

Choice in the Advisor Selection Processes of Doctoral Engineering Programs

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Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy  
In  
Engineering Education

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August 6, 2019  
Blacksburg, Virginia

Keywords: Doctoral Education, Advisor Selection, Faculty Satisfaction

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## ABSTRACT

Research on doctoral student attrition has shown that one of the main reasons for which students do not persist in the Ph.D. is because of a poor relationship with their doctoral advisor. The importance of the advising relationship is especially true in science, math, and engineering degrees because of the science model of advising as the student is the advisor's employee, close collaborator, and apprentice. While much attention has been given to understanding the dynamics of the advising relationship, little attention has been given to on how these relationships commence or the context in which they begin. This study ultimately contributes to understanding the context of the inception of advisor-advisee relationships and how it ultimately relates to both faculty and doctoral student satisfaction.

The following overarching research questions guide this dissertation: What are the processes for doctoral students to find advisors in engineering, science, and math? How is this process experienced by faculty and students? To address these questions, I conducted three studies. Through these studies, this dissertation: 1) Identified and described the types of advisor-advisee selection processes that exist in engineering, science, and math and examined trends and patterns across disciplines; 2) compared how two Chemical Engineering programs practice the advisor selection process and examined how faculty and graduate program directors negotiate agency in the process and 3) explored how students experience satisfaction of their basic needs in the advisor selection process of

one Chemical Engineering program and examined which student attributes influence this satisfaction of needs.

The results showed that there are multiple ways through which a student can find an advisor in science, math, and engineering doctoral program, but these vary widely by both discipline and field of study. The results also showed both students and faculty value the ability to select whom they will work with. However, both groups may also need support in making this decision regarding with whom they will work. Overall, the results of this dissertation highlight the importance of developing practices that balance an individual's need for support and autonomy to improve their satisfaction.

# Choice in the Advisor Selection Processes of Doctoral Engineering Programs

Mayra S. Artiles

## GENERAL AUDIENCE ABSTRACT

Studies have shown that roughly half of the doctoral students do not complete the doctorate degree. One of the main reasons for this departure is students having a poor relationship with the doctoral advisor. This relationship is particularly important for science, math, and engineering doctorates as in these fields of study the advisor and student work closely together. Much research has looked at how the relationship can be improved; however, little work has addressed how these relationships begin and the environment in which they start. This dissertation encompasses three studies that address the following research questions: What are the processes for doctoral students to find advisors in engineering, science, and math? How do faculty and students experience this process? Through these studies, this dissertation: 1) Described the ways through which doctoral programs help students find advisors in engineering, science, and math and how these ways varied by disciplines and fields of study; 2) compared how two Chemical Engineering programs help students find advisors; 3) explored how students experienced finding an advisor of one Chemical Engineering program. The results showed that there are multiple ways through which a student can find an advisor, but these vary widely by both discipline and field of study. The results also showed both students and faculty value the ability to choose whom they will work with. However, they may also need support in making this decision. Overall, the results of this dissertation highlight the importance of developing practices that balance an individual's need for support and free will to improve their satisfaction.

## Dedication

“Hijos del cañaveral  
Nunca se nos cae la pava  
Esta raza siempre es brava  
Aunque sople el temporal”

I am the granddaughter of two hand laborers and two orphaned women in rural Puerto Rico - none of which ever made it to college, or in the case of the women, past the eighth grade. With the odds stacked heavily against them, they gave up everything, so my parents could pursue higher education, specifically graduate education, and live a life far better than what they could dream.

It was their effort that broke the chains of poverty in my family forever. And it was because of these efforts that my sisters and I now live what was probably their wildest dreams: a J.D., a Ph.D., and Ed.D. on the way.

Gertrudis, Eulogio, Celinda, and Agustina believed in the transformative power of graduate education.

Esta disertación es para ustedes.

## Acknowledgements

One thing I keep learning in my research, over, and over, and over again, is that it truly takes a village to complete the doctorate. I'd want to thank mine.

First and foremost, I want to thank my advisor, Dr. Holly Matusovich. Studying the Ph.D. process while pursuing the degree itself was in many times confusing for both of us. Yet, I believe that it made our journey through this degree all the more special. You've exemplified what it means to be a truly exceptional advisor (I reiterate that I can say this empirically) and I know I will have immense shoes to fill when my time comes. Your generosity in supporting and resourcing all of my goals and ambitions is unparalleled. You were willing to listen to me, make space for my opinions, recognize my growing expertise, and be my advocate in sharing it with the world. And for that, I am forever grateful.

To my committee – Dr. Stephanie Adams, Dr. Catherine Amelink, Dr. David Knight, and Dr. Walter Lee. Thank you to each of you for accepting to join me on this journey. Thank you for pushing my boundaries and helping to mold me into the researcher I am today and for the countless opportunities outside of this dissertation that each of you provided so I could further establish myself in the field of graduate education and beyond.

To the Dissertation Institute team – Dr. Stephanie Adams, Dr. Holly Matusovich, and soon to be Drs. Coletta Bey and Juan Cruz Bohórquez. So much of this dissertation was inspired through our work executing the DI and seeing lives changed because of it. I look forward to continuing our work.

To my research group, SMILE, past and present – You've all had a hand in getting me to where I am today through editing, brainstorming, encouraging, recruiting, all of it. I'm so proud to belong to this academic family.

Brian Novoselich & Rachel Kajfez, my doctoral godparents. Brian, you helped choose an advisor, draw a solid plan for each phase of this degree, and set me up for finishing yesterday. I could not have gotten that head start without your advice. Rachel, you helped me finish it through - from helping me collect data, to understanding my results, and thinking about the next steps of this work.

To my writing buddies - Michelle Soledad and Kirsten Davis. I would have never finished this dissertation without your friendship, support, and accountability.

To the ENGE community – students, faculty, and staff. The more I research graduate education, the more grateful I am for our community. I'm so thankful to the faculty, particularly Homero Murzi and Jenni Case, who always took the time to listen and share with me in my ideas, offer advice, and mentor me in both teaching and research. I'm also grateful to the staff – Linda Hazelwood, Hope House, Margo Currie, and Mara Knott – who are always so willing, available, and helpful in assisting me in my never-ending

requests for help. But I'm especially grateful to the student community – you challenge and motivate me to become a better person.

To my Blacksburg family - Abdelaziz Alsharawy and Zichao Yang. We each come from the most remote corners of the planet yet somehow, we developed a home here in Blacksburg. Thank you for all of the times – from the deep conversations over hot pot, to becoming additional parents for Masha, and simply stepping in whenever or for whatever help is needed in our household. No words can thank you both enough.

To my sisters, Cristina and Mayrel – I'm so happy to have been born in a family of such strong women. I am proud of who we have become and how we continue to support each other in our never-ending journeys of pursuing higher education. Thank you both for holding the fort down at home for these past ten years, but especially for these past three.

To my parents. The sacrifices you've made and continue to make for me to be able to leave home and pursue this crazy dream of a Ph.D. are endless. You've been my role models of hard work throughout my whole life, but particularly these ten years overseas. Dad, you pushed me for years to give grad school a second chance and it worked. And Mom, you've been so supportive that it made taking the risk of quitting my job completely worth it. None of this would be possible without you and I am eternally grateful that we will be able to share our defense day together.

Finally, and most importantly, to my Alexis. Thank you for not flinching when we took on the challenge of both pursuing doctorates immediately after getting married. Also thank you for listening to all the unsolicited 'research-based best practices' on getting a Ph.D. that came after that. Thank you for making us and this dream of empowering people work every single day. Thank you for hugging me in every rejection and for celebrating in every one of my successes, even those that came at a cost. Your Ph.D. is next.

## **Attributions**

The three manuscripts presented in this dissertation are the products of original work where I, Mayra S. Artiles, had primary authorship. However, these works include the intellectual contributions of other researchers who will receive credit as authors in the final journal publications.

The study presented in manuscript one builds on a larger project led by Dr. David Knight and Dr. Maura Borrego of UT Austin. This manuscript was collaborative work with Dr. Knight and Dr. Holly Matusovich.

The studies presented in manuscripts two and three are a product of a larger project that focuses on understanding on the minority student experience in doctoral engineering programs. These studies were collaborative work with Dr. Holly Matusovich.

I have written this dissertation using the pronoun ‘we’ to include the collaborations of the above stated researchers and because “we” vs “I” language will be used for publication of the individual journal manuscripts. While they certainly influenced the final product, the design, the analysis, the interpretations, and the final written document was primarily conducted and authored by me.

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## **Glossary of Terms**

1. **Departments:** A collection of faculty members organized into a unit for resource management purposes.
2. **Program:** An organizational unit that houses students. Traditionally, it is in this unit where course planning and milestones are planned leading to a particular degree or certificate.
3. **College:** A collection of departments at a higher education institution. The management of this collective unit provides organizational leadership for the departments.
4. **Advisor:** The dissertation chair of a student's doctoral committee. This person oversees the student's development as a researcher and guidance towards degree completion. Can also be referred to as doctoral supervisor in literature outside of the US.
5. **Advisor Selection Process:** The process of students and advisors agreeing to begin a formal working relationship. Although seemingly from the student perspective this also refers to the faculty perspective in lieu of also using the term "student selection process"
6. **Advisor-Advisee Matching:** The process of matching doctoral advisors to doctoral students by the graduate program. It is a type of advisor selection processes.
7. **Graduate Program Director:** The university employee in charge of directing and managing the doctoral program. Traditionally, this person is a tenured faculty member.
8. **Graduate Program Coordinator:** The university employee in charge of the clerical work related to a doctoral program. Traditionally, this person is not a faculty member.
9. **Field:** A branch of knowledge. In this proposal, this term shall be used for science, engineering, and math individually; each of these would constitute a single field.

10. **Discipline:** A sub-branch of a field. A field is composed of multiple disciplines.  
For example, the field of engineering is composed of multiple disciplines such as Chemical Engineering, Electrical Engineering, among others.
11. **Agency:** the ability to act, be it on one's own or on someone else behalf.

# **Chapter 1. Advisor Selection Processes in Science, Engineering, and Math**

## **1.1 Introduction**

Doctoral student attrition is a persisting problem in higher education. In a ten-year study by the Council of Graduate Schools (2007), data showed that on average doctoral students departed from the pursuit of the Ph.D. at a rate of 50%. Much research has shown that one of the negative reasons for which students do not persist in the Ph.D. is a poor relationship with their doctoral advisor (Bair & Haworth, 2004; Barnes & Austin, 2009; Devos et al., 2016; Gardner, 2009b, 2010; Zhao, Golde, & McCormick, 2007). Most of the research on doctoral education has focused on the dynamics of the relationship between students and their doctoral advisor. However, little to no research has addressed how students and advisors enter these relationships.

Previous studies have described that students typically enter advising relationships in the first year of the doctoral process (Joy, Fen Liang, Bilimoria, & Perry, 2015; Nettles & Millett, 2006). While seemingly practical for degree progress, this timing is particularly concerning as it has been shown that students in these early stages of the doctoral pursuit often have misconceptions of the graduate education process (Holbrook et al., 2014; Lovitts, 2001). These misconceptions could work against the student by resulting in potentially poor judgments on critical decisions such as the selection of an advisor.

Within doctoral science, math, and engineering programs, a poor advisor-advisee relationship can often have more implications than in other disciplines because of the prevalence of the ‘science model of advising.’ The science model of advising consists of students working closely with their faculty advisor, often as colleagues, sharing research duties in large projects as well as authorship for group results (Zhao et al., 2007). Students and the advisors enter into these

working relationships under practices is often dictated by disciplinary and program traditions (Becher & Trowler, 1989; Joy et al., 2015). Thus, it is important to understand how programs facilitate these advisor selection processes and how the process impact a student's final selection. Therefore, the purpose of this exploratory study is to (1) identify & describe the types of advisor-advisee selection processes that exist in science, math, and engineering fields, (2) compare how two doctoral programs manage the advisor selection process, and (3) explore how students experience satisfaction of their basic needs in the advisor selection process of one Chemical Engineering program.

## **1.2 The Role of the Advising Relationship Towards Doctoral Degree Completion**

Much of the existing research on doctoral education has pointed to the relationship between the student and the advisor as a primary predictor in a student's successful completion of the doctorate (Austin, 2009; Austin & McDaniels, 2006; Baker, Pifer, & Griffin, 2014; Barnes & Austin, 2009; Devos et al., 2016; Gardner, 2010; Zhao et al., 2007). The doctoral advisor is the single-most important person with the responsibility of socializing the student through the different degree requirements of the doctoral program and into the broader community of the discipline as an independent scholar (Gardner & Mendoza, 2010). In a systematic literature review on doctoral attrition, Bair & Haworth (2004) stated that:

"the most frequently occurring finding in this meta-synthesis was that successful degree completion is related to the degree and quality of contact between a doctoral student and her or his advisors or other faculty in the student's doctoral program. Simply put, where positive relationships between students and their advisors or other faculty members were

present, students were significantly more likely to complete their doctoral degrees" (p.495).

This relationship has been described by Barnes & Austin (2009) as a complex one where the advisor not only develops the student in the practice of research within a discipline, but also socializes the student into a professional community with specific practices, traditions, and expectations.

The importance of the advising relationship is especially true in science, math, and engineering degrees because of the science model of advising (Zhao et al., 2007), and a number of studies have corroborated this practice. In a large study that compared the doctoral programs across fields of study, Nettles & Millett (2006) found that science and engineering programs ranked among the highest in student-faculty social interactions. Prior research has also argued that the pursuit of the Ph.D. in science, math, and engineering is different because the socialization of doctoral students is not just a product of the advising relationship but also the research group (Crede & Borrego, 2012) with unique mentoring structures (Jeong, Feldon, Maher, & Peugh, 2018). This concept of research groups is of particular importance because students do not merely select an advisor to work with, but a research group in which to be developed and socialized as a researcher.

### **1.3 Studying the Selection Process and Ph.D. Structure**

To date, the research on doctoral education has mostly focused on the dynamics of the student and faculty relationship after students have selected their advisor (Golde, 2005), but not the advisor selection process itself or the doctoral program in which this advising relationship takes place. More recent work has begun to question the importance of context (i.e., institution,

department, program, discipline, etc. policies and norms) but such work focuses mostly on the direct impact said context has on the student experience paying little attention to the context as the environment in which advisor relationships function (Ferrer de Valero, 2001; Golde, 2005; O'Meara et al., 2014; Sowell, Allum, & Okahana, 2015; E. Zhou & Okahana, 2016).

The advisor selection process is the way through which students find an advisor and formalize a working relationship with them, leading the student towards degree completion. Some doctoral programs assign students to an initial advisor until they find a permanent advisor, while others negotiate the selection of an advisor through the admissions process before initial enrollment (Goldman & Massy, 2001; Joy et al., 2015). This selection process, while influenced by the disciplinary traditions, is often managed by the department under the constraints imposed by both the department and the institution (e.g. resources availability and allocation) (Becher & Trowler, 1989; Ferrer de Valero, 2001; Goldman & Massy, 2001; Joy et al., 2015; Sowell et al., 2015; E. Zhou & Okahana, 2016).

The ideal outcome of an advisor selection process is one that allows students and advisors to build an advising relationship in which they will be satisfied and motivated. This outcome would allow for a student to have a successful relationship that would not impede progress to degree completion. However, it is often the case that this selection is less than ideal (Baker et al., 2014; Devos et al., 2016) and both students and advisors are 'mismatched.' Students and advisors are considered to be mismatched when they have a misalignment in expectations for each other in the advising relationship. Devos et al. (2016) found that when students are mismatched with their advisor they will either: learn to live with the mismatch, suffer through the mismatch without addressing it with the advisor, address the issues with the advisor and try to solve it, or not address the issue whatsoever and end the relationship with the advisor. Devos et al. (2016)

also found that students in particularly bad fits would be less likely to address the situation with the advisor and after numerous disagreements, they would depart from the doctoral pursuit.

Numerous research studies have argued that those students that remain in less than satisfactory conditions are more likely to lose satisfaction with the doctoral pursuit as a whole (Baker et al., 2014; Pyhältö, Vekkaila, & Keskinen, 2015; Zhao et al., 2007), more likely to develop mental health issues (Levecque, Anseel, De Beuckelaer, Van der Heyden, & Gisle, 2017), more likely to take a longer time to degree (Bair & Haworth, 2004), and risk not completing the doctorate (Lovitts, 2001). Therefore, by understanding the process through which students and faculty enter these relationships, one can avoid placing students in situations of advisor mismatch and provide them with the appropriate guidance and resources necessary to complete the doctoral journey.

While understanding the inception of the advising relationship is important, it is also imperative to understand the context in which these are taking place. This step is crucial to comprehend the advisor-advisee relationship as it is the departments in which the programs reside, the colleges that govern them, and the graduate school that oversee them, that ultimately define the policies, establish the norms, and influence how students develop and interact with faculty. Studying these contexts can help understand how to best leverage them to optimize the satisfaction and functioning of the people in it. This optimization is particularly true when it concerns a workplace (Gagné & Deci, 2005); which is what one could argue the academic department to represent for a science, math, or engineering graduate student (Gardner & Mendoza, 2010). In conclusion, understanding how the existing advisor selection processes and the structure that guide these processes will give us a full view of the formation of advisor-advisee relationships. This information is particularly important as the initial motivation for the

advisor and the advisee to work together could provide a necessary background to understand how the relationship develops in the long term. The longevity of this relationship, as understood from the milieu of its inception, could also provide alternative perspectives and insight as to why students choose to depart from or persist in the doctoral pursuit. Because advisor-advisee relationships do not function in a vacuum, it is equally essential to understand advisor relationship formation within the contexts in which they operate. At the same time, context, as defined so far, is quite broad and all-encompassing. Given the prior research on differences in student experiences across fields of study and disciplines, that would seem an appropriate place to start with regard to examining the context for advisor-advisee relationships. Thus, this study ultimately contributes to understanding the context (specifically defined as a field of study and discipline) of the inception of advisor-advisee relationships and how it ultimately relates to both faculty and doctoral student satisfaction.

