clues to individuals’ concerns about and interests in the professoriate. Like in previous research (Baker & Pifer, 2011; Baker, Pifer, & Flemion, 2013), to advance this line of inquiry, researchers might consider a social network approach that includes a sociocultural understanding of learning and professional identity development (Baker & Lattuca, 2010). This approach would need to also consider how the social identities of faculty prototypes influence individuals’ considerations of their potential for becoming faculty. Such an approach would provide an expansive view of individuals’ prototypes, beyond research group supervisors, and allow researchers to compare and contrast characteristics across prototypes and determine if there are context-specific (e.g., departmental, college, institutional) cues that negatively or positively influence professorial intentions.

Social comparisons are inevitable as group members attempt to make sense of their performance. The findings suggest that the faculty prototype prevalent in a group promotes further social comparisons with peers. If members feel a heightened sense of competition, perpetuated by social comparisons, they may also assume that their research group experience is representative of a future faculty career. More research is needed understand the ways research groups promote – intentionally and unintentionally – social comparisons among members. If using qualitative interviews to explore this line of inquiry, researchers may want to center questions around how group practices are learned by novice members, and the nature of competition in the group. If using observational techniques, researchers may want to observe where members sit during group meetings relative to the supervisor, the number of times

individuals speak relative to peers during group meetings, and priorities and/or preferences for lab and office space. Such examples may not be shared during interviews, and may be better identified using observational techniques. If using one-on-one interview techniques, researchers could ask individuals how they assess their research progress, and identify whom in their group or department they socially compare themselves to in efforts to self-assess their research performance.

In fields that do not use research groups, individuals likely socially compare themselves to peers engaging in other forms of research and in different types of settings, such as advanced graduate seminars. When not participating in a research group, individuals may gauge their progress and abilities against those of peers doing less closely related research, perhaps with other supervisors. Thus, students not in research groups may not be comparing apples to apples, but rather apples to oranges in attempts to assess their abilities. In such fields, researchers could conduct individual interviews asking graduate students how they assess their progress and to whom (if anyone) they compare themselves, which might yield insights that would suggest venues in which observational studies could be fruitful.

Scholars have already determined that “interest” in careers is a determining factor for career intentions (Gibbs & Grffin, 2013; Lindholm, 2004; (Baker) Sweitzer, 2009). “Interest” in the professoriate was also an explanatory factor here. More research is needed to understand the determinants of (dis)interest. For example, perceptions of the alignment or misalignment between faculty work and members’ values shaped their (dis)identification with academia. However, it remains unclear how competency (i.e., research self-efficacy) and feelings of incompetence influence (dis)interest. It is possible that individuals have less interest in faculty careers if they self-assess their skills as being less advanced than what they perceive is necessary

to succeed.

The interview protocols in this study focused on research group experiences and preparation for faculty careers, which explains why members related their interactions, participation, and learning about research to their professorial intentions. However, individual and institutional experiences also emerged as important (e.g., financial obligations, potential earnings, communication skills, and teaching). In addition, experiences not mentioned by participants may matter. These could include time-to-degree (i.e., the amount of time it takes to complete a graduate degree) and its relationship to financial debt (National Center for Science and Engineering Statistics, 2014; Nettles & Millett, 2006), and positive and/or negative experiences within one's academic contexts (advisor, research group, classroom, department, college, broader campus) (Burt, McKen, Burkhart, Hormell, & Knight, in press). It is likely that these factors, and others, influence individuals' thinking about academic careers.

The PI assumed that members made decisions about post-graduate careers during graduate school, and in particular, through their participation in the Houston Research Group. However, the data from this study indicate that members had working ideas about post-graduate careers prior to joining the group. Thus, professorial intentions may be formed prior to matriculation to graduate school. This study was not designed to retrospectively ascertain when participants became (dis)interested in the professoriate. Future research should investigate *when*, *where*, and *how* students make determinations about pursuing faculty careers. Quantitative methods might offer appropriate tools to investigate the aforementioned inquiries. Specifically, scholars might attempt to operationalize this study's holistic theoretical framework by developing scales to measure the framework's factors. When testing the TMEPI in quantitative research, scholars could examine correlations between the various components of the framework,

as well as direct and indirect relationships between these components and professorial intentions. Finally, a longitudinal, mixed method research design that captures career intentions earlier in STEM pathways might provide stronger indications about when students' interests form, and when and how they change.

