International Journal of Engineering Education Vol. 38, No. 5(A), pp. 1212–1222, 2022
Printed in Great Britain

0949-149X/91 $3.00+0.00

Choosing a Doctoral Advisor: A Study of Chemical Engineering Students' Perspectives Using Basic Needs Theory*

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Choosing a doctoral advisor is the most critical decision students will make in their doctoral journey. The relationship between doctoral students and their advisors can determine if students will complete the doctorate. Yet, little is known about how students experience this decision process and whether students are supported in this selection. The purpose of this study was to explore how students experience the satisfaction of their basic needs in the advisor selection process of one Chemical Engineering program. Using case study methodology, we interviewed 14 doctoral students about their experience in selecting an advisor. Self-Determination Theory guided evaluative and theoretical coding. The findings revealed that most doctoral students who participated in research experiences prior to the doctorate are more satisfied with their choice and practiced a better-informed selection. They had a clearer understanding of what they needed to look for in an advisor when compared to students who had not participated in such research experiences. This study shows that the process of finding an advisor in the Chemical Engineering Program studied may not provide sufficient competence support for students who have not participated in research, limiting their ability to make a decision when selecting an advisor.

Keywords: doctoral students; self-determination theory; advising relationship; engineering; graduate education

1. Introduction

Doctoral attrition rates in engineering within seven years of enrollment are abysmally high at 36–48%, depending on student demographics [1]. Significant research demonstrates that a poor advising relationship is a primary reason [2–4]. Specifically, an ill-informed advisor selection can lead to an unsatisfying advising relationship [5, 6]. Yet, advisor selection is a key decision made early in the doctoral process [7], when students may not yet fully understand their role and still possess ill-informed perceptions of the doctorate [8, 9]. Making important decisions in this initial stage, such as choosing an advisor, without fully understanding this person's role in the process, can profoundly impact the doctoral experience and even prolong time to degree [10].

As shown in a study of over 60 STEM doctoral programs, many doctoral STEM programs engage in similar advisor selection processes where most students and faculty self-assemble with minimal department intervention [11]. However, Chemical Engineering differed from this pattern by offering a structured process for incoming students to select an advisor. While a deeper study on this advisor selection process showed its supportive intent, it did not describe the student perspective [7]. Understanding the student perspective can reveal insights on equity when considering that students enter the doctorate with varying and unequal understandings of what it comprises [12, 13].

In support of developing equitable advisor selection processes from the student perspective, this case study focused on the experiences of 14 students currently enrolled in a single Chemical Engineering program's advisor selection process. Grounded in Self-determination's Basic Needs Theory [14, 15], we addressed the following research questions:

(1) What is the doctoral advisor selection process as experienced from the student perspective?
(2) How are doctoral students' basic needs for autonomy, competence, and relatedness met during the advisor selection process?

Our findings showed that prior undergraduate research experiences provided critical knowledge that helped students navigate their advisor selection process differently than peers without such experiences and resulted in differences in how basic needs were met.

2. Background

Although much research has looked at doctoral

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* Accepted 19 March 2022.

advising relationships, little work has addressed the process through which advisors and students opt into such relationships. Though the process is not well understood, studies have uncovered key factors about what students look for when finding a fit in the advising relationship. For example, Nettles and Millet [16] found that across multiple disciplines, students that select an advisor based on fewer criteria were less likely to be satisfied with their advisor choice. Also, Joy et al. [10] found that a potential advisor's funding availability and research topic were the most dominant factor in the choice for STEM students. Research also shows that fit with an advisor is also important. Specifically, Maher et al. [17] showed how students conceptualized fit and made tradeoffs when selecting a research group. Perceptions of fit can also be impacted by student characteristics. For example, women undergoing laboratory rotations in the biological sciences considered their 'fit' in a research group often above other factors to ensure their long-term sustainability in a group [18]. Moreover, Main [19] showed how within STEM, women doctoral students working with women faculty advisors were more likely to complete the doctoral degree, thus showing the long-term impacts of individuals' attributes on advisor selection.