#### **1.4 Studying Advisor Selection Process in the Science, Math and Engineering Doctoral Context**

This dissertation consists of three manuscripts. Each of the three manuscripts is part of a larger NSF-funded project. The first manuscript is a secondary analysis of data obtained through NSF grant # 1535226. This grant studies how the different types of funding mechanisms and the sequence of such impact doctoral student time to degree. The larger NSF-funded project uses a mixed-methods approach and investigates programs in multiple institutions across the United States (US). Part of the data collection for this project included interviews with doctoral program leaders and administrators in science, math, and engineering colleges regarding the allotment of resources for funding doctoral students. As part of the questions in these interviews, most of

these doctoral program leaders were asked how students find a doctoral advisor in their programs. The participants' responses to this question are the primary data source for the first manuscript in this dissertation.

Manuscripts two and three are part of NSF grant # 1723314, which focuses on understanding and improving the experiences of underrepresented minority (URM) students in doctoral engineering programs. The larger project consists of a boot camp-style intervention designed to support URM students in the pursuit of the Ph.D. by providing these students tools and mentoring to help them succeed. We<sup>1</sup> used the results from previous data collection efforts for this grant as a springboard to understand how doctoral programs can best support students, particularly those less privileged in higher education, through the execution of practices and procedures in the doctoral pursuit. While the intervention removes students from their context, the research has shown that the context still influences their experiences (Artiles, Hasbun, Matusovich, Adams, & Bey, 2017).

## **1.5 Dissertation Overview**

As stated, this dissertation is comprised of three manuscripts. Together, these manuscripts tell a narrative on how the different structure of advisor selection processes existent in science, math, and engineering limit and stratify students and faculty choice and satisfaction. Altogether, the studies address the following overarching research questions:

- **What are the processes for doctoral students to find advisors in engineering, science, and math?**
- **How is this process experienced by faculty and students in Chemical Engineering?**

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<sup>1</sup> For details on the authors here referred, please refer to the Attributions section in page viii.

The first study examined the types of advisor-advisee selection processes that exist in engineering, science, and math fields. The study identified the existing processes and described trends and patterns regarding how selection processes within these fields of study vary. Using a secondary analysis, the study analyzed interviews with science, math, and engineering graduate program directors in institutions across the US through a principal-agent theory lens (Eisenhardt, 1989; Shapiro, 2005) to understand the varying degrees of structure and departmental support in the process of choosing an advisor and how these relate to other parts of doctoral study (such as time to degree and funding mechanisms). Findings from this analysis showed that doctoral programs in engineering tend to provide a shorter time frame and had less required tasks and information systems available for students to select an advisor than programs in science and math. These findings are important because selecting an advisor is a decision made early in the Ph.D., typically in a stage of graduate student development where most students are ill-aware of their advising needs for degree progress (Austin & McDaniels, 2006; Lovitts, 2001; Weidman, Twale, & Stein, 2001).

A notable exception to the trends described above was the Departments of Chemical Engineering. The results from manuscript one suggest that most Chemical Engineering doctoral programs in our sample engage in matching students with advisors, a practice that is uniform across multiple departments and different from most engineering programs. This matching process is accompanied by required seminars and interviews that students needed to participate in before being matched. It was this contrast to the dominant practices in engineering that informed the designs of the second and third study of this dissertation.

Manuscript two focused on comparing two Chemical Engineering programs practice of the advisor selection process. The study compares how the process of advisor selection is

practiced in two institutions and examines how agency is negotiated between students, faculty, and the program director. This comparative case study used semi-structured interviews with program directors and faculty members to understand their experiences in doctoral student admissions, recruiting, and the advisor matching process. The analysis was also grounded in principal-agent theory (Eisenhardt, 1989; Shapiro, 2005). Findings from this analysis demonstrated that most of the time, programs deferred to the student's preference to conduct the match. Although the process may be run in a fairly similar manner at both of these institutions, how the faculty and program director negotiate agency varied significantly and was shown to impact faculty satisfaction. Faculty stated understanding that matching students to faculty is a difficult task, and they were willing to make sacrifices for the larger good of the department. However, they would quickly grow weary when these sacrifices did not yield a student match over multiple rounds of student matching. Similarly, we observed that junior faculty possessed a basic set of criteria on how to assess which students they preferred to work with and these criteria was enriched over time as they had multiple experiences in recruiting and working with students. These findings are important because they demonstrate how faculty satisfaction is related to their perceived agency (O'Meara, Lennartz, Kuvaeva, Jaeger, & Misra, 2019) and offers specific insight into how departments can foment faculty satisfaction.

After understanding the nuances of the process as described in the second study, the third study focused on the student experience in a single Chemical Engineering program selected from the second study. The purpose of this final study was to examine how the advisor selection process meets student's needs and whether their experiences in choosing an advisor differed based on students' characteristics and background. This manuscript used Basic Needs Theory from Self-Determination Theory (Deci & Ryan 1987) to understand how student's need for

autonomy, competence, and relatedness are satisfied in the advisor selection process. These findings were then compared across multiple student attributes and evaluated for whether specific attributes influenced their experience in selecting an advisor. The study used semi-structured interviews with individual students at multiple stages in the doctoral process. Findings from this study showed that student's need for autonomy was met through the process but the satisfaction of their need for competence and relatedness varied across two groups of students. Those students who had a prior research experience had a more precise understanding of what they needed in an advisor and maximized the process to obtain this information. Students who did not have such experiences, were more likely to feel overwhelmed by the process, thus having a stronger need for support or competence. Finally, students who had prior research experience valued the need for relatedness in an advising relationship and sought this information before choosing an advisor, while students who did not have this experience did not seek this information and expressed wishing they had known this when they made such choice. These findings are important because they demonstrate a stratification occurring across incoming doctoral students that influence students' decisions of who will be their advisor.

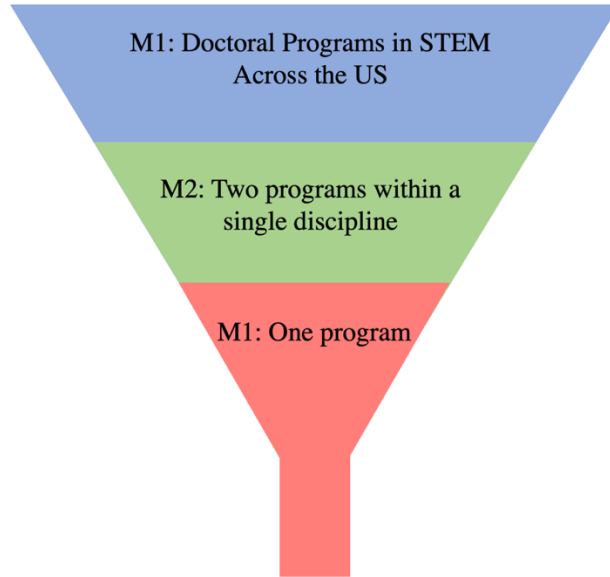


Figure 1. Reducing Scope of Manuscripts.

These three manuscripts, in the established order, have a reducing scope from multiple programs across disciplines in science, math, and engineering to a single program (see Figure 1). The reducing scope was designed to understand how the advisor selection is not only dependent on the field of study and discipline, but also on the individual program and student background. Table 1 summarizes the manuscript purposes, data sources, and questions.

Table 1. Summary of Manuscript Purpose and Research Questions

Manuscript	Purpose Statement	RQ	Data Sources	Key Findings
1	Identify and describe the types of advisor-advisee selection processes that exist in engineering, science, and math and examine trends and patterns across disciplines.	<p>What advisor selection process exists across doctoral programs in science, math, and engineering?</p> <p>How do these processes advisor selection processes vary by fields of study?</p>	<p>Graduate Student Handbook</p> <p>Interviews with Doctoral Program Leaders</p>	<p>Participants described <b>four main types of processes through which students can find advisors</b>: advisors and students self-select, advisor-advisee matching, temporary advisors prior to the permanent advisor, and funding dependent process.</p> <p><b>Engineering doctoral programs structure</b> the advisor selection process less than Science and Math programs because advisor selections are made earlier and fewer information systems and required tasks can be implemented.</p>
2	<p>Compare how two Chemical Engineering programs practice the advisor selection process.</p> <p>Examine how faculty and graduate program directors negotiate agency in the process.</p>	<p>How do two Chemical Engineering doctoral program compare in how they manage the advisor-advisee matching process?</p> <p>How do faculty negotiate agency with the doctoral program director in the advisor-advisee matching process in such programs?</p>	<p>Graduate Student Handbook</p> <p>Interviews with Doctoral Program Leaders</p> <p>Interviews with Faculty</p>	<p><b>Both programs practice a fairly similar matching process</b> - the processes are connected to admissions and both face the same challenges in managing student's evolving research interest and the faculty's research needs.</p> <p>How agency is negotiated between the program director and the other faculty was different and ultimately impacted faculty satisfaction. <b>Faculty value having agency over the matches.</b></p>
3	<p>Explore how students experience satisfaction of their basic needs in the advisor selection process of one Chemical Engineering program.</p> <p>Examine which student attributes influence this satisfaction of needs.</p>	<p>How are student's basic needs satisfied in the process of selecting a doctoral advisor in a Chemical Engineering program?</p> <p>What student attributes impact the satisfaction of basic needs in selecting a doctoral advisor?</p>	<p>Graduate Student Handbook</p> <p>Interviews with Doctoral Students</p>	<p>Overall, <b>students with prior research experiences had a high satisfaction of competence</b> because this prior experience resulted in them possessing a better understanding of what they were looking for in an advisor. This difference results in <b>students with prior research experience having a higher likelihood of having all of their basic needs met when choosing an advisor.</b></p>

## **1.6 Significance of the Research**

This research contributes to doctoral education in three significant ways. First, this work describes the multiple processes through which students enter the advisor relationship in engineering, science, and math as managed by the doctoral programs. The findings and discussion provide specific consideration for departments and benchmark their processes in comparison with the general population of doctoral programs. The study also demonstrates the underlying beliefs held by the processes practiced in the fields of science, math, and engineering regarding student support. This study also shows that considerable differentiation does exist within science, math, and engineering, and future research should consider the implications of grouping these fields in their research.

The second study demonstrates existing variations of a single practice across two doctoral programs and its impact on faculty satisfaction. It showed that when faculty are limited in their agency to recruit doctoral students the culture in the department will shift, and they will recruit students outside the established processes. However, their satisfaction and compliance with the established process will remain if they perceive to have agency over their choices. The study also demonstrates that learning to recruit doctoral students is a process that faculty learn over time and our findings reiterated the importance of departments taking a more active role in helping faculty learn to advise and recruit doctoral students.

Finally, this study expands on the existing literature on the doctoral student experience by exploring how processes can impact student self-determination. It shows a specific description on how multiple students chose their advisor, and how having prior research experience helped some students make a more informed advisor selection than others who did not participate in research before the Ph.D. By considering the individual student needs when designing

doctoral programs, we can develop programs that can cater to each person, regardless of their prior experiences, and improve doctoral student retention. The findings across all manuscripts can inform the future design of processes and policies in higher education as well as retention and recruitment graduate students.

## Chapter 2. Manuscript One

*Doctoral Advisor Selection Processes in Science, Math, and Engineering Programs in the US.*  
*Target Journal: International Journal for Researcher Development*

*This manuscript includes intellectual contributions from Dr. David Knight and Dr. Holly Matusovich, who will be credited accordingly as co-authors in this work.*

### 2.1 Introduction

Research has shown that the relationship between a doctoral student and their advisor is the foundation of the student's success in completing a Ph.D. (Bair & Haworth, 2004; Barnes & Austin, 2009; Gardner, 2010; Zhao et al., 2007). The importance of this relationship is particularly true for science, math, and engineering fields as the advisor and the student often work in close collaboration (Zhao et al., 2007). While much research has shown the importance of the relationship and its role in doctoral student persistence (Bair & Haworth, 2004; Barnes & Austin, 2009; Barnes, Williams, & Archer, 2010; Burt, McKen, Burkhart, Hormell, & Knight, 2016; Devos et al., 2016; Hilmer & Hilmer, 2007; Noy & Ray, 2012; Schlosser & Gelso, 2001), few studies have focused on how these relationships form and specifically, how the doctoral program facilitates such formation. This practice is particularly troubling considering that not all disciplines hold the same traditions and practices and these have been shown to influence the doctoral pursuit (Ferrer de Valero, 2001; Gardner, 2009a; Golde, 2005).

Multiple theoretical frameworks suggest that people and their actions are a product of their environments (Edwards, Caplan, & Van Harrison, 1998; Kristof, 1996; Weiner, 1985). This argument has been shown to hold in doctoral education and studies have shown how departmental and disciplinary differences influence the experiences of its students and faculty (Ferrer de Valero, 2001; Gardner, 2010; Golde, 2005; Hopwood & McAlpine, 2007; Torka,

2018). Doctoral advising relationships are influenced by the environment in which they take place (Gardner, 2010; Zhao et al., 2007). Their formation, in particular, is a process facilitated by the department in which it takes place (Golde, 2005; Nettles & Millett, 2006), often through a process established in the graduate student handbook established by the department. Thus, we contend that to understand how to best help students manage the advising relationship, we need to examine how they find an advisor in the first place.

The purpose of this descriptive qualitative study (Creswell, 2013) is to identify and describe the types of advisor-advisee selection processes that exist in engineering, science, and math and examine trends and patterns across disciplines. Using principal-agent theory as a theoretical lens (Eisenhardt, 1989; Shapiro, 2005), this study aims to address the following research questions:

***RQ: What advisor selection processes exist across doctoral programs in a sample of science, math, and engineering?***

***RQ2: How do these advisor selection processes vary by fields of study?***

Our study sheds light on how doctoral programs help students find advisors across a sample of disciplines in science, math, and engineering. We define disciplines as the subdivisions of fields of study (e.g. engineering is a field of study, and mechanical engineering is one of its disciplines). The primary data for this study are interviews with doctoral program directors that are currently in leadership positions and the doctoral program handbooks disseminated to doctoral students. Understanding how advisor selection processes happen is essential as it will offer insight on the early doctoral student's experiences. These results will

also show the context where doctoral advising relationships are formed and develop; which could help understand students' long-term satisfaction with the advising relationship. This study also offers insight into the disciplinary norms of doctoral programs.

## **2.2 Advisor Selection Processes: Review of the Literature**

Although research is rich with information about doctoral advising relationships, little is known about how these relationships are formed or how doctoral programs guide these processes. Some studies have given insight into students and faculty experience in pairing students with advisors. For example, Joy et al. (2015) used a qualitative exploratory approach to examine the factors that influenced the process through which students selected advisors in science, math, and engineering programs at a large research institution in the US Midwest. The authors interviewed roughly 50 students and faculty from multiple science, math, and engineering programs to discuss the factors considered in the process of selection. Among their main findings, the authors asserted that students mostly focused on funding availability and the area of research when selecting an advisor. As a secondary factor, students also considered the personality of the advisor and their ability to help students graduate in a timely manner. From the faculty perspective, the same study showed that faculty members focused on student credentials such as GPA or standardized test scores as well as their ability to contribute to research; i.e., the alignment of the student's research interest to the faculty member's desired future research directions. The study briefly discussed some program factors that influenced advisor selection such as the timing of the selection relative to enrollment, the sources of information available to both students and faculty about each other, limits on advising load for faculty, and pressure to graduate students to obtain tenure. While this study provides key

information on doctoral advising selection processes, it has several weaknesses, most notably its conflation of multiple science, math, and engineering degrees under the assumption that their processes were the same and its lack of analysis regarding the program's influence in the selection process. This gap is what we intend to understand further through this study.

While to our knowledge, no study has analyzed the selection process directly and comparatively across science, math, and engineering fields, findings regarding the selection of an advisor have been reported in the literature. In particular, several studies have uncovered critical knowledge regarding what students look for in an advisor. For example, Zhao et al. (2007) used a quantitative data set to understand differences in advising styles across multiple disciplines. The authors found that students in the sciences tended to select an advisor based on pragmatic benefit over intellectual compatibility or an advisor's reputation. Also, Golde & Dore (2001) found through a national survey of doctorate holders in the arts and sciences that overall students mostly select an advisor based on the intellectual match or research interests. However, they also found that the larger the number of factors students considered when selecting an advisor, the better their satisfaction with their advising relationship in the long term. Regarding the selection itself, a study done in the field of counseling psychology education, Schlosser et al. (2003) found that students value the ability to choose and tend to select advisors with whom they believe they can work comfortably and successfully; these students reported being happier than those who were assigned to their advisor. Specifically in engineering, Crede & Borrego (2012) have argued for doctoral engineering programs being distinctive from other disciplines because of the student organization into research groups allowing one to argue that the advisor selection process not only influences their selection of advising faculty but the selection of their closest work colleagues. While this study only focused on doctoral engineering students, this practice of

research groups has also been studied in other science disciplines (Jeong, Feldon, Maher, & Peugh, 2018).