The research group identified in this study was selected partly because it had more doctoral students than post-docs. However, there were two postdoctoral students in the Houston Group. Data from the post-docs illustrates that they continue to learn about faculty careers after completing the doctorate. Future research should examine the experiences of post-doctoral scholars to better understand what they learn in their research experiences, and how their experiences influence their career intentions. Further, because research experiences are important pathways to the professoriate in many fields, studying students throughout their graduate and post-doctoral research experiences could provide a more nuanced understanding of pathways to the professoriate.

Future scholarship on research groups could implement similar ethnographic observational and interview techniques as those used here, with a specific focus on the components introduced from this study. Such an investigation would extend this study by providing additional information about this study's six components. Studies of this kind, focused on engineering specializations outside of chemical engineering, as well as fields outside of engineering, would provide greater nuance to the theory and widen the corpus of scholarship on research groups as sites for teaching and learning, and on the influence of research group participation on the pursuit of the professoriate.

Implications for Practice

Findings from this study provide implications for the practice and implementation of

research groups and the supervision and mentorship of research experiences. They show that when faculty lead students' research experiences, they not only influence learning about research, they also shape perceptions of the professoriate and considerations of other careers. Professor Houston was thoughtful about developing students' research competencies, specifically designing practices and activities to cultivate specific research competencies (Burt, 2017). However, less consideration was given to how the group's practices and activities would influence students' career outcomes (for example, how having weekly subgroup meetings rather than one-on-one meetings gave students the perception that they were being prepared for careers in industry rather than academia). Because research experiences bear on what students learn about and how they perceive the professoriate, when the experience does not align with a desired career outcome (e.g., increasing students' interest in faculty careers), advisors should make adjustments (Hollingsworth & Fassinger, 2002). Like crafting a syllabus, research experiences should be designed with learning outcomes in mind. For example, this might take the form of collaboratively working with group members to develop a conference proposal, providing feedback along the way, and explaining reviewers' feedback accompanying rejections and acceptances (Burt, Lundgren, & Schroetter, 2017). Whether in a research group or an individualized apprenticeship research experience, a research supervisor can intentionally share insider knowledge of the conference submission process with students to expose them to this research practice. This exposes them to the process of receiving and responding to criticism and submitting manuscripts to journals. As a result of such intentional research experiences, participants in Burt, Lundgren, and Schroetter's (2017) study described feeling more confident in considering doctoral programs, and research-related careers (e.g., the professoriate) after graduating.

The findings in this article suggest that professorial intentions are partly related to self-assessment of research competence. Lack of transparency on a supervisor's part may prevent novice researchers from explicitly recognizing the existence of skills they are in fact developing. For example, although Houston Group members were not directly involved in writing grants, Professor Houston had them write summaries of their research findings, which he used in grant applications. However, through interviews with him, it became apparent that he had not explained how they were contributing to the grant-getting process, and that getting funding requires demonstrating findings from existing work. Because Professor Houston did not reveal this critical aspect of grant writing, members felt unprepared to apply for grants. If research-related progress is not explained to novice researchers, they may not know they are engaged in – or capable of performing – the practices and activities of faculty work. With more feedback and/or transparency about the transferability of their skills, novice researchers may become more confident about their research abilities and potential success as faculty.

Finally, supervisors should regularly share balanced depictions of their experiences as professors. At the conclusion of data collection, Professor Houston acknowledged that he rarely shared information about his faculty experience. Without open conversations about the benefits and challenges of the professoriate, students made assumptions about faculty careers based on their observations and value systems (Burt, 2014). Professor Houston shared that he might consider using portions of group meetings to discuss what he does as a professor. Although group meetings provide an optimal teaching and learning site to discuss career options with a wider audience, candid conversations about the professoriate can also be had during individual meetings. The key to this recommended practice is to open up communication about faculty careers to offer a more expansive understanding.

Conclusion

Common in faculty careers – regardless of field and discipline – are intense interactions with students, and thus the expectation to mentor students. This study provided a deep understanding of one teaching and learning environment where mentoring takes place in many science and engineering fields: a research group. Many components of the Theoretical Model of Engineering Professorial Intentions, however, can also be applied to fields that do not use research groups. Research experiences are necessary sites for investigation because of the intergenerational mentoring and learning that takes place between faculty, post-doctoral scholars, and doctoral, master's, and undergraduate students. As suggested through this article, research experiences have the potential to encourage (dis)identification with and (dis)interest in the professoriate. Whether in the fields of social sciences, humanities, or other disciplines, scholars and practitioners should continue to think about how they design research experiences that promote positive images of the professoriate, which may include creating opportunities for intergenerational mentoring and being cognizant of the intentional or organic ways that social comparisons take place among students.

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