In addition to the demonstrated impact of gender on the advisor selection process, a significant amount of doctoral education research has shown how other dimensions of student attributes can impact the overall doctoral journey. For example, researchers have shown how doctoral experiences vary based on student demographics [20, 21], such as race and ethnicity [1] and international status [22, 23]. Research has also shown that experiences prior to the doctorate relevant to academic life can influence a student's journey through graduate education [9]. For example, studies have shown that students who have participated in undergraduate research have better research and writing skills when they pursue a Ph.D. [24].

Since advising relationships are critical, it is clear that understanding advising relationships – by studying the student perspective of the process leading to its inception – is a key next step. To that end, we draw on self-determination theory to operationalize student experiences along critical dimensions of autonomy, competence, and relatedness to explore their relative satisfaction with the advisor selection process regarding their different student characteristics.

3. Theoretical Framework

Self-determination Theory (SDT) [14, 15], a macro theory of motivation that focuses on individual growth and needs, is composed of five smaller theories, with Basic Needs Theory (BNT) underlying them all. BNT states that all human beings have three innate and instinctive needs: autonomy, competence, and relatedness [25]. As the needs are met or satisfied in our everyday lives, individuals grow in optimal conditions and become more motivated people. Although literature on graduate education broadly may not always be situated in SDT, the concepts of autonomy, competence, and relatedness have been widely discussed as critical to doctoral education as elements of SDT are also similar to concepts and ideas represented in other frameworks.

3.1 Autonomy

Autonomy is described by Deci and Ryan as the need to act out of one's own volition consistent with one's interests and/or values [14, 15]. This concept is often studied in doctoral education regarding advising relationships. For example, Overall, Deane, and Peterson [26] showed that students with a high research autonomy had a higher research self-efficacy when advisor support was also high. However, a high autonomy alone was an insufficient condition for a high research self-efficacy when the advisor support was low. When considering the broader doctoral experience, O'Meara et al. [27] found that departments can enhance student autonomy towards career advancement by providing structures and opportunities aligned with the needs of pursuing careers outside of academia. These studies, along with others in the doctorate literature, consistently demonstrate that not only is autonomy crucial for student motivation but that it must be guided with support to ensure student success.

3.2 Competence

The need for competence is described by Deci and Ryan as (1) the need to feel effective and capable (not unchallenged but matched in ability regarding task difficulty) and (2) the existence of support such that one can then feel effective and capable [25]. In this analysis, the term "competence support" refers to external conditions that sustain a person's competence need satisfaction.

In doctoral education, this need for sufficient support such that one can feel competent, has most commonly been discussed as emergent from the advising relationship. For example, Cockrell and Shelley [29] found that doctoral students' satisfaction with their advisor, particularly how they were taught research, the reception of feedback, and – when needed – emotional support, were crucial to the students' persistence. Similarly, doctoral student frameworks and descriptions have

argued that students entering the Ph.D. program do not have an accurate conception of what the doctoral pursuit entails [9, 30, 31]. Collectively, existing research and theory demonstrate a strong case for competence support being crucial at the early stages of the doctorate to sustain student motivation and success in the long term [32].

3.3 Relatedness

The need for relatedness is described as the need to connect and belong in a social group, not only to take from others but being able to contribute socially [15]. The need for relatedness can often overlap with psychosocial aspects of the doctorate and has been argued to relate to students' sense of belonging [33]. Existing research demonstrates the importance of relatedness to advisors, faculty more broadly, and to peers. For example, Curtin, Stewart, and Ostrove [34] found that advising relationships had a strong influence on students' sense of belonging in the doctorate and their academic self-concept. Similarly, Jairam & Kahl [35] found that students benefitted from having academic friends seeking similar goals as well as having a good rapport with the advisor. In sum, these studies show that students need to experience a connection to others or relatedness with both faculty and peers to persist in the doctoral degree.

3.4 Summary

While satisfying the three innate needs is important, so is balancing them. Imposing too much control or structure over a student's choice (in this case advisor choice) can hinder a student's intrinsic motivation, in this case, to work with such advisor and can create a negative backdrop from which the advising relationship has to recover from before it even begins. Yet, since not all students may have a clear idea of what graduate school entails upon entering, students with less clarity need structure to guide their decision. Therefore, for a self-determined advisor selection process, doctoral programs need to balance the ways they support these competing needs of autonomy and competence.