What we can conclude from these studies is that while students value the opportunity to select an advisor, the specific factors they consider and the weight they place on such is not consistent and is likely to be influenced by the field of study or disciplinary traditions. It is important to note that most of these studies did not focus on the advisor selection process directly, but discussed the selection process as part of a larger research question. By not focusing on the process itself, much of the nuance of how each process is practiced in each program can be lost. These nuances can provide critical information for understanding the process through which students find advisors in doctoral programs. This study aims to fill this gap by describing the existing processes in a sample of disciplines of science, math, and engineering fields and examining for trends across such fields of study.

### **2.3 Disciplinary Trends and Differences**

Academic disciplines have been long studied as sources of differentiation in the university experience. Pursuing a degree in one discipline can be a very different experience than pursuing a degree in another (Becher & Trowler, 1989; Biglan, 1973; Muller, 2009). Disciplines work as ‘tribes’ preserving longstanding traditions and by consequence maintaining a status quo in academia (Becher & Trowler, 1989). By traditions, we do not mean practices that are outdated or ungrounded in research, but simply practices that have prevailed over time. An example is the organization of graduate students into research groups or laboratories within a doctoral program (Crede & Borrego, 2012; Jeong et al., 2018).

This preservation of disciplinary traditions can be most easily observed in doctoral programs where the doctoral experience is more likely to resemble others in the same discipline across institutions than other doctoral programs within the same institution (Goldman & Massy, 2001). The traditions held by disciplines range from the broad, such as the ontological perspectives accepted within the community, to the everyday processes such as the initiation rituals undergone by novices to the discipline (Muller, 2009). An example of a tradition common to many doctoral programs is the comprehensive examination which students must pass before continuing to pursue the doctoral degree (Lovitts, 2001; Weidman et al., 2001).

It is because of disciplinary similarities that we often see science, math, and engineering fields of study grouped in universities (Lattuca & Stark, 2009). Disciplines in science, math, and engineering possess the commonality of agreeing with regard to what is believed to be real and how knowledge is produced and disseminated (Muller, 2009). Their common lenience towards a postpositivist paradigm (Lincoln & Guba, 1985) allows traditions to be strictly preserved within its disciplines and for uniformity of beliefs and practices to be commonplace across institutions. As a consequence, academic organizations regularly group science, math, and engineering fields together, which further influences how they behave, how power is distributed among them, and what practices dominate within them (Hammond, 2004).

Despite the consistent grouping of science, math, and engineering in academic organizations, we do find that individual disciplines within these fields of study possess differences between them, particularly in graduate studies. The advisor selection process is often influenced by disciplinary traditions (Goldman & Massy, 2001). Some programs assign students to an initial advisor until they find a permanent advisor, while others negotiate the selection of an advisor through the admissions process before initial enrollment (Goldman & Massy, 2001; Joy

et al., 2015). This advisor selection process, while influenced by the disciplinary traditions, is often managed by the doctoral program under the constraints imposed by both the department and the institution (Goldman & Massy, 2001; Joy et al., 2015; Sowell, Allum, & Okahana, 2015; Zhou & Okahana, 2016).

Few studies focusing on disciplinary differences have examined beyond the individual student experience towards the role of programs in doctoral education, particularly in assisting students in finding an advisor. This study aims to fill this gap by describing the existing processes and their variations by academic disciplines, specifically in a sample of disciplines in science, engineering, and math.

## **2.4 Theoretical Framework**

The study is grounded in principal-agent theory (Shapiro, 2005). Principal-Agent Theory (PAT), stemming from the field of economics, posits that there is a principal who desires a task to be done, an agent to whom the principal outsources the task, and a contract which stipulates conditions for the completion of the task (Shapiro, 2005). The agent and the principal are bound to each other by a contract which leads to an outcome (see Figure 2). PAT furthers that this contract can be classified as one of the two following kinds: one that is outcomes based and one that is behavior-based (Eisenhardt, 1989). For contracts that are behavior-based, the principal specifies behavior for the agent to perform as they complete the task. For contracts that are outcome-based, the principal requests a specific outcome from the agent without regulating their behavior. In its most simple form, PAT dictates that both the principal and the agent have conflicting goals and posits several propositions on how the relationship between the agent, the

principal, and the task will dictate the type of contract that will exist between them (Eisenhardt, 1989).

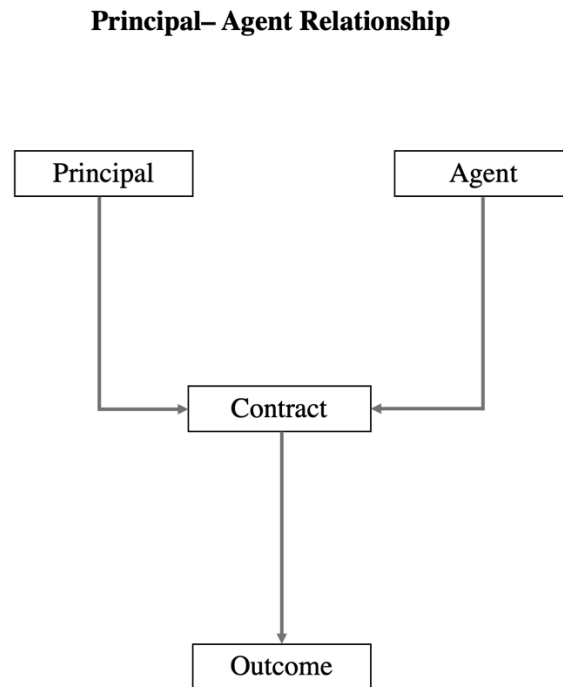


Figure 2. Diagram of Principal-Agent Relationship

PAT has been predominantly used in higher education research used to study the relationship between the government and higher education administration (Lane, 2012). However, some newer studies have focused on the institution's interactions with students. For example, Lozano & Hughes (2017) used PAT to study how student representatives in governing boards act on behalf of the student body's interests. The authors explored whether the representatives engaged in behavior traditional of representatives (advocates strictly focused on students' issues) or if they followed their individual best interest when voting on said issues. The authors found that students that were elected rather than appointed reported having more

pressure from the student peers when it came to voting on issues. While PAT was only loosely engaged in the study, it served as a lens to understand people acting on other's behalf. Another example is work by Dill & Soo (2004) who argued this theory helps represent the inefficiencies in how students select institutions and courses. Because PAT demonstrated the students' inability to thoroughly evaluate all of the courses and institutions places them in an information asymmetry that keeps them making the most rational decision when selecting an institution. As a consequence, these students select an institution based on the information they are available to find and analyze. The authors conclude that the concept of perfect competition, as assumed in a free market, does not transfer to the case of students selecting a university because the student will never be informed enough to make decisions that will maximize their benefit. Closer to graduate education, Flora (2007) synthesized the legal arguments on whether graduate students are employees of the university or not through the lens of PAT. The author argues that indeed graduate students act on behalf of the university, particularly when executing teaching assistantships as they have authority to teach and grade often to their own volition yet on behalf of the institution. Therefore, through the lens of PAT graduate students indeed act as faculty and the author argues that they should be honored by the university to receive benefits commensurate with such responsibility.

Within PAT, Eisenhardt (1989) states ten propositions that describe the contract between an agent and the principal in terms of how information is shared between parties, what tasks must be completed per the contract, who holds the most risk, and how the contract develops over time. How these elements are managed will determine if a contract is behavior-based or outcome-based. For example, proposition one states that *“when the contract between the principal and the agent is outcome-based, the agent is more likely to behave in the interests of*

*the principal*” (Eisenhardt, 1989, p. 60). What this proposition implies is that regardless of how the agent pursues the outcome, the agent will be evaluated by how close this outcome achieves the goals of the principal. Therefore, in contracts where the outcome is specified instead of the agent’s behavior, the agent will make sure to achieve such outcome and meet their end of the contract.

The present analysis uses these PAT propositions as a lens to analyze the different processes through which advisor selection happens. To achieve this, we examined the practices and handbooks used to find an advisor to analyze how information is shared between parties, what tasks must be completed before selection, who holds risk, and over how much time the contract takes place. Analyzing this information about the advisor selection process through the lens of the propositions posed by Eisenhardt (1989), provides fundamental understanding over existing advisor selection practices.

In this study, the PAT propositions can be abbreviated into the following four parts of the process, or elements: who is making the selection of the advisor, the timelines for the selection, the information provided for the selection, and the influence of funding in the selection process. The timeline for selection speaks to the length of the contract, as stated in PAT. The information systems speak to the dissemination of information that helps students and advisors get to know each other and decide on who they want to work with. The required tasks speak to the activities students are required to undertake before committing to an advisor. Risk aversion can be operationalized to all four of the components: for example, choosing too early has the risk of not enough information being shared while choosing too late has the risk of lengthening time to degree. Similarly, sharing no information can be simple to the program as it would require little work but carries the risk of a higher chance of poor advisor-advisee matches which could lead to

higher attrition. Because risks are incurred by all parties in all possible combinations of the process, it impossible to state at any given time who carries the most risk. In this study, we simplified the concept of risk to who is making the decision. If the graduate program director is making the decision, then both the faculty and the student run a risk. If the students and faculty make the decision on their own, the risk is on the program that everyone will be able to place themselves in a research group.

Recalling our prior example of proposition one, “*when the contract between the principal and the agent is outcome-based, the agent is more likely to behave in the interests of the principal*” (Eisenhardt, 1989, p. 60). In the context of advisor selection, it could be exemplified as a contract that says ‘Students will select an advisor by the end of the first semester’. In this contract, the program acts as a principal stating their objective of having all students formalizing a relationship with an advisor by the end of the semester. The student will then have to ensure such task is completed by then. It is the student’s prerogative how they select an advisor, as long as they do so by the prescribed date. Therefore, such a contract is outcome-based as it does not tell the student how to approach the task but only by when it needs to be completed. Table 2 summarizes the operationalization of the PAT framework to the advisor selection process. The operationalization of the ten propositions as established by Eisenhardt (1989) is included in Appendix A.

Table 2. Aligning PAT Propositions to Advisor Selection Processes

<b>PAT Element</b>	<b>Aligned Process Component</b>	<b>Examples</b>
Information System	Activities to share information	Research seminars with faculty
Contract Length	Timing of the Selection	Select advisor by year one.
Required Tasks	Activities required before selection	Required number of interviews prior to selection.
Risk Aversion	Who makes the decision	Graduate program coordinator makes the selection.

It is important to note that the goal of this study was not to classify for each program who is the principal or the agent, but to understand how the previously described elements of PAT in advisor selection processes manifest across doctoral programs. These processes vary from program to program and each process may have a different conceptualization of which person is a principal or each agent. However, identifying these actors is difficult to do without first understanding how the contract between them is practiced and is ultimately beyond the goal of this study.

While research using PAT in higher education exists, there is still much room to grow, particularly in studying interactions between academic programs with faculty and students. As Lane (2012) stated, “the assumptions associated with self-interest, information asymmetry, and incentives provide an opportunity to deconstruct and identify alternative explanations for actor and subsystem behavior” (p. 297). Further, theories stemming from economic traditions can provide insight into what human behavior one can expect from certain scenarios (Thaler & Sunstein, 2008). Therefore, this study moves forward from the traditional uses of PAT by using it as an interpretive means for the interactions occurring between students, and faculty in a doctoral program.

## 2.5 Methods

The goal of this national study is to describe the types of advisor selection processes that exist in science, math, and engineering doctoral programs and how these processes vary across disciplines. This study is grounded in supplementary secondary analysis methods (Heaton, 2004), which is when an emergent aspect of the data previously collected was not fully addressed in the primary study is investigated in depth (Heaton, 2004). The study consists of two main data sources: previously collected semi-structured interviews with graduate program directors at multiple Ph.D. programs and the student handbook that describe the rules of each Ph.D. program interviewed. By using both data sources, we were able to obtain a holistic view of the process as practiced in each program.

**2.5.1 Data Origin.** This study was conducted in accordance with approved human research subjects research protocols. The interviews used in this study originated from a different study where the main objective was not to understand the advisor selection process but the allocation and distribution of graduate student funding in science, math, and engineering doctoral programs. The original study intended to gain insight towards the impact of specific funding mechanisms in the doctoral experience as well as trends across disciplines and science, math, and engineering fields of study. While the original objective of these interviews differs from the current study, these interviews ask the question “How do students find advisors in your program?” as well as they follow up on the advisor selection process as practiced in the sampled doctoral programs. These responses were used to capture features of the process that may not be available in the graduate student handbook.

**2.5.2 Data Collection.** The main unit of analysis for this study was the doctoral program. Each doctoral program has been examined using two sources of evidence: interviews with the faculty program directors and the student handbook for each program. The primary data source for this analysis are interviews with the specific faculty program directors. As described previously, these interviews originated from a study whose main objective was not to understand the advisor selection process but included questions on the advisor selection process as practiced in the sampled doctoral programs. The interviews were held between the Fall of 2017 and Spring of 2018 and sum to a total of 58 doctoral programs in the fields of science, math, and engineering in high research institutions, as defined by the Carnegie classification system (Shulman, 2001), across all of the US. Figure 3 summarizes the programs by counts per discipline. It is important to note that the disciplines included in this dataset are not a complete sampling of all existent disciplines in science, math, and engineering, but a purposive sample of those disciplines with the largest enrollment in such fields.

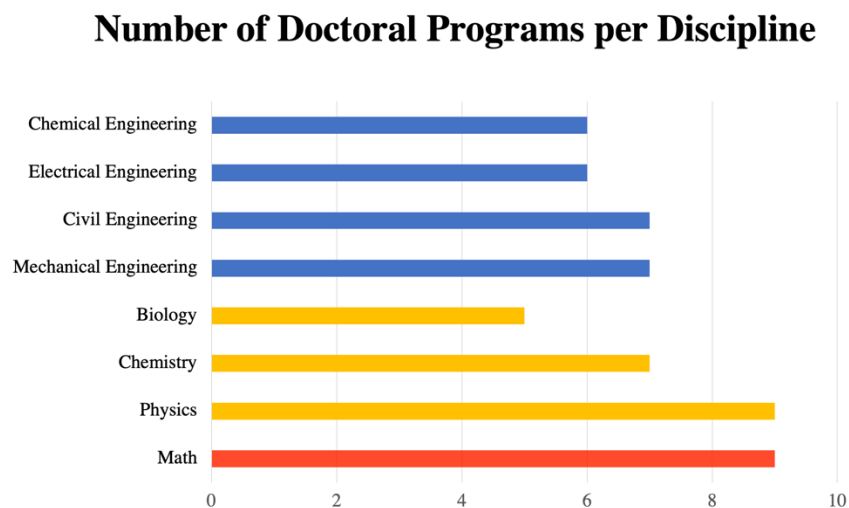


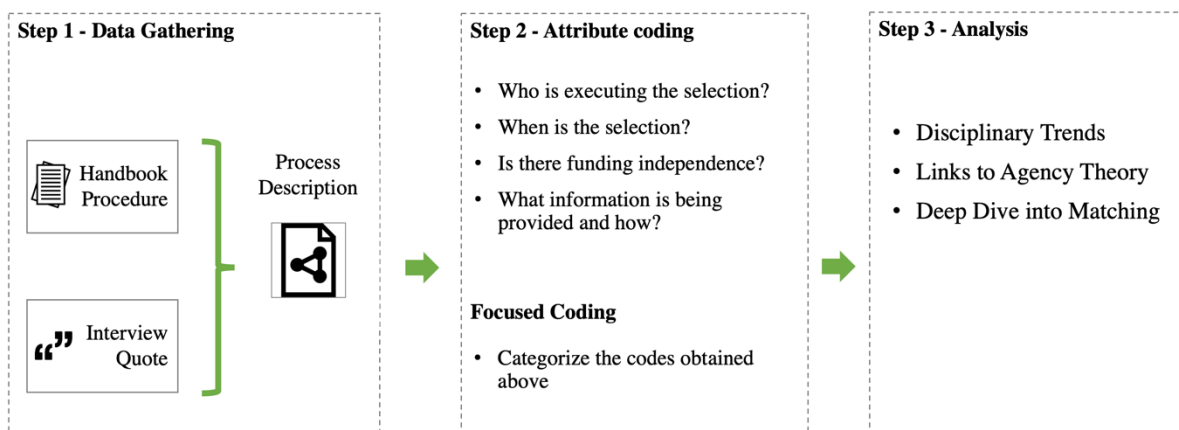
Figure 3. Number of Doctoral Programs per Discipline

To complement the original interviews, we corroborated these responses through an document analysis of the advisor selection process as written in the graduate student handbook or equivalent (Leech & Onwuegbuzie, 2007). These documents have been obtained via a search of the programs' websites or through an email request to the program coordinators. The combination of these two data sources helped identify what is the formal advisor selection process practiced in the program, exceptions or variations to process, and information regarding the process that would not typically be documented in a graduate student handbook. This combination also provided a holistic description of the advisor selection process in place in each of the programs as well as information that could help clarify the practice of such and other details relevant that may not be captured in a single source of data. It is important to note that the original handbooks were not cited but were paraphrased as a direction citation would make the programs identifiable.

## **2.6 Data Analysis**

This analysis uses PAT as a lens to understand the process that guides the formation of advisor-advisee relationships. Studying how these processes compare across disciplines provides insight into the organizational behaviors of doctoral programs. Our process consisted of three steps: data preparation, coding, and analysis (see Figure 4).

## Analysis Steps



(Saldaña, 2009)

Figure 4. Data Analysis Steps for Manuscript 1

In this first step, we developed a full characterization of the processes found in each program. Using a pragmatist worldview (Lincoln & Guba, 1985), the first step of the data analysis was to gather the two data sources described above and compare the written procedure as found in the student handbooks with the interview description of the process (See Figure 5).

### Analysis Step 1 – Triangulation of Interviews & Manuals

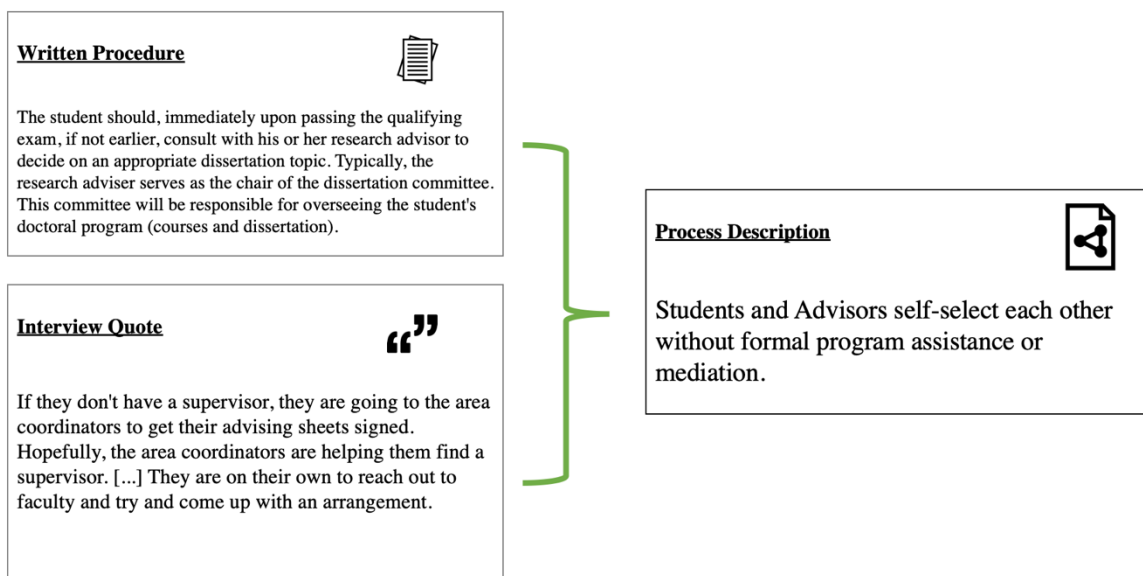


Figure 5. Triangulation of Interviews and Graduate Student Handbook

In the second step, these process descriptions were classified into groups of similar processes. These groups were coded using attribute coding (Miles, Huberman, & Saldaña, 2014) along four dimensions: who is making the selection of the advisor, the timelines for the selection, the information provided for the selection, and the influence of funding in the selection process. As described previously, these dimensions represent elements from PAT. The attribute codes were not prescribed but instead emerged from the data (see Table 3).

Table 3. Codebook for Attribute Coding in Manuscript One Data

PAT Element	Code Category	Sample Codes
N/A	Process Interpretation Overview (obtained from step one)	<ul style="list-style-type: none"> <li>• Student enters sponsored by a specific faculty but can switch later.</li> <li>• Student and Faculty self-select</li> <li>• Formal matching</li> <li>• Temporary advisor, student can switch later</li> <li>• Process depends on funding mechanism.</li> <li>• Faculty member offers research position and student cannot switch.</li> </ul>
Risk	Who makes the choice?	<ul style="list-style-type: none"> <li>• Student and Advisor</li> <li>• Program Director</li> <li>• Faculty during admission; student only accepts funding</li> </ul>
Length of the Contract	When is the Selection Made?	<ul style="list-style-type: none"> <li>• During admissions/enrollment</li> <li>• By 1<sup>st</sup> semester</li> <li>• By 2<sup>nd</sup> semester</li> <li>• Before third year</li> <li>• Depends on initial funding mechanism</li> <li>• No timeline specified</li> </ul>
Information Systems	How is information shared prior to the selection?	<ul style="list-style-type: none"> <li>• Research Seminars</li> <li>• Interviews</li> <li>• Independent Study</li> <li>• Rotations</li> </ul>
Required Tasks	Were any tasks required before selection?	<ul style="list-style-type: none"> <li>• Yes</li> <li>• No</li> </ul>
N/A	Is funding available before selection?	<ul style="list-style-type: none"> <li>• Yes, attached to advisor.</li> <li>• Yes, not attached to advisor.</li> <li>• Depends on funding mechanism offered.</li> </ul>

After attribute coding, we conducted focused coding (Miles et al., 2014) on the data, which helped collapse the data into discrete categories of like attributes. Finally, the results of such coding were analyzed for disciplinary trends and its adherence to the propositions in PAT. Table 3 includes a sample of the initial codebook used for the analysis described above and Table 4 shows a sample of moving from attribute codes to focused codes.

Table 4. Attribute to Focused Coding

Attribute Code	Focused Code
Student enters sponsored by a specific faculty but can switch later.	<i>Temporary Advisor</i>
Student and Faculty self-select	<i>Self-Selection</i>
Formal matching	<i>Matching</i>
Temporary advisor, student can switch later	<i>Temporary Advisor</i>
If faculty member offers research position and student cannot switch. Students on teaching assistantships have a year before selection.	<i>Funding dependent</i>

**2.6.1 Research Quality.** To assure the quality of the analysis, the results presented here were analyzed as described above and were then triangulated between both data sources to ensure that the process was not misinterpreted from any one source (Tracy, 2010). The approach and results were audited by researchers both within the original project from which the interviews were sourced and outside of the project to ensure multiple vantage points were being considered when interpreting the findings (Heaton, 2004).

**2.6.2 Limitations.** The main limitation is that this study was achieved with a sampling of doctoral programs in science, math, and engineering. Although the sample is geographically representative of the major doctoral degree-granting institutions in the US and the largest disciplines in science, math, and engineering, not all of the disciplines within these fields were included in the original interviews. Therefore, any conclusion obtained from the secondary analysis of this data is limited to the sampling scope of the original study. The data here presented only provides the viewpoint of the department director and what they believe the department to be doing to help students find advisors as well as the handbooks they develop and share with students and faculty. This view may not reflect faculty and student experience and perspectives on the process. Similarly, the process described is what is commonly practiced. While in no occasion did the interviews explicitly contradict the manuals, the interviews did provide occasional examples of exceptions to the process. For these instances, the programs were classified by the process experienced by the majority of the students in the programs as described in the interviews. Further research should look at these perspectives and exceptions to the common practice to further understand what occurs in departments.

The second limitation pertains to the PAT itself. While PAT can provide great insight into the conditions that programs put in place for selecting advisors, it also has some limitations. PAT ignores the complexities of real-life scenarios such as transient preferences and variable knowledge asymmetries between what would be in this case, students, faculty, and the department (Shapiro, 2005). Further research into students and faculty could take a deeper look into how these dynamics impact the process of advisor selection.

## 2.7 Results

The purpose of this study was to describe the existing processes found in the data and the patterns and trends we observed across the disciplines and fields of study. All of the processes found consisted of a variety of combinations of the following four elements: the classifications of the processes that exist, the influence on funding on the process, the selection timing for each process, and the information made explicitly available to students in the process. These four elements emerged from the data and represent the main components of each process. These elements align with the previously discussed propositions of the PAT framework.

The processes found can all be classified under one of the categories described as types of processes. These types of processes can then be combined with the other elements listed, such as timing of the selection or information systems, to form the complete process as described in the manuals and interviews. In the following sections, we discuss the patterns within each element across disciplines and fields of study.

**2.7.1 Types of Processes.** Through the analysis, we identified four main types of advisor selection processes categorized by who makes the decision. Each program in our data can be classified distinctly into one type of process. These types of processes represent how the choice is made and vary on how is the choice structured. The most common processes were students and advisors self-selecting without program intervention, programs assigning a temporary advisor, process dependent on funding, and the program matches students and advisors.

In this first type of processes, the **student and the advisor are free to select** whoever they want to work with as long as the other party also agrees. In this process, students and advisors have complete control over the advisor selection process. The program does not intervene in such process outside of establishing a deadline for which this selection must be

completed. The following quote is the handbook description of how the process is described to students in a civil engineering Ph.D. program:

*“As the fall quarter begins, you should begin the process of identifying a faculty member who will serve as your Ph.D. advisor for the duration of your studies. CEE does not have a formal matching process by which students are assigned to advisors. We allow the process to happen organically, and in order for this to work properly, students must reach out to faculty to identify mutual interest. The program area coordinator can help you to get this process started – speak to this person if you are unsure of how to proceed. Your goal should be to identify a thesis advisor no later than the end of your third quarter of study.”*

[Civil Engineering, Graduate Student Handbook]

This process was found to be the most common across all programs. This process was practiced in most of the sciences, math, and electrical engineering programs.

In the second type of processes, students and advisors have complete control over their selection. However, the **programs assign incoming students with a temporary advisor** to help guide them until they select an advisor. The following quote is from a program director explaining the practice used in their program:

*“We poll them in the summer for their preferences and give them a temporary home in a lab based on space available, and they tend to be in the labs that they're going to probably want to join anyway. That's usually what happens is they'll join the lab of their temporary, but in the meantime, we really push them to go to seminars and group meetings, talk to grad students, interview faculties as much as they can and then commit by around Thanksgiving.”*

[Chemistry, Program Director Interview]

While students and advisors continue to have an option to not stay with the temporary assignment, in multiple cases students that chose a different advisor than the one initially assigned were not always guaranteed with funding along with the switch. Thus, changing advisors would also entail initiating a search for funding, limiting a student's mobility within the program. This process was mostly found in Civil engineering, Mechanical engineering, as well as some outlying sciences and math programs.

In the third type of processes, was the process were **selection depended on the funding mechanism** students were offered. In this process, students enter the doctoral program accepting a specific funding mechanism. Students entering under a research assistantship commit to the faculty member for whom they research as their primary advisor as a condition of funding. It was often described that faculty would select from the pool of program applicants who they would be willing to advise and fund, and an admissions letter would be sent to the student along with a specific funding offer to work for such faculty member. Thus, the student's funding in the program is contingent on them working for that particular faculty member. Other students that were also qualified but did not receive a research assistantship offer would often be offered a teaching assistant position with their acceptance letter. These students were allowed more time before they selected an advisor. Therefore, the process through which one selects an advisor is dependent on the funding mechanism. This process was only found in engineering programs, specifically Electrical and Mechanical Engineering. An example of this process comes from a program handbook:

*“If a new graduate student has accepted a GRA offer, the advisor is the faculty member who offered the GRA. A new graduate student that is self-funded is usually assigned an advisor for the first semester. If both the student and the advisor are satisfied with this relationship, the relationship can be formalized. However, a different faculty member may be a more appropriate advisor. In such case, after discussing the change with the present and potential advisors, the student should use the [redacted] form, have the advisors sign it, and submit the form to the Graduate Program Coordinator, who will file the change.”*

[Electrical Engineering Program, Ph.D. Student Handbook]

The fourth type is where **faculty and students are matched by a third party** (or a ‘broker’), usually the graduate program chair. In this process, programs provide initial funding for their students (either a teaching assistantship or fellowship funding) for either the first year or the first semester. During this time, students are expected to meet faculty and determine their

preferences for an advisor. Similarly, faculty are encouraged to meet students and decide who they would prefer to advise. On a predetermined date, students submit their top choices for an advisor to the program coordinator. The program coordinator then collects faculty's preference and, using these two sets of information, they assign students and faculty through a process known as 'matching.' A program director describes this process as follows:

*“Within the first couple of weeks of autumn semester. So, all of the students will go to these presentations, listen to the research presentations, and then they'll have a few weeks to go and meet with faculty members to have a more in depth discussions, attend group meeting, do more lab tours, talk with their graduate students. Then we collect a form from all of the students who may list their top three or four choices. Those get turned in to the graduate studies committee. Usually the chair takes on most of the responsibility. Some years it worked that great where everybody sort of fits and get their top one or two choices. Other years, it's a little bit more difficult trying to make matches between faculty, [...] it's all done in the first, I think two months of autumn semester. So I say by the end of September to October, they should be matched with a faculty advisor.”*

[Chemical Engineering, Program Director Interview]

In sum, we found four main types of processes through which student select an advisor. Within each of these types, we observed variations in time to selection, the information systems provided, and the required tasks. Thus, the processes through which students find an advisor act as the main puzzle piece which can be tailored to meet a program's preferences by varying the activities and the timeline leading to the formalization of an advising relationship. The distribution of the processes per disciplines and field of study are presented in Figure 6 via counts of the programs per discipline by type of selection process.

## Types of Selection Process

	Students & Advisors	Temp Advisor, then Students and Faculty choose	Funding Dependent	Formal Matching
<b>Engineering</b>	Electrical - 5 Mechanical - 2 Civil - 1	Mechanical - 2 Civil - 4	Electrical - 1 Mechanical - 3	
<b>Science</b>	Biology - 1 Chemistry - 8 Physics - 6	Biology - 1 Chemistry - 1 Physics - 2		Chemical - 6 Biology - 1 Chemistry - 3
<b>Math</b>	Math - 5	Math - 2		

Figure 6. Types of Selection Processes by Counts of Programs

**2.7.2 Selection Timeline.** The timing of the advisor selection varied across all programs, ranging from upon admission until the third year of study but most commonly occurring in years one or two of study (see Figure 7). We found that all of the engineering programs required students to select an advisor by the beginning of the second semester but sometimes before arrival. Programs in the Sciences on average required students select an advisor by the end of their first year, but on occasions, some programs did not require until past that initial year. Finally, programs in Math were found to on average require students to select an advisor by the end of the second year, but on occasion not until the third year.

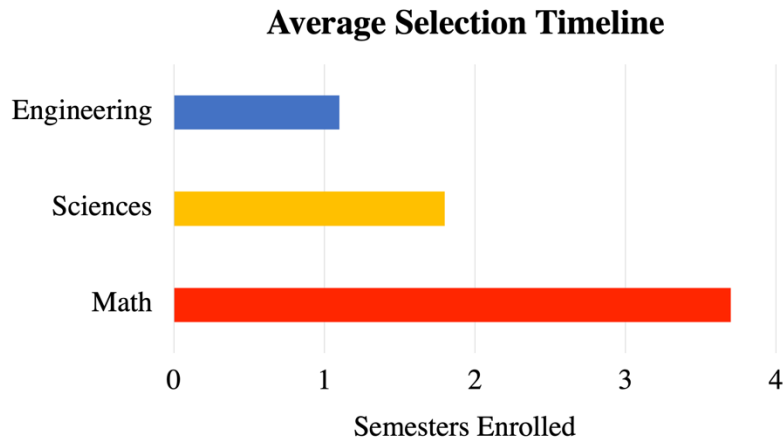


Figure 7. Average Selection Semester per Field of Study

**2.7.3 Funding Dependence.** Regarding the role of funding, our results showed that processes in the sciences and math were less likely to be determined through a student’s funding situation relative to those in engineering. For students pursuing a science or math doctorate, they were often admitted under a teaching assistantship that is centrally funded by the department allowing them time in the program before committing to a selection. Conversely, engineering programs were more likely to admit students directly into research assistantships where the funding is coming directly from individual faculty. Through the interviews in general, we observed that students funded by the department had more time before committing to working with an advisor. Students who were funded to work directly by a professor more often than not had an expectation for continuance in such project and by consequence pressure to commit to that faculty member as their advisor

**2.7.4 Information Systems and Required Tasks.** To facilitate an educated selection process, many programs developed events or processes for students to participate in as they find an advisor. The main goal of these activities is for students to obtain information that would help them make an informed decision when committing to a doctoral advisor. For the engineering

programs (Chemical Engineering being the notable exception), the activities were typically optional and often non-existent. In Chemical Engineering, sciences, and math, activities to grant information were always a requirement for students previous to committing to an advisor. The activities described were research seminars, one on one interviews, rotations, oral exams, summer research, and independent study courses.