Although previous studies show some depth of knowledge on doctoral students' basic needs, few focus on the initial phases of the doctoral student experience, such as the selection of an advisor. Additionally, despite knowing what students value in an advisor [10], how students experience choosing an advisor and how this experience varies across students is lacking. Our study addresses this gap by comparing how students in one program experienced the satisfaction of their basic needs while finding an advisor, as well as showing possible links between students' background and their need satisfaction.

4. Methods

Grounded in case study methodology as described by Yin [36], this analysis is part of a larger case study that also examines the faculty perspectives towards advisor selection [11].

4.1 Case Background

Conducted in accordance with Institutional Review Board requirements, the study took place in a large public institution in the U.S. Midwest known for its engineering programs and its Chemical Engineering program is ranked in the top 30 in the U.S. The study focused on a single institution to understand the variety of student experiences while controlling for institutional and departmental variation. However, the doctoral advisor selection within this department is similar to that of many other chemical engineering programs [11].

In this doctoral program, students are admitted without a commitment to a specific advisor and are funded by the department in the first semester. Students participate in a research seminar to become familiar with the faculty, ongoing research in the department, and specifically faculty with funding available on research projects. Students are also required to meet with a minimum of three faculty. Finally, students submit a form indicating three faculty, in ranked order, that they would like to have as an advisor. The graduate program director compiles these preferences and assigns students to advisors. The primary criteria used to make advisor/advisee matches are a mutual preference for a student and a faculty to work with each other, meeting junior faculty's needs for doctoral students, and faculty having funding available to support the student for a predetermined period of time. Further details of the process have been reported elsewhere [7].

4.2 Data Collection

The data consisted of two sources: the graduate student manual for the doctoral program and interviews with doctoral students. The graduate student manual provided a backdrop for this study in terms of the context, policies, and practices related to advisor selection processes. Semi-structured interviews with doctoral students served as the primary data. The interview protocol was designed to elicit student experiences relative to their individual advisor selection process, the information they sought through, and the support they received in such through a BNT lens. Interviews were audio-recorded and transcribed verbatim.

4.3 Participant Recruitment

A purposive sample of graduate students in the

Table 1. Self-Reported Participant Attributes

Attribute	Sample
Resident Status	7 International 7 Domestic
Sex	4 female 10 male
Underrepresented Racial Minorities (URM) / non-URM	3 URM, 11 non-URM
Direct Ph.D. or MS	3 with MS 11 Direct Ph.D.
Length in the Program	Year 1 – 1 Year 2 – 2 Year 3 – 6 Year 5 – 4 Year 6 – 1
Prior Research Experience	6 with prior 8 without prior

program was invited to take part in the study, out of which 14 accepted. Compared to the populations described by the NSF as engineering Ph.D., the enrolment trends published by the Council of Graduate Schools [38], and the larger graduate demographics of our site's College of Engineering, our sample is demographically representative. Importantly, we do not argue that our sample is representative of all experiences, rather that it is consistent with trends such that no one group is intentionally oversampled. Self-reported demographics are summarized in Table 1. While we did not ask about differences in experience based on demographics, we remained open to such differences and did some limited analysis by attributes (including demographics) to be sure emergent patterns were not ignored. Our results did not yield any findings based on gender, race, or ethnicity. That does not mean that differences in experiences are not present but that they did not emerge in our data as salient to our participant's advisor selection.

4.4 Data Analysis

Interview analysis included three phases of coding: theoretical, evaluative, and attribute coding [39], followed by identification of emergent patterns across students' experiences of finding an advisor and comparing them across such. The theoretical coding was *a priori* informed by BNT [25] (see Fig. 1).

In evaluative coding [39], we classified each instance where students referred to a basic need regarding whether or not the need was satisfied from the student's perspective. For example, if a student described feeling prepared to select an advisor, the relevant text excerpts were tagged '+' to indicate a positive competence-related experience.

In attribute coding [39], we relied on attributes (Table 2) that emerged by either asking students to self-identify in an open-ended question regarding demographics or through the data such as prior education and research experience.

Finally, we sought meaning-making through identifying emergent patterns across students' experiences. Specifically, we examined the coded excerpts tagged with attributes to see if certain attribute patterns emerged in association with the theoretical and evaluative codes or notes. For example, participation in undergraduate research tended to be associated positively with autonomy, competence, and relatedness.

We engaged in measures to promote research quality, such as a theoretical framework guiding the development and usage of the interview protocol [40] and triangulating interview findings across participants and with the graduate manual to ensure that the interpretations were consistent with each individual's complete account and the context [40]. Finally, the lead author and the second author in continuous engagement as a form of

Basic Need	Definition from Deci & Ryan [25]	Operationalization	Sample Excerpt
Autonomy	To act out of one's interest or volition.	The need to be able to select or have an input in selecting your advisor.	"I believe I had authority over my Ph.D. because I was matched to my first choice."
Competence	To feel effective and capable in undertaking a task.	The need for succeeding in selecting an advisor; including both the need for support in the decision or feeling prepared to make the decision.	"I wish I had more time and more information when I was choosing an advisor."
Relatedness	To connect with others and belong socially.	The need to be or seek connection to others in the process of finding an advisor.	"I was more concerned with finding someone I would like to work with than findings a desirable research topic."

Fig. 1. Theoretical Coding Operationalization.

Table 2. Example Evaluative and Attribute Coding Operationalization

	Basic Needs Theory		Attribute Coding				
Sample Excerpt	**Theoretical Coding**	**Evaluative Coding**	**International / Domestic**	**Sex**	**URM/Non**	**Direct Ph.D. or M.S.**	**Prior Research**
"I believe I had authority over my Ph.D. because I was matched to my first choice."	Autonomy	+	International	M	Non	Direct Ph.D.	Yes
"I wish I had more time to find an advisor."	Competence	–	Domestic	M	Non	Direct Ph.D.	No
"I was more concerned with finding someone I would like to work with than findings a desirable research topic."	Relatedness	+	International	F	Non	Master's	Yes

researcher triangulation, enabling the research team to wrestle with researcher positionality and consider implications of such. The first author, who was a graduate student at the time, self-identifies as an underrepresented minority in engineering and had attended two different graduate programs and worked professionally as an engineer. The second author is a white female faculty member who has graduated many doctoral students, served in academic administration and worked professionally as an engineer.

5. Results

Our analysis revealed important findings regarding how students experience the satisfaction of their basic needs in the selection of an advisor. Specifically, our results revealed prior research experience to be the most salient trait in the satisfaction of basic needs. Although most students generally had a sense of autonomy in selecting their advisor, students who had research experience prior to the Ph.D. described having adequate competence support. Students with prior research experience also demonstrated understanding their need for relatedness early in their advisor selection. Students who did not have this prior research experience described lacking competence support and only later understood the importance of this need. While we evaluated students' experiences across the multiple attributes described in the analysis section, we were only able to observe research experiences as having salience and relevance to students when selecting an advisor.

5.1 Autonomy

Regarding the advisor selection process, most students reported positive autonomy experiences. 12 out of 14 participants were matched to work with their first choice for an advisor. When asked if they believed they had authority over their advisor selection process (autonomy), most students responded similarly to the quote below:

> "It's hard to say because I got my first choice. In a certain sense, I would probably say yes [. . .]. I've talked to plenty of students who didn't get their first choice, and they said, 'This isn't what I wanted,'" [Participant 2, no prior research experience]

Students with Prior Research Experience	**Students without Prior Research Experience**
Autonomy	**Autonomy**
• *Described as whether students had obtained their first choice.*	• *Described as whether students had obtained their first choice.*
Competence	**Competence**
• *Relied on peers and mentors to identify potential advisors.* • *Used a list of potential advisors to help determine to which schools to apply.* • *Possessed extensive criteria including both negotiable and non-negotiable characteristics in an advisors* • *Knowledge of how to 'work the process' and secure their top choice.*	• *Determined advisors predominantly by finding a research topic match and available funding.*
Relatedness	**Relatedness**
• *Used relatedness to determine the final decision*	• *Did not seek.*

Fig. 2. Findings Summary – Emerging differences in the choice process.