Research seminars were the most common feature for students to become familiar with the research positions and projects available in the department as well as to meet the advising faculty in the program. Research seminar was described in a program handbook as follows:

*“A departmental list of the schedule of research presentations to groups of students, including title of research presentation and number of openings that each faculty member expects to have available, will be prepared and distributed to the students prior to the interview period. Research presentation will be held during weeks three through six of the Fall semester.”*

[Chemistry Program, Graduate Student Handbook]

The second most common form of information systems is one on one interviews with faculty members. While many programs encourage students to meet with advisors before committing to an advising relationship, some programs required students to meet with a minimum number of faculty before committing to an advisor. A program handbook describes the required interviews as follows:

*“Prior to the join date, students are required to attend faculty research presentations and follow up with individual meetings with faculty and their research groups. Students must meet with at least three faculty members. The meetings will be verified on a departmental signature form, and individual faculty are free to decide what is needed for a signature (such as one-on-one discussions, group meeting attendance, etc.).”*

[Chemistry Program, Graduate Student Handbook]

The third type of information systems that was common in the sciences is rotations. Students are either required or given the option to conduct a specific number of rotations through

different research groups to test both advisors and fellow lab members before committing to one. This type of information system was mostly present in biology and chemistry programs and was often but not always a requirement before selecting an advisor. Rotations were described in a handbook as follows:

*“Experience with various research projects and styles are an important part of graduate preparation. To deliver this training, all graduate students are exposed to different groups through a series of rotations. Rotations serve various functions. Everyone has the opportunity to explore various laboratories, to find the laboratory where they will do thesis work. Ideally, one will explore different sub-disciplines and techniques relating to their main interest. Each rotation gives the student a place for contact with faculty and other students. Students are required to complete three lab rotations.”*

[Biology Program, Graduate Student Handbook]

The fourth type of information systems is summer work prior to enrollment. This system was mostly found in the sciences and it offered students the opportunity to begin their Ph.D. a summer early as a way for students to experience the research group prior to commencing coursework. This system is similar to rotations but in this case, a student can only commit to one advisor and research project for the duration of summer and may find a different advisor upon completion. A handbook described summer work as follows:

*“In some cases, students are fairly certain about what they want to do and who they want to work with when they arrive, and they have already spoken to a prospective advisor. For these students it is very important to begin work with that group either in the summer before they arrive, or during their first year. Having an idea of what you want to do and who you want to work with is a great advantage in getting into a research group, but once there you may change your mind. It is best to go through that process sooner rather than later, so you can begin acquiring the skills and experience you will need to start your own research project for your dissertation.”*

[Physics Program, Graduate Student Handbook]

The fifth type of information systems common to math and physics is the independent study course. Common to math and physics, students are expected to take an independent study

or 'reading course' with their potential advisor before they commit to working together. The course typically consists of reading and discussing literature or faculty posing problems to observe the students approach to solving these. The expectation is for the student and faculty to decide if they are willing to do so by the completion of the course. The course is described in a handbook as follows:

*"After narrowing to possible specialties, students can trial faculty and topics by taking various reading courses with prospective advisors. These provide introductions to future research areas that are too specific to be covered in regular courses. The one-on-one nature of a reading course may also serve as a test of the advisor- advisee interaction in future thesis work."*

[Math Program, Graduate Student Handbook]

Finally, one math program required students to participate in an oral exam through which the exam committee decided who would be that student's advisor as the outcome of the exam.

While this process only appeared in one program, it is worth noting as a way to familiarize students with faculty. The process was described by the graduate program director as follows:

*"So they have to take an oral exam at the end of the second year. Which is a major, and a minor, two faculty on the major, one faculty on the minor. Typically, the advisor comes from one of the members of the oral exam, because they have more exposure with them before the oral exam. They choose among the faculty, the ones that they think that they might work with. And that has been pretty successful, so there's also discussion, in the oral exam, who might be the advisor, who might be ready to take on the student? Assuming he does well, and passes the oral exam. So that has not been a problem, in the past."*

[Math Program, Interview]

In conclusion, we observed a number of different strategies for sharing information with students. Most were practiced in the science and math programs. Although some engineering programs had some of the information systems previously described, these were seldom required. A summary of the information systems per disciplines and field of study are presented in Figure 8.

## Types of Information Systems

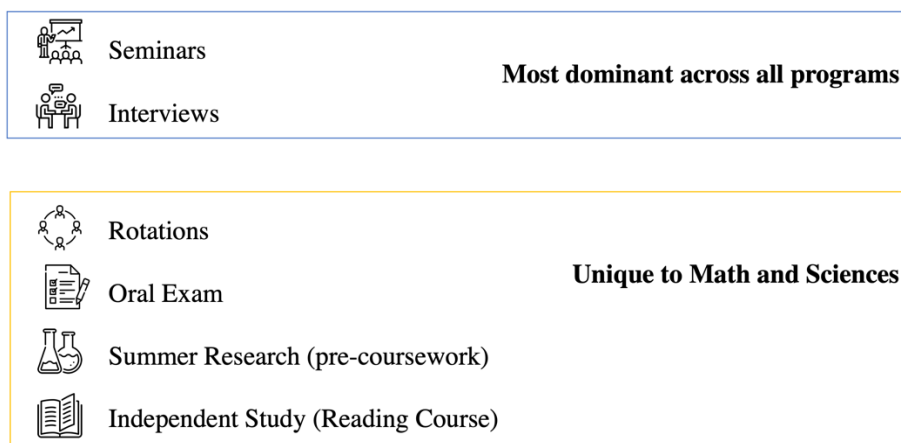


Figure 8. Summary of the Types of Information Systems

### 2.8 Discussion

The purpose of this study was to describe the existing practices through which students find advisors in science, math, and engineering and to identify trends and patterns across the fields of study. We found four main types of processes through which students can find advisors: students and advisors self-select, program facilitated matches, funding dependent process, and temporary advisors prior to the permanent advisor. The processes varied in their timing selection, required tasks before selection, and the ways to make information available to students before selection.

**2.8.1 Comparing across Fields of Study.** When comparing across disciplines and fields of study, our main observation is that engineering programs approach the advisor selection process differently than science and math. Most engineering programs had students choose an advisor very early in the doctoral process, often before their enrollment (Chemical Engineering being a notable exception that will be discussed later in this section). On the other hand, science

and math programs rarely had students select an advisor before their arrival. Math programs, on average, had the most prolonged period of time for students to meet and find an advisor. These findings could connect to those of other studies that have shown math doctoral students to have a longer time to degree than engineering and science (Ferrer de Valero, 2001; Sowell, 2008).

Our findings also demonstrated that engineering programs did not provide as many information systems or required tasks for their students. This practice is likely because in engineering programs, students often had to select an advisor prior to arrival and advisor selections were commonly associated with funding. Therefore, information systems and required tasks related with finding an advisor were not necessary. Conversely, science and math had a significant number of students enter their programs through teaching assistant positions which allowed for such students to take some time before formalizing a relationship with an advisor and granted programs time to provide and/or enforce informational tasks to students. These findings align with Knight et al. (2018) who showed doctoral programs in the sciences as funding more of their students through teaching positions compared to engineering who fund more of their students through research positions. This distribution of funding also aligns with our finding that very few of the programs in science and math practiced systems that were attached to specific funding mechanisms or ones that are in any way dependent on funding.

**2.8.2 Through the lens of PAT.** When analyzing our results, we find implications across the two parts of principal-agent theory: the principal-agent relationship and the contract. As described in Eisenhardt (1989), a contract can be characterized on a spectrum between behavior-based, where the principal is primarily concerned with the process through which the agent reaches the outcome, or outcomes based, where the principal is primarily concerned with the outcomes and not the process. We notice in our results that programs in science and math tended

to practice behavior-based type of contracts as they tended to require activities from the students and overall established more attempts to help bridge the information gaps between students and advisors. These findings align with multiple propositions from contract theory as presented by Eisenhardt (1989), but in particular, proposition three which states “*Information systems are positively related to behavior-based contracts and negatively related to outcome-based contracts*” (p. 61). We observe these information systems being present in Math and Science programs but not in engineering. Similarly, when we consider that programs mostly in Math and Science have rules about mandatory student participation in these information systems, our findings also closely resemble proposition eight which states “*Task programmability is positively related to behavior-based contracts and negatively related to outcome-based contracts*” (Eisenhardt, 1989, p.62). Conversely, engineering programs processes were mostly based on having decided by a specific date. Activities to seek information were sometimes present but rarely enforced. Therefore, engineering processes tended to act as outcome-based while math and science tended to act as behavior-based.

Regarding the management of risk, we observe that most programs allow the students and faculty to self-assemble and not intervening in the final matches. This mechanism gives programs time to enforce activities that bridge information asymmetries and aligns with proposition five which states “*The risk aversion of the agent is positively related to behavior-based contracts and negatively related to outcome-based contracts*” (Eisenhardt, 1989, p.62) as the student is told what to do to have a fruitful selection.

Comparing these two main behaviors between programs in engineering and programs in science and math we can also conclude on the influence of institutional organizations. Our findings align with previous literature that discusses how the similar behaviors in fields of study

can be due to institutions grouping fields of study under which was discussed in the literature review (Hammond, 2004). As stated by Hammond (2004) "it may well be that a critical influence on how some kinds of faculty members come to be grouped together into 'departments' in a university is simply how the various academic disciplines evolved historically" (p.10). While our data does not provide the historical context through which these processes took place, it is possible that the similarities in behaviors between the fields of science and math could be attributed to institutional organization. However, further research into the origin of these practices would have to confirm such assertion.

In sum, when comparing the patterns emergent from the data across under the lens of PAT, we can conclude that sciences and math programs' processes prioritize students receiving help and time in selecting an advisor, while engineering programs' processes prioritize students selecting earlier. When considered alongside the fact that engineering programs also have students select an advisor earlier than Science and Math, this prioritization could potentially have retention implications for the doctoral student population as making a decision as critical as an advisor (Bair & Haworth, 2004) during a stage shown in prior work to not be the most informed for graduate students (Lovitts, 2001; Weidman et al., 2001) can lead to detrimental results later on in the doctoral pursuit.

**2.8.3 Chemical Engineering and Matched Advising Relationships.** The findings discussed above do hold one exception. The practices we found across the Chemical Engineering programs in our sample were consistently at the crossroads between those observed for the sciences/math and engineering. Chemical Engineering provides initial funding for students so they undergo a selection process without influence from faculty to stay on in any one project and they have students go through seminars and interviews; the level of participation enforcement in

such tasks did vary among programs. Both of these behaviors align with the models observed for the sciences and math. However, these programs allow exceptions for faculty doing ‘direct-hires’ into their research group as long as the faculty commit to fully fund such student from day one; a practice only observed in the engineering programs. Uniquely, Chemical Engineering programs placed the selection in our sample on the program director as this person creates advisor-advisee matches based on students’ preferences and resource availability. We were unable to find literature as to how the uniqueness of this program came about and recommend these findings to be explored with further research.

## **2.9 Conclusion**

This analysis provides three significant contributions to the existing research on doctoral education. The first contribution of this study is that it provides an analysis of the disciplinary norms and practices that exist within the fields of science, math, and engineering. This study showed where the disciplinary differentiation lies within science, math, and engineering and how the practices that are unique to each of these fields, and the disciplines within them.

The second contribution of this study is the expansion of the analytical generalizability of PAT in the space of student interactions within the practices of disciplines in higher education. Following recommendations made in previous descriptions of using PAT in higher education (Lane, 2012), this study furthers such research by discussing the interactions within academic departments and presents how information and risk are distributed within a commonplace process in such.

Third, the study provided extended descriptions of the advisor selection processes currently in practice. By furthering the literature on doctoral education through exploring the

process of advisor selection, this study presents a fuller picture regarding the formation of the relationship between the advisor and the advisee. This information could also be used to further understanding of doctoral attrition and to foster the development of student support structures aiming to foment a positive advising relationship.

We recommend future research should evaluate the individual faculty and student experiences in these processes, particularly how they may affect the development of the advising relationship. We also recommend an in-depth look into how these processes compare for faculty and students who are assigned rather than self-selected.

## **2.10 Acknowledgements**

This work is based on research supported by the National Science Foundation under Grant No. 1535226. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

## Chapter 3. Manuscript Two

### *Doctoral Advisor Selection in Chemical Engineering: A Comparative Study of Two Doctoral Programs.*

*Target Journal: To be determined.*

*This manuscript includes intellectual contributions from Dr. Holly Matusovich, who will be credited accordingly as co-author in this work.*

### **3.1 Introduction**

Choosing an advisor has been argued to be the most important component to a doctoral student's progress (Bair & Haworth, 2004; Barnes & Austin, 2009; Barnes et al., 2010; Devos et al., 2016; Lovitts, 2001; Noy & Ray, 2012; Schlosser & Gelso, 2001; Zhao et al., 2007). Prior work has yielded some knowledge on the perspectives of students and faculty have about the selection process (Joy et al., 2015), yet little is known about the ways that doctoral programs support students in this process. In the few studies that have addressed advisor selection, the focus typically has been on the individual student's preferences. Further, existing studies assume: 1) that the advisor selection process is the same across programs, and 2) that students and faculty both have a choice on who they work with (Hilmer & Hilmer, 2007; Joy et al., 2015; Nettles & Millett, 2006). Prior work (Artiles, Knight, & Matusovich, 2019) showed that while many programs do allow students and faculty to select who they work with, many Chemical Engineering Ph.D. programs do not. The study showed that the majority of Chemical Engineering programs practice a 'matching' system where students submit a list ranking their advisor preferences to the faculty member serving as doctoral program director. The director then uses this information along with faculty preference and faculty availability to develop 'matches' between students and faculty. This system structures the advisor selection process and

centralizes it with the doctoral program which acts as a mediator across both students and faculty.

How choice is managed in the advisor selection process is important because an individual's ability to make decisions over their own life is one of the core human needs for individual development and overall satisfaction (Deci & Ryan, 1987, 2010; Eccles, 1983; Eccles & Wigfield, 2002; Ryan & Deci, 2000; Weiner, 1985). This ability to make a decision (choice) has been equated to agency in psychological theories (Snibbe & Markus, 2005). In the context of choosing an advisor or an advisee, agency matters for three reasons. First, the perception of agency of both faculty and students over their own respective careers and academic journeys influences their satisfaction and ultimately their retention (O'Meara, Griffin, Kuvaeva, Nyunt, & Robinson, 2017; O'Meara et al., 2019). Second, faculty satisfaction and perspectives of both academia and their academic journey have been shown to influence doctoral students' own perceptions about academia (Utzinger, 2019). This faculty influence shapes the faculty that students eventually become and the culture they promote in their future departments. Third, few studies have addressed perspectives outside of students regarding doctoral education and the development of researchers, thereby limiting the ability to have a holistic insight into the processes occurring in graduate education.

We begin closing this gap by examining faculty perspectives on advisor selection processes. Knowing that the practice of such process is likely to vary by department; thus, we focus our study in examining these faculty perspectives through a departmental perspective. The academic department is the epicenter of where disciplinary traditions are developed and negotiated by the current faculty (Becher & Trowler, 1989; Fairweather & Paulson, 2008). The department is also where these traditions are learned and perpetuated through the training of

graduate students as future academics. However, each department has its nuances; each develops its variations of commonplace disciplinary practices and negotiates such with its institutional identity and its faculty needs (Golde, 2005). Therefore, it is important to understand how faculty perceive their department's management of the advisor-advisee matching process and their perceptions of agency in such processes.

The purpose of this case study is to compare how two programs in Chemical Engineering practice the advisor-advisee selection process from the perspective of their faculty and to examine how faculty perceive agency is negotiated in this process between students, faculty, and the graduate program director. This purpose leads to the following research questions:

- *How do two Chemical Engineering doctoral programs compare in how they manage the advisor-advisee matching process?*
- *How do faculty negotiate agency with the doctoral program director in the advisor-advisee matching process in such programs?*

By answering these research questions, this study will elicit and compare how the advisor matching process works in two Chemical Engineering programs. This comparison will further understanding on faculty perceptions of agency in doctoral education as a function of departmental practices. An outcome of this study will include points of consideration for departments on how to best negotiate agency with faculty.

### **3.2 Departments' Influence on Faculty & Doctoral Education**

The academic department is the most basic organizational unit in academia. They house academic programs in which students enroll, and they house the faculty. Yet, few studies have addressed differences across academic departments, even when they belong to the same

discipline though many studies have examined differences across disciplines. The following review of the literature presents studies that have addressed the influence of departments in both doctoral education and faculty agency.

**3.2.1 The influence of departments in doctoral education.** The academic department is the epicenter of doctoral education and socialization into the discipline (Golde, 2005). Departments set the norms and policies under which students can progress and obtain a doctoral degree. Yet, despite its crucial role, we know very little about departmental differentiation within a discipline. The following review presents studies that have addressed components of the academic department and conclude that further work is needed to understand its role in the doctoral pursuit.

Golde (2005), which is one of the first studies advocating for the study of individual departments in doctoral education, aimed to understand how the department and the discipline influence doctoral student attrition through their culture and practices. The author selected four departments in one institution postulating that by holding institution constant, they would be able to discern those factors unique to the disciplines. The two departments studied in Golde (2005) differed in whether the students entered to work for a specific advisor or through a rotation system as well as the advisor selection timeline. The author concluded that disciplinary and departmental factors could not be separated from one another but encourages future work to look into the role of departments, the impact of policies, and to not assume such impact is uniform across programs. The author asserted that this research is valuable as it “makes explicit the impact of departmental structure, requirements, and culture on students [...] graduate programs are a hodgepodge of inherited requirements and longstanding norms and traditions, some of which unintentionally contribute to attrition” (Golde, 2005, p. 695).

A similar qualitative review of doctoral programs by Gardner (2010) compare factors for attrition in departments with high and low completion rates. Also taking place in one institution, this study sought to understand the reasons given by faculty and students for doctoral attrition across six disciplines. The author conducted over 90 semi-structured interviews and used attribution theory (Weiner, 1985) as a lens through which to frame the analysis. Gardner (2010) found that faculty often stated students' lack of ability, motivation, or understanding as the reason for attrition, while students mostly stated department issues of fit as the reason for departure. While the author did not specify findings specific to certain departments, she concluded that faculty need to consider the role of the department in doctoral student departure and that departments should make their expectations of students both clear and explicit such that students know to what level of performance they are held accountable. She also called for further research across institutional types and departments of varying rankings as the perceptions of student and faculty performance in such vary significantly from smaller research institutions.