Regardless of receiving the first choice, some students still thought that they lacked autonomy:

> "It was just a preference system. I just had to write his name on a preference. [. . .] So, I guess you don't have too much authority on it. It's kind of just luck. If the timing matches, the funding matches." [Participant 4, no prior research experience]

The two students who did not get their first preference described lacking this autonomy precisely because of this:

> "I was kind of disappointed, because it was my third choice. And I thought 'well, I'm sure it'll be fine,' right? I trust that this is going to work out and going to be fine. I wasn't super thrilled about it." [Participant 3, no prior research experience]

We see here this result influenced the attitude with which this student entered the advising relationship. The outcome of the matching process made her perceive she didn't have autonomy, and she was not excited about the outcome itself.

Our data suggest most students had their autonomy satisfied in the advisor selection process and – although they mostly associated autonomy with getting their first choice of advisor – getting this first choice was not a guarantee of autonomy satisfaction. Of note is that the two students who did not get their first choice in advisor and did not have autonomy satisfaction also did not have prior research experience.

5.2 Competence

Competence satisfaction emerged in the students' experiences as being prepared to list their preferred advisor. Again, a clear distinction emerged when comparing students who had the attribute of having prior research experiences and students who had not. Participants who had research experiences of over one year (either as undergraduates or pursuing a research master's) described feeling prepared to select an advisor. They had a clearer understanding of the role of the advisor, provided extensive criteria on what they sought in such a person, and described an extensive and advisor-first process to select the institution in which they would ultimately pursue the Ph.D. One student described their process:

> "When the time came to apply for graduate school, I asked my [undergraduate] advisor, where do you recommend me looking at? He gave me a list of people he knew in our field. I went digging around [. . .] It turns out I found the person who is now my advisor, and I went back to my undergrad advisor and [. . .] He encouraged me to apply for her. He said she'd make a great advisor. She's very kind and creative." [Participant 7, undergraduate research for two years]

The student had a specific idea of what research topic they wanted to pursue and only applied to institutions that had faculty working on that research topic.

Not only did these students list more extensive and specific criteria of what they wanted in an advisor, but they also knew what factors could be negotiable for them, such as being flexible with the research topic. For example, another student kept his options open strategically when selecting an advisor:

> "I knew that there was a matching process, and [. . .] that there's always a possibility of not being able to work with somebody, but I had a chance to meet a bunch of professors. At the time, I was really looking to expand my experience as a researcher. As long as the topic was at least appealing and not in the same field that I had worked on for the past, I would have been good." [Participant 9, undergraduate research for two years and M.S.]

This same student also understood that, in order to get their first choice of advisor, they would need to convince the professor to vouch for him in the matching process and took pre-emptive actions beyond those required so he could all but guarantee that he would match with his preferred advisor:

> "I sent an email to [Advisor] a month before I intended to move and expressed my interest. I asked her if it was okay for me to get a feel for the lab before the program started. [. . .] I hung around the lab, talking to people, learning what they were doing [. . .] I had a first official meeting with [Advisor] soon after the program started. She knew I was attending all the group meetings and that I was really into the research. [. . .] We started to develop ideas [. . .] then she said, 'Okay, why don't you go ahead and join the lab'". [Participant 9, undergraduate research for two years and M.S.]

In contrast, students without prior research lacked a nuanced understanding of the advisor selection process from both a procedural perspective and the factors that mattered in an advising relationship. These students followed the procedure laid out by the department to help them select an advisor but did not necessarily understand the purpose of these seminars and meetings beyond finding a research interest match. The following quote describes how a student who had no prior research experience expressed a lack of competence support in finding an advisor:

> "It was a little stressful at the time because I felt like I was making a pretty uninformed decision. I felt like I was just picking, right? Because the person that I put as number one was the one who I knew didn't have much funding [. . .]. The person I picked second had a lot of money [. . .] And then my third choice . . . I didn't really understand what his research was much." [Participant 3, no prior research experience]

This participant mentions feeling stressed and uninformed in the process of choosing an advisor. Other participants reported similar feelings in learning

what they needed to know before selecting. The following quotes present how a student sought competence support in selecting her advisor:

> "It's hard, because I didn't really know what questions to ask my advisors. I got to meet an older student, and she was giving me advice on how to navigate the advisor selection process. [. . .] I don't hate the way my department does it. I just felt like I needed more time." [Participant 6, one summer REU experience]

Despite having participated in research one summer, she states feeling rushed to determine the questions she needed to be asking when selecting A third participant, expressed lacking knowledge on what to look for in an advisor as he was unsure of what he wanted out of graduate school:

> "Part of the problem is, again, to be quite honest, other than teaching, I really didn't know what I wanted out of [graduate school]." [Participant 2, no prior research experience]

This participant went on to describe that he was not sure whether he desired to fully pursue a doctorate but that he understood that it would open more doors for him in teaching. Thus, his lack of understanding of the research component of the doctorate caused a competence support gap that limited hindered an informed advisor selection process.