In a more recent publication, Zhou and Okahana (2016) described a quantitative study that compared STEM programs time to degree and completion rates to those in other fields of study. In a survey of over 5,000 doctoral programs across more than 200 universities, the authors found that financial support was influential in both doctoral completion and time to degree between STEM vs non-STEM fields of study, particularly for financial support offered in the form of research assistantships. However, the authors did not find a correlation for academic support. The authors concluded that further research is needed to explore departmental differences across and within specific fields.

Another recent study has approximated the potential influence of the department by focusing on the 'funding portfolios' of doctoral programs and their distribution across academic

fields of study. Among other findings, Knight et al. (2018) demonstrated that even within the field of engineering, doctoral programs vary widely in their proportions of students' funding mechanisms (e.g. how many students have a research assistantship vs. a fellowship among other possible mechanisms). Given what has been shown in the literature on the role of funding in the student experience (Border & Barba, 1998; Kinoshita, Amelink, & Knight, 2016; Torika, 2018), one could conclude that the pursuit of the doctoral degree could vary within the same discipline depending on which program a student decides to enroll in.

The studies above show that both disciplines and departments do influence how doctoral education is managed but understanding the effects of each is difficult to do as separating these influences would warrant studying a phenomenon across multiple institutions within the same discipline. While most of the available literature has looked at the disciplinary differences, little work has addressed the departmental influence from a comparative standpoint. This study aims to understand this relationship by comparing two departments belonging to the same discipline in different institutions.

**3.2.2 Faculty Agency, Departments, and Doctoral Education.** Departmental cultures affect not just the doctoral pursuit in their programs but also the perspectives and behaviors of the faculty within them. Multiple studies that have sought to understand the relationship between faculty agency and the academic department have concluded that they are inextricably related and that departments can indeed empower their faculty. Faculty agency is crucial as it is important for the retention and advancement of faculty members in research (Niehaus & O'Meara, 2015; O'Meara, Campbell, & Terosky, 2011); it has been linked to various outcomes including satisfaction with life, work, and productivity as well as career development (Bozeman

& Gaughan, 2011; O'Meara et al., 2014). The following studies have examined the connection between departments and faculty agency.

O'Meara, Campbell, & Terosky (2011) developed a framework that describes how the multiple factors, including but not limited to the environment, influence the faculty agentic perspective or how their environment or themselves can facilitate a goal. This agentic perspective, in turn, influences their agentic actions or strategic behavior taken towards a goal or in this case career advancement. In Campbell & O'Meara, (2014), the authors extended the previously described framework by studying the influence of multiple department factors on faculty agentic perspectives and actions. Through a quantitative approach, the authors found a strong correlation between faculty agentic perspective and three elements of the department: person-department fit, professional development resources, and work-life climate. Knowing that agentic perspectives correlate with agentic actions, these departmental elements correlate with how faculty behave towards their goals and career development.

A few authors have addressed the intersection of faculty agency and doctoral education from the lens of learning to advise. For example, Mcalpine (2013) argues that doctoral advising is something traditionally learned over time and individually by negotiation with the environment around oneself. Faculty learn to advise while balancing multiple priorities and negotiating the push and pull of agency with students. Further, university practices influence newcomer faculty integration and network development. (Fleming, Goldman, Correll, & Taylor, 2016) Faculty learning occurring in this informal and unstructured way can be troublesome as it is:

“neither assessed nor discussed as something that institutional leaders can study, shape, or influence. Yet, it is closely connected to the environment and is influenced by

institutional structures, processes, and cultures” (O’Meara, Rivera, Kuvaeva, & Corrigan, 2017, p. 356).

We can synthesize across the previously presented studies that the department’s practices and environment dictate both doctoral education and faculty agency. Faculty agency can be expressed in the doctoral education process, but not much has been published about how it is practiced and how does it vary across multiple departments. This study aims to further understanding of the departmental differences by comparing two departments practices in matching students to advisors and how faculty experience and negotiate agency in such a process.

### **3.3 Theoretical Framework**

This study is framed in principal-agent theory (PAT) (Eisenhardt, 1989). PAT states that there is a principal who needs a task that needs to be completed, and this principal employs an agent to do so. The relationship is governed by a contract negotiated at the beginning of the relationship by the principal and the agent that lays rules for how the agent will engage in that task. This contract details how the agent will complete the task and how the task will be assessed for completion by the principal.

For the study of Chemical Engineering programs, the programs act as an agent for both the student and the faculty. The student and the faculty (the principals) trust the program director will find them a suitable match, and they make their preferences known to this agent. The handbook or contract states this process as their responsibility. The program director now falls into the multiple principal dilemma as this person needs to accommodate multiple student and faculty preferences.

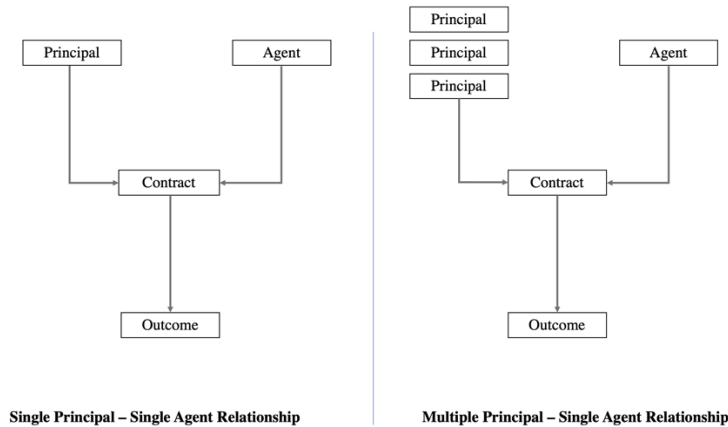


Figure 9. PAT Theory for Single and Multiple Principals

In the multiple principal dilemma, the task is being outsourced from two or more parties to a third party (see Figure 9). The multiple principal dilemma has two variations: one in which the principals agree on the outcome and one in which the principals have opposite preferences (Lane, 2012). When the principals agree on the outcome, *“the major agency problem is one of enforcement. Someone should be responsible for monitoring of the contract”* (Lane, 2012, p. 285). Thus, the process of ensuring that the task is completed to meet the stated preferences is diluted across multiple parties that may or may not enforce its execution. This difficulty can compound with the existing challenges common to the outsourcing of the task. For example, sometimes the agent possesses expertise or information that the principals do not have and is needed for completing the task (Eisenhardt, 1989). This information asymmetry makes enforcement difficult to pursue. Similarly, if the contract is designed strictly to assess the outcome of the agent’s actions and not the actions themselves, the principals would have to be in complete alignment with the desired outcome to ensure appropriate enforcement (Lane, 2012).

When the principals disagree on the desired outcome, *“the agent must decide which contract to fulfill, sometimes flip-flopping between contracts based on factors such as*

*convenience for the agent or shifts in power among the principals. [...] leading to incoherent policy outcomes and agent behavior.”* (Lane, 2012, p. 285). This is to say that how the agent reconciles their actions relative to both principals’ preferences becomes grounds for inconsistency in the actions of the agent. This inconsistency in the agent’s actions can also become ground for implicit principals, or hidden principals, to step in and influence the actions of the agent.

This study expands on the previous use of PAT, by using it to understand the relationship development between students, faculty, and program directors and how the latter reconcile preferences and power differentials across the formers. This study also compares how this task is undertaken at two different institutions and the contextual factors that may play an influential role in the differences across these institutions.

### **3.4 Methods**

This study is grounded in multi-case study methodology as the goal is to compare the faculty perspectives in two Chemical Engineering departments on how students are matched to advisors. This study meets the criteria set forth by Yin (2003) as the context under study is evolving, uncontrollable, and the goal of the study is to explore the factors unique to each case that influence advisor selection processes. It also meets the criteria set forth by Stake (1994, 2006) for a case study as each case is bounded in space to the individual department and in time by the professors currently advising graduate students and the advisor selection process currently in place.

**3.4.1 Cases.** This study was conducted in accordance with approved human research subjects research protocols. This comparative analysis studies two Chemical Engineering

departments which will be labeled Department A and Department B. We scoped our study to the academic departments as this is where faculty and the doctoral programs they work with are housed. Department A is housed in a large public institution with a Carnegie classification of Highest Research Activity (Shulman, 2001). Department A's Ph.D. program is ranked in the top 15 programs for Chemical Engineering in the US. Department B is also housed in a large public institution with a Carnegie classification of Highest Research Activity. Department B's Ph.D. program is ranked in the top 30 programs for Chemical Engineering in the US. Both departments admit doctoral student cohorts of approximately 30 students each year and have a similar number of faculty associated with Ph.D. advising, about 30 members. Both departments reported similar levels of doctoral student retention ranging from 90-95%. These values are well above the average for doctoral engineering programs as published by the Council of Graduate Schools (Council of Graduate Schools, 2007). These details are summarized in Table 5.

Table 5. Summary of Department Characteristics

<b>Department Characteristics</b>	<b>Department A</b>	<b>Department B</b>
Institution	Public	Public
US News Ranking	Top 15	Top 30
Doctoral Cohort Size	25-30 students	25-30 students
Research Faculty	~ 30 members	~ 30 members
Doctoral Retention	90-95%	90-95%

Each case was analyzed using two main sources of data: interviews with faculty and graduate student handbooks. The graduate student handbooks were obtained from each program's website. The graduate student handbooks include instructions for students and provided the baseline for the process through which students are matched with faculty.

**3.4.2 Sample** Individual faculty were invited to participate in interviews for this study through snowball sampling (Patton & Patton, 2002). Faculty were selected to participate based on their experiences in advising and recruiting doctoral students. We specifically sought faculty currently advising doctoral students and/or holding the title of doctoral program director, or faculty member who oversees the doctoral program. We aimed to obtain a faculty sample that included a variety of levels (Assistant, Associate and Full Professors) and research topics to maximize the experiences represented in the interviews. While we recognize that there are often differences in the experiences of underrepresented faculty in each department (with regard to both sex and race/ethnicity; e.g. O’Meara et al., 2019; Ong, Wright, Espinosa, & Orfield, 2011), we did not intentionally sample for such differences. For all programs, we were sure to invite at least one current or recently former graduate program directors to have their experiences in arranging the matching process in their departments. **Error! Reference source not found.** summarizes participant faculty ranks.

Table 6. Summary of Participant Organizational Status by Department

Faculty Characteristics		Department	
		A	B
Faculty by Rank	Former Ph.D. Program Directors	2	1
	Full Professors	3	3
	Associate Professor	0	1
	Assistant Professor	2	1
Time Working as Faculty in the Department	0-5	0	1
	5-15	0	3
	15+	5	2
Doctoral Students Advised & Graduated	0-5	1	2
	15+	5	4
	Yes	4	2

Currently or Previously Involved in the Graduate Committee	No	2	4
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**3.4.3 Data Collection.** The interviews were approximately one hour in length and included questions on participant’s experiences in advising and recruiting doctoral students. Sample questions for these interviews were: “What is the advisor selection process in this department?”, “What would you change to the selection process?” and “How satisfied are you with this process?”. Additionally, participants answered questions related to admissions, funding, and doctoral advising more broadly.

### 3.5 Data Analysis

The analysis of the data consisted of three steps: development of case descriptions, applying replication analysis to the cases, and conducting a cross case analysis. This analysis is grounded in an interpretivist worldview (Lincoln & Guba, 1985). Following the case study approach recommended by Yin (2003), the first step was to create a case description for each department. These case descriptions were anchored in the description of the matching process stated in the graduate student handbook and consisted of annotations contrasted with the salient themes from the interviews. From this description, a codebook was developed addressing all of the parts of the process including those not written in the handbook. This codebook emerged from the case description and lists the different parts of the advisor selection process that either the manual or the faculty interviews presented as being either connected or important to the process. These codes are listed and operationalized in Table 7. This codebook was applied to all of the interviews, and the excerpts were analyzed for emerging patterns. The emerging patterns

were also compared across the participants within a single case, verifying for differences across faculty ranks and involvement in the graduate program.

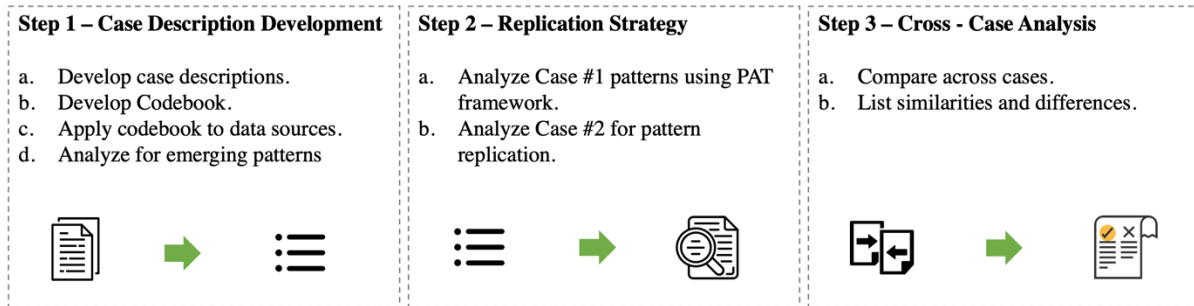
Table 7. First Round of Coding

<b>Code</b>	<b>Operationalization</b>	<b>Sample Quotes</b>
Admissions Process	Quotes relating to the admissions process and its influence on student-faculty interactions.	<i>We admit a varied pool of students because we want all faculty to have options to recruit for their labs.</i>
Recruiting Students	Quotes relating to recruiting students after they have been admitted to the program.	<i>I only begin to recruit students once they have been accepted into the program.</i>
Matching Process Mechanics	Quotes relating to the mechanics regarding the advisor-advisee matching process.	<i>We sometimes prioritize junior faculty's needs for students over student preference.</i>
Matching Satisfaction	Quotes relating to the faculty's satisfaction with the matching process	<i>I was not thrilled with the match but it was better than not getting matched at all as I needed someone for the project immediately.</i>
Veto Match or Back negotiations	Quotes relating to back negotiations led by faculty to either obtain or push away a specific student.	<i>I was particularly interested in a student so I took these specific actions to make sure they were matched with me.</i>
Circumventing Process	Quotes relating to instances where a student circumvents the process completely and enters the Ph.D. program working directly for a faculty member.	<i>Sometimes we see a student who is supported from day one by a specific faculty skip the matching process.</i>
Resource Impact	Quotes relating to the process impacting an individual faculty's resources (e.g. workload, funding, etc....)	<i>There have been times when I cannot fill the positions I have because the program does not match me with a student.</i>

The second step consisted of analyzing the patterns found in Department A through the lens of PAT. This step included determining the agent, the principals, and the interactions across these from the perspective of faculty in the matching of students. The findings were then tested in the second case to see if the patterns held and if the framework can be applied in the same

manner. The third step consisted of comparing the findings across cases and noting similarities and differences between them.

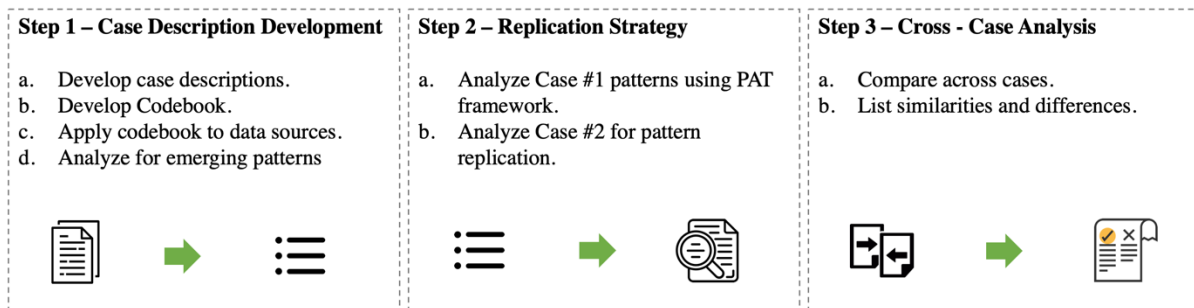
## Analysis Steps



(Yin, 2003)

Figure 10 summarizes the three phases of this analysis.

## Analysis Steps



(Yin, 2003)

Figure 10. Data Analysis Steps for Manuscript 2

**3.5.1 Research Quality.** To assure the quality of our study, the results here reported were first triangulated within data sources, within cases, and across cases for the credibility of the findings (Creswell, 2013). This triangulation ensured that the findings here reported were not single instances of the phenomenon. To test the transferability of the results, we used replication

logic across cases to test emerging themes in the cases (Miles et al., 2014; Yin, 2003). Finally, a third researcher was brought in to audit the final results and coherency of the chain of evidence (Tracy, 2010). All the previously described measures are strategies recommended to assure trustworthiness specifically in qualitative case studies (Creswell, 2013).