When looking at commonalities across the participants who had no prior research experience, most of these participants had selected doctoral programs, based on ranking and location, prior to considering who they might have as an advisor. For example, one participant said:

> "I didn't want to go super far away. I'm originally from [Midwest], so I wanted to stay generally in the area, and all of those schools had a good engineering school." [Participant 3, no prior research experience]

In sum, students that have research experience found adequate competence support in the established process; they demonstrated a more thorough understanding of the advisor's role and characteristics that would help them succeed. The majority of these students first selected specific advisors they would like to work with and from there selected the graduate programs. In contrast, students without research experience tended to prioritize institutional factors such as ranking and geography when considering where to attend. After which, they then considered who to work with, typically based only on the available research positions.

5.3 Relatedness

Regarding relatedness, again a clear attribute pattern emerged with regard to having research experience or not. Participants with prior research experience described seeking relatedness in the advisor selection process. Participants without prior research experience did not describe considering relatedness when choosing an advisor, though they realized over time that this was an important factor in the doctoral process. This reflection from a participant exemplifies this idea:

> "One of [advisor]'s students gave me advice [. . .] you should work with an advisor that you get along with, [. . .] you should not let the research subject be the driving factor, because you might love the research, but if you hate working with that person, that's going to be miserable. [. . .] The more you work with someone, the more you understand their flaws as well as their virtues [. . .]. That's nothing I could have known without working with the guy for several years." [Participant 2, no prior research experience]

Like many, this participant realized over time that relatedness was important. This participant also realized that when choosing an advisor, they did not have a way to know the importance of relatedness. In essence, students without prior research described not understanding they had a need for relatedness that was important to satisfy when they selected their advisors, but in hindsight, the importance of satisfying such need became apparent.

In comparison, students with prior research experiences understood the role of relatedness in conducting research under an advisor and sought to ensure this person was one they could relate to from the start. When one student was asked what they attributed their success in graduate school to, they responded:

> "I think maybe a good relationship with the professors [. . .] a good relationship means you have better communication. [. . .] Just makes your life comfortable and easy to do the research work. [. . .] also, the personality of the professor. It will be good if you have a similar personality with your professor like you have a common interest or topic to discuss beyond the research world. You'll be boring if every time you meet just discuss your data and results." [Participant 10, M.S.]

6. Discussion

Our findings confirmed that within the heavily structured Chemical Engineering advisor selection process at one University, students felt generally autonomous. Yet only those students with prior research experience described having adequate competence support and relatedness in their advisor selection process.

6.1 Autonomy

We found that most participants felt autonomous in selecting an advisor suggesting an appropriately structured process. This is an important finding because research shows that the right amount of structure can support autonomy while too much structure can inhibit it. With too much structure,

people feel restricted, and with too little structure, people can be overwhelmed by choices [41]. Our results suggest an appropriate amount of structure that supports rather than thwarts autonomy can be beneficial for students, which aligns with the previously mentioned findings by O'Meara [27].

6.2 Competence

Deci & Ryan argue that a higher satisfaction of competence when completing tasks can "enhance intrinsic motivation for that action because they allow satisfaction of the basic psychological need for competence" [25, p. 58]. However, Ryan and Deci [15] further state that feelings of competence will only enhance intrinsic motivation to the degree this event or structure is accompanied by a sense of autonomy as this gives the person an internal perceived locus of causality. This notion was clear in our findings as participants who articulated experiences with adequate competence support often described discrete actions taken before selecting their advisor, allowing them to be in control of the process. Moreover, students with prior research experience have knowledge and experience that enables them to better leverage what the program provides and/or fill in gaps towards a successful selection. These students typically listed more extensive criteria, with both internal and external factors, on what they sought in an advisor than students without prior research experience. Whereas students without such competence support "felt as if they were just picking." Although all students were encouraged to take place in the department's activities that would help them find an advisor (e.g., one on one meetings, talking to prior students), their lack of understanding of what they were supposed to look for in an advisor kept them from making the most of such opportunities. The system they engaged in was seemingly set up to support those students who knew what they were looking for and needed less competence support. Thus, for students who didn't know how to find an advisor, the selection experience needed to better balance competence and autonomy. These findings align with prior studies in doctoral education that also state autonomy and competence complement each other in the pursuit of intrinsic motivation; a high competence structure needs to be matched with a high autonomy [13, 26, 27].