**3.5.2 Limitations.** Like any study, our findings do have some limitations. First, our study focused on two relatively high ranked institutions with similar faculty characteristics and experiences. This similarity in institutional traits limits the transferability of our findings to institutions different from our sample. However, it is important to note that institutions that produce large amounts of doctoral students are more likely to reflect the traits of our sample than not. A second limitation is the heterogeneity of our participants. The literature reports women and racial/ethnic minority faculty members to have distinctly different experiences. While this was not the goal of our study, we did consider this to possibly limit the transferability of our results to all faculty participants. Third and finally, our sample was predominantly tenured faculty. In the context of our study, this limitation may restrict what we could interpret to be the junior faculty perception of the process and comparisons across this group. However, as senior faculty have a longer experience in recruiting doctoral students, we were able to obtain richer descriptions of experiences in recruiting doctoral students. Further studies would have to be conducted to fully understand the assistant professor's experience in recruiting doctoral students.

### **3.6 Results**

The aim of this work was to compare how two doctoral programs practice advisor matching and how agency is negotiated within these programs between students, faculty, and the program director. Our results showed that the process of matching students to advisors was

similarly executed in the two departments, specifically with regard to the role of research interests and connection to admissions processes. Because of these similarities, the outcome of the matching process could look the same from the student perspective across both programs (e.g. students submit their ranked preferences and are assigned to someone on their list). However, what differs across the programs is how the faculty negotiated agency between themselves and the graduate program director (person in charge of making the matches), a process invisible to the students. Importantly, this negotiation of agency impacted faculty satisfaction. Consistent with case study research (Stake, 2006), the findings are provided in terms of similarities and differences across both departments and then finally in relationship to satisfaction.

**3.6.1 Similarities.** Our findings showed that Departments A and B held similar views on both the practice and the challenges of using a matching process to pair students with advisors. We first describe the matching process, its connection to the admissions process, the challenges presented on using research interest as the main matching criterion, and how faculty recruit students into their research groups.

**3.6.1.1 Similarities in the Matching Process.** The matching process as described in graduate student handbooks for both Departments, consists of students being admitted to the department and asked in their first semester to list their top 3 choices for a faculty advisor. Before students list their preferences, both programs held a series of research seminars and required students to meet with a minimum number of faculty (such number varied by year). The graduate program director collects these preferences and makes matches across all of the faculty and all of the students in such cohort.

While no one faculty member's report of the process in any department differed from the handbook, participants were all more aware of what occurred behind the scenes for this process. For example, the Graduate Program Director in Department A described the process as to work as follows:

*“All the new students go through the matching program. So, they come in September [...] so all the faculty during the first month they're here gives a maybe 20 minute presentation on their research. And then we have actually other events too, a picnic, to try to have students meet the faculty. And then we require the students to talk to four or five faculty, [...] October they make a list of their preferences [...] And then we work with the faculty, we try to match them up with the faculty. [...]. But then if we have like 10 students want to work with one faculty member, first choice, then we have to start going down to second choice and so on. [...] we always try to match first or second choice.”* [Former Graduate Program Director, Department A]

This description generally matches the graduate handbook. While the described process is mostly based on the students' preferences, multiple faculty members described it as also taking into consideration the needs of junior faculty as they are less likely to recruit easily:

*“So the graduate chair, in doing the assignments, keeps that in mind and specifically they keep it in mind and the junior faculty get a higher priority. If you're a brand new professor walking in, getting a student in your group is vital to the survival of you. So they get priority. [...] And this is a community decision.”*

[Full Professor, Department A]

In Department B, the matching process was similar to Department A. The following quote is from a full professor describing their experience at Department B:

*“All of the faculty, they get all of the graduate students together over a course of about two weeks for about a two hour session, two nights a week. And they run the faculty through in like 15 minute time slots. And you go in and describe your research program and talk about what students would do in your group, and how many slots have available and those kinds of things. Students get a chance to ask you questions. And then the students get a chance to list their top three choices. And then the graduate studies chair tries to make everybody happy, which is an impossible task.”* [ Full Professor, Department B]

Department B is also described as being mindful of junior faculty when assigning their matches by the former Graduate Program Director:

*“One of the things that we really avoid in this department is having very senior famous faculty get all the great students, and then the junior faculty and especially the new faculty end up with nothing. That's something that I've seen at certain other universities that shall remain nameless, but I have plenty of friends who have horror stories of eventually being denied tenure because they couldn't get their labs going.”* [Former Graduate Program Director, Department B]

Therefore, the processes are practiced in a very similar manner in both institutions.

**3.6.1.2 Connection to Admissions.** Our data showed that the advisor-advisee matching process is inherently connected to the admissions process across both institutions. If a program admits too many students interested in a specific research topic, they risk having a more difficult matching process later on because they only have so many faculty members to advise students researching a specific subject. However, given that a program cannot control which admissions offers will ultimately yield to enrollment, they try to protect themselves as well as possible:

*“Well, we have, you know, three or four main areas of research in our department [...] So we do try to basically admit students in all areas. But, you know, we admit a lot more students. We admit maybe 100 students to come here. [...] it's very hard to know exactly how many students, you know, we only get like one-third of the students who come here. So, it's very hard to say we want so many in each area. So basically, we just try to admit in all areas. Our main criterion for [admitting] students is to try to get the best student.”*

[Former Graduate Program Director 1, Department A]

We can observe in this quote how a former graduate program director for Department A describes the limitations to admitting student that fit the specific research interests available so they optimize their chances by offering admission to more students than they can admit.

Although Department B did not discuss a strategy, they also expressed concern over trying to tailor admission offers to any specific year's advising needs.

To further complicate student admissions are conducted in the early Spring and the results of grants are typically not known until later in the semester. This timing gap keeps faculty from admitting a number of students tailored for any one year's specific needs.

*“In December when we're making [...] admissions offers. And at that time, we often told the faculty how many students [do] you want? [...] they'll just say, ‘Oh, no. I don't want students.’ Then September rolls around and all of a sudden they say, ‘Oh, I have a grant. I need students.’”*  
[Former Graduate Program Director 2, Department A]

From the previous quotes one can conclude that despite the connection between admissions and the matches made between students and advisors, the timing of the admissions process makes it difficult for a department to predict which research needs a department has this early on and which students would ultimately accept an admission offer.

**3.6.1.3 Students' Research Interests.** The matching process uses students' expressed research interest and advisors research availability as its main criteria to develop matches. Yet, these criteria bring about their own challenges. Faculty expressed that the bigger challenge was being able to determine what a student truly wants to do for their doctoral research. Faculty described that while some students come in with a clear idea of the type of work they would like to do, other students are not as clear and often list as their preferences a combination of faculty that may not represent a cohesive research interest. Almost all of the faculty interviewed expressed that incoming students are not self-aware of their preferred research interest, and even when they did have clear preferences, they could likely be happy with any topic:

*“What a student thinks they're interested as a senior in college applying for graduate school isn't necessarily what lab they want to end up joining when they get there and get a better sense of what's really happening and get the complete picture of what's available [...] it's very common for someone to say, ‘Oh I want to do something in Life Science,’ then they end up doing [something else] instead [they] didn't even know that existed and so that was way cooler.”*  
[Former Graduate Program Director 2, Department A]

*“So sometimes you get people that are like, “Oh, I don't know. I'm interested in these four faculty,” and like the four faculty do everything from experimental catalysis to theoretical polymers to my biomedical nano technology, and I'm like, “That's really broad. It sounds like you have no idea what you want to work on.” Whereas someone who comes and says, “I really want to work on medical technology, and I know there's three of you that do that, and I'm interested in those three.” I'm like, okay. I get that. So it'd be nice if they had some vague notion of what they might like to do.”*

[Full Professor, Department B]

*“I would say that 50% of the students are wrong about what they're interested in or could be much more flexible.”*

[Full Professor, Department B]

Thus, we can observe through the previous series of quotes that most of the faculty agree that many incoming students do not have a clear understanding of their research preferences and that by consequence, matching students to faculty by research interest can lead to difficulties.

**3.6.1.4 Faculty Recruitment as a Function of Experience.** Despite their agreement that students can be unaware of their research interests, faculty at both institutions use expressed research interest in a research topic as a gauge for recruiting students. The use of research interest as an indicator became particularly true for the junior faculty who had less experience in recruiting students to their lab:

*“For me, I would get the students that are inherently interested in the kind of work that I do and are prepared for that. So I guess the matching would be that everybody gets that.”*

[Associate Professor, Department B]

However, as faculty moved up the ranks, they became more critical of judging students strictly on research interest. An associate professor eagerly made the point that sometimes a student's methodological preferences (e.g., experimental vs. computational research) began to matter more to her than the actual subject of the project itself and they criticized the matching process for not taking this aspect of a student into consideration:

*“They try to give you the best student, but they don't necessarily look [...] what are the characteristics of the students [referring to interest in methodological approach rather than interest in research subject]. Cause people usually switch between in bio related things and non-bio related things. And they're not switching between, if they want to do computations, they're not going to send experimentalists. [...] So there's a few different pods of people [based on research subject] and I think they're paying too much attention to that [research topic in lieu of methodological approach].”*

[ Associate Professor, Department B]

Finally, at the full professor rank, the criteria used by faculty to evaluate students became more refined. These faculty also included their own rationale for recruiting students which they had typically developed through their experience in recruiting students:

*“I'm typically looking for demonstrated interest. I'm looking for a fit with the group, as well [...] the fit with the group also goes with, there's a kind of maturity that I'm looking for. is I've started to ask students about how well [my] current students that meet with the prospective candidates, how well they think they would fit into their understanding of not just the group dynamic but how the group works and actually the group's relationship with me as well. [...] That's pretty recent.”*

[ Full Professor, Department A]

Therefore, while research interest does not yield a complete picture of a student's potential, the program relies on it to offer admissions and make advisor-advisee match. This system forces faculty to initially use research interest as their main criteria for assessing students. Yet over time, as they gain experience on how to recruit students, they start looking beyond a research topic and into other student preferences or traits for selecting who they prefer to work with.

**3.6.2 Differences in the Matching Process.** While the perspectives on the process in both departments have multiple similarities, we found some critical differences in how these were practiced on the faculty side of the match. We will first describe the differences in the information faculty receive regarding the ranking results, then we discuss how each department practices faculty agency in accepting students. We then describe how faculty at each department

choose to participate or not with the match process, and conclude with a comparison of faculty satisfaction in both departments.

**3.6.2.1 Communication During the Matching.** As described in the similarities section, the process in both programs essentially works the same way. However, we did observe one notable difference concerning the information communicated to the faculty. Faculty in Department A described that the ranking students give to their preferred faculty is anonymous; faculty are only informed the names of students that expressed an interest in working with them but not the order in which they were placed.

*“Usually it's private information where you don't know what choice you were with the student. So if the student put you one, two or three, in principle, the professors do not know that.”*

[Assistant Professor, Department A]

Faculty in Department A described that the rationale behind this information being withheld was for faculty to protect the students' preferences, as faculty could then use this information to reject student that did not place them as their first choice. Conversely, faculty members in Department B are told which specific preference order students had assigned to other:

*“I'll give them the list of students who want to work for them. Most of them may have a set number of positions that they want, and I'll say these students put you down first.”*

[Former Graduate Program Director, Department B]

We can observe that there is a difference in how the graduate program director communicates student preferences to the advising faculty. Keeping this information from the faculty protects the student's interest from faculty who may only accept to work with a student that lists them in a certain position or higher.

**3.6.2.2 Negotiation of Agency.** An important part of the matching process is understanding how agency is negotiated between faculty members and the graduate program director regarding the matches made by the latter. It was in this negotiation of agency that we observed the main difference between their individual department's practices and ultimately the satisfaction of the faculty members. Department A had a balance in the decision making between the advising research faculty and the program while Department B did not.

When faculty in Department A were asked if they felt that they could veto a match made by the program all of the faculty expressed being able to do so. The following quote shows an example of a junior faculty in Department A that declined accepting a student despite financial offers from the department to help support this student:

*“There's been times where they say, oh, can you take another student? There's a student that really wants to join your group, and you'd be the best match for them. Then I would just say, well, I actually don't have funding to take another student on. Then they say, okay, well, we can give you a year's worth of funding if you can take this student. Then I can say yes, or I still said no, actually, one year, when the funding would not solve those problems. So, ultimately, through the selection process, professors ultimately have the final say whether they want to take on someone or not.”*

[Assistant Professor, Department A]

For comparison, in Department B, Faculty did perceive themselves as having as much agency. When asked if they could veto a match made by the department faculty expressed that they were typically offered the option of taking the student with some financial assistance from the department to help them support such student similar to Department A. However, if they'd decline taking on the student completely it typically came at the cost of not getting matched with any student that year:

*“You do have veto power [...] Only in the sense that, so then we had, I guess then the department can bribe you. So we ended up jointly with someone else. I ended up taking a student, a joint student that had been with someone else for a year and then wanted to change [...] We got bribed by having him supported, so we didn't have to support him initially. And in the long*

*run, was that a good choice? Not really. So I can be bribed, but I think it would be harder to bribe me again."*

[Full Professor, Department B]

**3.6.2.3 Circumventing the Process.** Faculty in both departments were also asked if they could circumvent the process of matching by hiring a student directly and how often this occurred in this department. Neither department mentioned that faculty were explicitly prohibited from directly recruiting students. But in both departments, the graduate program directors discussed that it was a community agreement for all faculty to participate in the matching process. However, we saw differences on faculty actually following these behaviors. Faculty in Department B were more likely to discuss alternatives to recruiting students outside of Chemical Engineering. Many of the faculty discussed using their joint appointments to recruit students in other departments when their home department of Chemical Engineering could not match them to a Ph.D. Student. However, the mismatch in the recruiting timeline for both programs made this task nearly impossible:

*"I have difficulties because the BME program you have to match before you're accepted [in the Spring previous to initial enrollment]. So I have to come to [BME] and say, "I'm going to take Suzy." Well, I'm usually hoping to pick up a Chem-E student because that's my primary appointment ... By the time I realize [ChemE matches] failed, all the BMEs have been admitted. [...] I either have to take the BME student straight out of the beginning, and there's no Chem-E chance, or I have to gamble on Chem-E and hope for the best."*

[Full Professor, Department B]

Faculty in both departments were also asked if they could circumvent the process of matching by hiring a student directly and how often this occurred in this department. Some of the faculty in Department B discussed no more than one occasion in which they directly recruited a student that they had engaged with through work at some point or another before their

commencing graduate school. However, a majority of the faculty referred to their colleagues with international connections and those who gained some form of research fame in a specific topic as frequently circumventing the existing process:

*“Every now and then you'll see a student coming in from ... And it's typically one of my Chinese colleagues who has a student through a colleague who they either have a research collaboration or it's such a strong personal relationship that this faculty member is actually bringing that person in on research grants directly into their lab. All they're worried about is getting the student accepted into the graduate program. They're not using any departmental funds to support that student [...] or anything like that. So faculty members can do that. That's basically like hiring a graduate student directly.”*

[Full Professor, Department B]

Faculty interviewed in Department A expressed not having recruited students directly in the past. They also expressed not seeing many exceptions for direct recruiting with their colleagues:

*“I don't see a lot of that. If that was the case, you would expect the Chinese professor to have a whole bunch of Chinese students in his lab and we don't have that.”*

[Full professor, Department A]

Faculty in Department A also had the ability to recruit students that were in the midst of switching research groups. However, they discussed this process as carrying a risk in terms of both potentially questionable student performance and/or possibly ruining a relationship with a colleague:

*“You're always a little hesitant to figure out why this person is in the situation they're in and whether that's the type of person you'd want to recruit. But if you find out that it's for legitimate reasons, then it's not a problem, but it's just this extra layer that surrounds people who it happened to.”*

[Assistant Professor, Department A]

So what we can observe through these comparisons is that in Department A faculty are more likely in participating in the process and do not see their peers circumventing the process.

However, in Department B faculty were able to articulate multiple ways through they and their peers circumvent the process.

**3.6.2.4 Faculty Satisfaction with Advisee Match.** Despite the differences in agency perceptions across departments, faculty were still satisfied with the process itself. Faculty were finally asked about their satisfaction with the process and whether they'd make any changes to the process already practiced. In Department A, we observed general satisfaction with the process, particularly due to being able to get an assignment that they were satisfied with:

*Oh, we get very top tier students, but what I will say is we lose students [...] to top 10 programs, but the students that we are getting are darned good. Their degree might be not from a top 10 institution, but you know, I don't think that matters all that much. I get students who have nearly a 4.0 at a good solid Chemical Engineering program and with experience in lab and industry. Like, what else would I want, you know? That's pretty darned good."*

[Full Professor, Department A]

In Department B, faculty were not as satisfied but it was primarily because they would not always get a Ph.D. student when they requested one and if they pushed for one it might not be someone as interested in working with them:

*"I'm dissatisfied, [...] The bigger problem is I'm not always able to get a student. So that's the difficulty. So last year, I had money for a student for a project that no one was working on, and I desperately needed a body [...] I pointed out this would be the third year in a row that I had no student for Chem-E, and I threw a giant hissy fit, and I got a student. I shouldn't have to do that."*

[Full Professor, Department B]

While faculty in this department were not completely satisfied, they had a difficult time thinking of a better process and completely rejected a laissez-faire recruiting approach without departmental interventions. They believed the system currently in place was the best to help all

students succeed. When asked about whether they would like another version of the process they responded:

*“I don't think so because I think this process is pretty standard. The process I do not like is pre-accepting students or accepting students outside of the prescribed pattern, which does happen in this department too. Because I don't think it's fair to the student, because then the student is beholden to that faculty member and suppose that they run into problems later, they can't really ... I mean, it's harder for them to change their mind.”*

[Full Professor, Department B]

In sum, faculty were not likely to follow a different process even when they were dissatisfied with their department's execution of advisor-advisee matching often because it meant students had the best chance of finding an advisor; even if it came at a cost to them as faculty. We can observe across departments that faculty in Department A describe perceiving agency to refuse matches. This allows faculty to have more choice over the students they desire. Consequently, they did discuss needing to partake in circumventing the process established by the department or recruiting for students in different doctoral programs. Conversely, in Department B we see how the perception of a lack of agency in refusing matches (or the ability to do so limits a faculty member's recruiting) forces the faculty to hire students directly outside of the process established or even outside the departmental confines.