6.3 Relatedness

By using BNT, the role of relatedness emerged as critical and differentiating in the selection process between those students that had prior research experience and those who did not. Students who did not possess prior research experience typically relied on research topic match as their main if not only criterion for selection. While research topic is an important criterion in selecting an advisor, using it as a single criterion excludes one's need for relatedness, which most students described in hindsight as a factor that ultimately became important in maintaining a positive relationship with the advisor [16]. This risk could lead to higher levels of dissatisfaction with the doctoral pursuit, which in turn could potentially lead to a longer time to degree and noncompletion [2, 4, 9]. Thus, those students without prior research experience who only selected their advisor based on matching research interests may run the risk of being less satisfied than their peers who performed longer assessments before selecting their ideal advisor.

We found that students with prior research experience sought relatedness as part of the selection process through interacting or volunteering in the advisor's research groups to learn more about their interactions with students. This action shows that these students understood their need for relatedness and made it part of their criteria for selecting an advisor. These findings align with prior work since research groups are one of the primary forms of learning in the engineering doctorate [42], and their dynamics may influence a student's perception of fit in the doctoral process, which impacts their doctoral persistence [43, 44].

6.4 Limitations & Future Work

Our research has limitations though none that detract from these conclusions. First, our interview protocol did not fully evaluate all aspects of the student's prior participation in research as this was an emergent characteristic of importance. While we can conclude that prior participation in research helped students achieve a more informed selection, we cannot pinpoint which aspect of research participation aided students the most in the selection task. Future research could further examine the role of prior research participation and advisor selection. Second, we did not find differences by gender, race, or ethnicity, but we believe it is important to note that we did not specifically ask questions about the influence of these demographics. Research shows that graduate school experiences broadly can vary for people from different backgrounds [45], so differences could be expected in the advisor selection process.

7. Implications

The practice of prioritizing research topic in the selection process is consistent with maximizing resources in a department as faculty have vacant research assistantships they need to fill, and the goal is to match such with interested students [46–48].

However, the goal of developing Ph.D. students is not necessarily furthering work in available research positions but learning how to conduct independent research [49], a process that requires internal motivation [50]. Therefore, students who do not have prior research experience when starting the doctorate could be assisted in understanding what they may need from an advisor throughout it. This awareness will help students have a fuller understanding of the characteristics they should seek in an advisor rather than merely research topic match and funding availability. This finding is also important for its relationship to doctoral attrition. Berdanier and colleagues [51] identified goals (both research topic and long-term career) as an engineering-specific factor related to attrition since such goals can often change throughout the doctorate. Thus, if an advisor selection is based only on research topic interest and this interest changes, the relationship may no longer be a good fit, and consequently, the student's willingness to persist subsides.

Finally, an important implication of this work is that the role of the relatedness is often underplayed when recruiting and retaining doctoral students. To enhance recruitment and retention, doctoral programs could help students assess and find research groups that match their working style as well as their individual relatedness preferences. As indicated in the results, many of the participants described consulting other students under the advisor or visiting research groups as a way to holistically assess a potential advisor. These findings align with prior research that has suggested a positive research group environment and a social fit within a group is a motivator for doctoral students [18, 32, 42, 52].

8. Conclusion

In conclusion, this study provides empirical evidence of the ways in which prior research experiences can impact the satisfaction of basic needs in the advisor selection process and how students without prior research may be limited in their ability to select an advisor. Through using SDT to dissect the student experience, we were able to uncover this hidden inequity in the advisor selection process of this doctoral program.

Acknowledgements – This work is based on research supported by the National Science Foundation under Grant No. 1723314. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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