### **3.7 Discussion**

The goal of this study was to compare how different programs manage the process through which students find advisors in two Chemical Engineering programs from the perspective of faculty and to understand how agency is negotiated across such process. Our results showed that both programs practice a fairly similar matching process. Both processes are connected to admissions and both programs face the same challenges in managing student's evolving research interest and the faculty's research needs. However, how faculty negotiate

agency between the program director and the other faculty was different and ultimately impacted faculty satisfaction. Faculty strongly valued perceiving that they had agency over the matches even if it may not mean their ideal candidate.

Although seemingly similar from an operational perspective, the process in the two Departments can be interpreted quite differently from a principal-agent perspective. In Department A the agent (Graduate Program Director) works with both principals (students and faculty) to develop an outcome. While the priority is laid on the student preference, the graduate program director does convene with faculty to ensure they are satisfied with the outcome and negotiate the outcome. In Department B, we see that the agent not only sides with the student but limits faculty agency perception despite the faculty being also a principal (summarized in Figure 11).

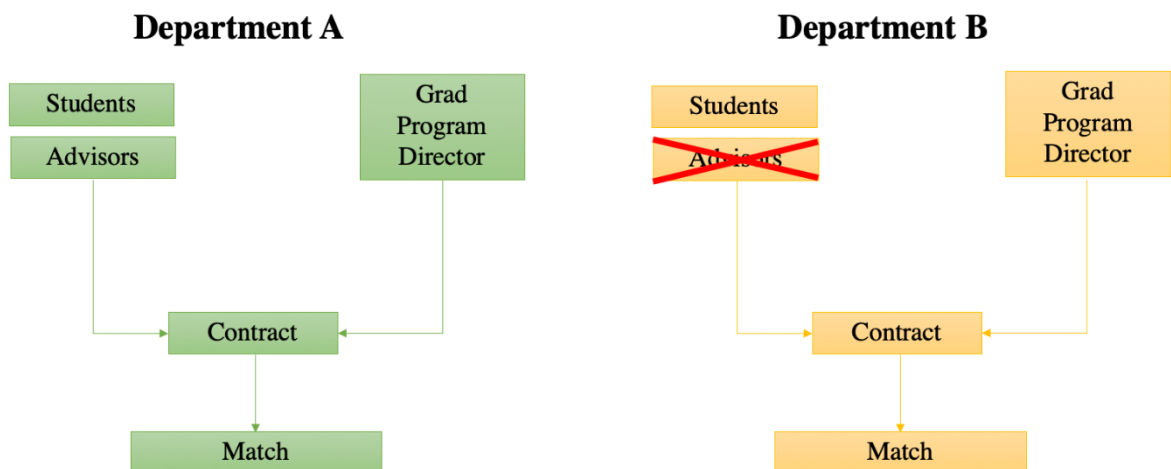


Figure 11. Principal Agent Theory in Departments A and B

Consequently, faculty describe taking actions that circumvent dealing with the agent rather than monitor or regulate the actions of the agent in order to promote satisfaction. Faculty

in Department B do not feel that they obtain the students they need by using the preestablished process. Thus, being dissatisfied with the process, these faculty resort to recruiting students outside of the preestablished process for the department. Faculty in Department A, however, are satisfied with the process and receive students that they like. Thus, they use the process to recruit students and do not deviate or observe their peers deviating from the process (summarized in Figure 12).

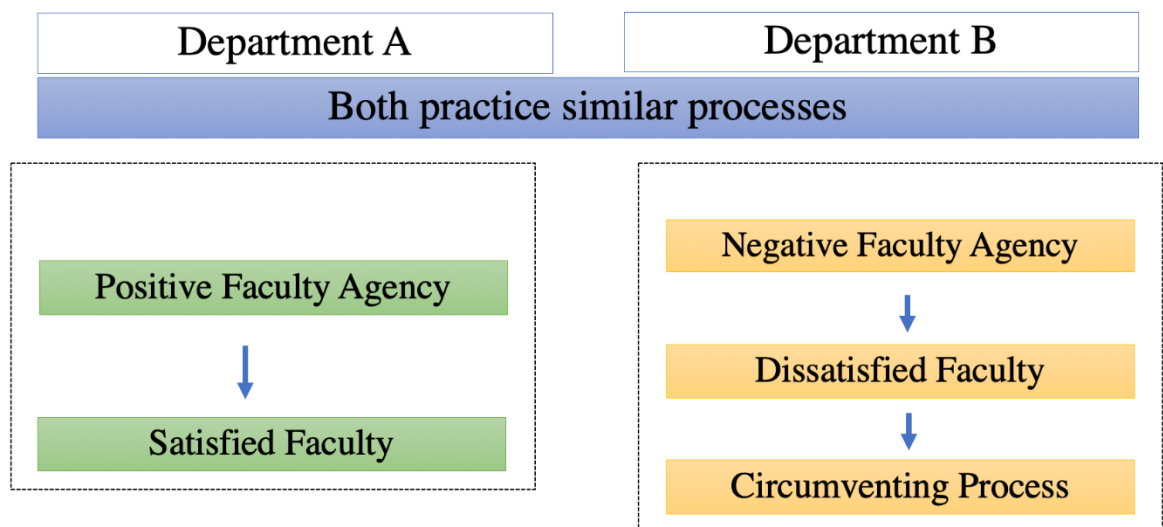


Figure 12. Comparison of Faculty Actions in Departments A and B

One possible explanation for our results comes from a study by Ensminger (2001). While studying nomads in Africa, Ensminger (2001) described that in certain principal-agent relationships, the principals prefer to trust the agent in executing the agreed upon contract rather than engage in monitoring activities to assure the outcome meets their needs. This trust between parties has been previously shown to increase the cooperation and the overall value gained by both parties from the transaction. When the agent trusts the reasons for the principals to not accept the outcomes are valid, we observe a reciprocal agency negotiation and higher levels of

satisfaction across parties. We observed similar behavior in Department A when a junior faculty shared they were free to decline an offer within reason and his overall satisfaction with the process. However, if the principals do not trust the agent to produce a good match or outcome and the agent does not trust the principals to be rational when vetoing the outcome, the agency negotiation breaks down across parties and the person that holds the information, in this case the agent, end up holding the power. This behavior was similar to that of faculty in Department B where faculty did not feel they were able to decline a match they did not like without repercussion. This observation of higher satisfaction and reciprocity among colleagues matters as advisor matching is but one facet of an academic job which has been shown to flourish in a collaborative and collegial environment (O'Meara et al., 2019).

It is worth noting that the language in either handbook did not describe the part of the process that involved faculty being able to communicate their desire to accept or decline a specific student. Faculty also did not mention this process existing in writing elsewhere. The lack of such written process or 'contract' between the faculty and the graduate program director speaks to a potential substitution of a relationship based on a contract for one of kinship and balanced reciprocity (Ensminger, 2001). Such relationship can be defined as one where there is no precise process in place, there is less overseeing of the graduate program director decision by the faculty, and the faculty have a greater tolerance for the long term sacrifices in the matching process. The nature of Department A is a good example of this process. We observed little to no scorekeeping among faculty and willingness to make sacrifices for the greater good of the department. However, this relationship is hard to maintain if faculty keep getting shortchanged in the process. We observe in Department B that the lack of agency is starting to become a problem for some faculty members as described in the results section of this chapter. If this perception of

lacking agency persists, PAT proposes that it could lead to the need for explicit contracts stating how the matches would be made and monitoring of the graduate program directors (Eisenhardt, 1989). Therefore to maintain faculty collegiality and cooperation there needs to be an assurance that any sacrifices made for the better good of the departmental community are more representative of investments than costs in the long run (Ensminger, 2001). As stated by Ensminger (2001) *“Trust occurs neither randomly nor prematurely. It occurs in direct measure to a decreased risk of the probability of cheating on the parts of both the principal and the agent, and this assessment is based on their incentives for long term cooperation their reputations and the general social context of norm enforcement. This is a story of trusting in order to diminish accounting for very calculated reasons”* (p. 199).

Another important aspect of our results is how faculty are defaulted to look at research interest initially, but as they develop their own criteria over time, they learn to judge students across multiple aspects. Because the process relies on research interest, neither students nor faculty are taught or encouraged to ask questions beyond that have been shown to matter in an advising relationship (Nettles & Millett, 2006; Zhao et al., 2007). This finding matches what the literature has said about faculty learning the doctoral advising process through what their environment teaches them and reflective perspectives of their own doctoral experience (Mcalpine, 2013; O’Meara, Rivera, et al., 2017). Our results showed established faculty having deeper and broader criteria for gauging if a student would be a good fit; however, these criteria were only developed through practice and over time. Thus, it is important to consider the influence these processes have on junior faculty recruitment of doctoral students.

### **3.8 Conclusion**

In conclusion, this study showed that how doctoral programs negotiate faculty agency can impact faculty satisfaction. While the process of matching doctoral students to an advisor in chemical engineering can seem similar from an outsider perspective, it was through the faculty members' viewpoints that we were able to assess the nuances of each doctoral program. This study also showed that recruiting, just like advising, is a process learned through experience. Departments should consider how they support junior faculty development in their journey as doctoral advisors.

Our findings also opened questions for future research. We believe it may be worth considering the effect of faculty satisfaction with institutional prestige (Morrison, Rudd, Picciano, & Nerad, 2011). While we observed that faculty at the higher ranked institution were more satisfied and had a more positive belief about the quality of the students they received than the lower ranked institution, it may be worth further evaluation if there is a larger trend across multiple institutions. We also recognize that individual faculty member's experiences are a function of their characteristics and demographics. While it was not the purpose of this study to evaluate the experiences of individuals but rather the aggregate of faculty within a department, we recommend future research use this to observe if the experience of recruiting and being matched to students varies across faculty based on faculty characteristics commonly studied demographics such as gender and/or race (Callister, 2006; Ong et al., 2011). While it was not a salient theme in our findings, further research could also look into the role of the information asymmetry that differentiates these cases (whether professors know which ranking students placed them as a top or last choice) as an influencer of the agency negotiation. Understanding the

influence of this information asymmetry on the process could help refine this practice for the maximum satisfaction across students, faculty, and department administration.

### **3.9 Acknowledgements**

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

## Chapter 4. Manuscript Three

### *Achieving Autonomy, Competence, and Relatedness in Advisor Selection Processes*

*Target Journal: Journal of Engineering Education.*

*This manuscript includes intellectual contributions from Dr. Holly Matusovich, who will be credited accordingly as co-author in this work.*

#### **4.1 Introduction**

In US doctoral education, one of the first roles of the doctoral program is to facilitate the process through which students' find a doctoral advisor. Selecting an advisor is a particularly important decision made early in the doctoral process (Bair & Haworth, 2004; Barnes & Austin, 2009; Barnes et al., 2010; Hilmer & Hilmer, 2007; Noy & Ray, 2012; Zhao et al., 2007). An ill-informed advisor selection could lead to an unsatisfying advising relationship, which has been one of the most contributing factors for doctoral attrition (Bair & Haworth, 2004; Baker et al., 2014; Devos et al., 2016; Hilmer & Hilmer, 2007; Noy & Ray, 2012). However, not all students enter the Ph.D. prepared to make an advisor choice (Lovitts, 2001). Students come into the Ph.D. with different expectations of doctoral work (Holbrook et al., 2014; Lovitts, 2001). These expectations are often based on their previous experiences which could range from students fully aware of the purpose of the Ph.D. to students with incomplete, ill-informed perceptions that lack nuance about the doctoral pursuit (Holbrook et al., 2014; Lovitts, 2001). These preconceptions could hurt students in the advisor selection process, especially if they belong to programs that force them to make this selection early in the doctoral pursuit (Artiles & Matusovich, 2019)

Motivation theories suggest that for a person to feel self-determined and internally motivated to pursue a task, they need to have a balance between feeling supported in the pursuit

of a task that meets them at their skills level but also maintain their ability to act in it out of their own volition. For the context of advisor selection, all students need to be able to select their advisor so they can be intrinsically motivated to work with them, but the task of choosing should not be one that removes their autonomy or one in which they feel unsupported.

Chemical Engineering differs from most other engineering disciplines by offering a relatively structured process for incoming students to select an advisor (Artiles et al., 2019). When examining how two Chemical Engineering programs practice advisor selection processes, data revealed that the faculty gave most of the autonomy to the students in the process, even if that meant them sacrificing their own (Artiles & Matusovich, 2019). While that study showed that students have autonomy, it did not determine whether students have the structure to support them in choosing the right advisor for them. Understanding this support structure is particularly relevant when knowing that not all students enter the Ph.D. with equivalent experiences or preparation and their individual backgrounds often influence their doctoral journey (Artiles, Matusovich, Bey, & Adams, 2018; Bluestein, Amelink, & Artiles, 2018; Gardner & Holley, 2011; Gilmore, Vieyra, Timmerman, Feldon, & Maher, 2015; K.A. Holley & Gardner, 2012; Jaeger et al., 2017; Le & Gardner, 2010; Wood, Campbell, & McGee, 2016). Thus, the purpose of this study is to explore how students experience the satisfaction of their basic needs in the advisor selection process of one Chemical Engineering program and which student attributes influence this satisfaction of needs.

***RQ1: How are student's basic needs satisfied in the process of selecting a doctoral advisor in Chemical Engineering program?***

***RQ2: What student attributes impact the satisfactory of basic needs in selecting a doctoral advisor?***

Grounded in self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000), this study will expand existing literature on the doctoral student experience by exploring how advisor selection processes can impact student self-determination and how this is experienced across students with diverse backgrounds. The findings list specific considerations for departments on the specific support students may need when selecting an advisor. The study also provides considerations for departments regarding the design of processes and policies for students of diverse backgrounds.

#### **4.2 Background and Theoretical Framework**

This study is grounded in Self Determination Theory (SDT) (Deci & Ryan, 1985, 2010). SDT is a macro theory of motivation that focuses on individual growth and needs. The macro theory is composed of five smaller theories: basic needs theory, organismic integration theory, goal content theory, cognitive evaluation theory, and causality orientation theory (Ryan & Deci, 2000). Basic Needs Theory (BNT) is fundamental to all of the mini-theories. BNT states that all human beings have 3 innate and instinctive needs: autonomy, competence, and relatedness (Ryan & Deci, 2000). The need for autonomy is the need to be the causal agent of one's own life. The need for competence is described as the need to be successful or feel like one can succeed in a task. The need for relatedness is the need to interact with others. As the needs are met in our everyday lives, we grow in optimal conditions and become more motivated people. These needs were used in this study to explore the experiences of graduate students in finding an advisor, particularly how students assessed and negotiated the satisfaction of their basic needs while finding an advisor. This study also takes a look at their experiences to understand how the advisor selection process they practiced promotes specific needs over others.

While these innate needs are sought to be satisfied it is important to note that they also need to be balanced. For example, the imposition of too much control or structure over a student's advisor choice can hinder a student's intrinsic motivation to work with such advisor and can create a negative backdrop from which the advising relationship has to recover from before it even begins (Deci & Ryan, 1987). However, because all students may not have a clear idea on what graduate school entails upon entering, they also need structure to guide their decision. Thus, programs need to balance these competing needs of autonomy and competence.

Self-Determination theory has been more recently framed as a way to look at organizations. Gagné & Deci (2005) assert that work climates that encourage the satisfaction of basic needs increase employees' intrinsic motivation and internalization of the work goals as well as satisfaction with their workplace. One could argue that the doctoral program in engineering can act as a workplace environment since students are effectively employed by the program and/or by the advisor throughout the Ph.D. or, at a minimum for those students on funding external to the department, they are beholden to the program's policies and processes.

**4.2.1 The Doctoral Pursuit through a Motivational Lens.** Broadly, research has shown that student basic needs often vary dependent on student's individual backgrounds. A commonly discussed line of research is how the doctoral experiences varies based on students demographics (Ong et al., 2011; Wood et al., 2016) race and ethnicity (Sowell et al., 2015; Wood et al., 2016), and international status (Le & Gardner, 2010; J. Zhou, 2014). Another line of research has focused on how previous experiences and interactions with academic life influence student's later experience in graduate education. For example, studies have shown that students that have participated in undergraduate research have better research and writing skills when they go to pursue the Ph.D. (Gilmore et al., 2015; Maher et al., 2008). Similarly, studies on 'returners' or

doctoral students who enter the Ph.D. after a considerable amount of time in the workforce, tend to possess different views on their motivation compared to student who pursue the Ph.D. directly after obtaining their undergraduate or master's degree (Mosyjowski, Daly, Peters, Skerlos, & Baker, 2017). While the previous studies show a variety of student attributes that can yield varying doctoral experiences, motivational theorists argue that all human needs can be classified into three basic needs.

Self Determination Theory is one of the most common motivation theories used in educational contexts and particularly Engineering Education (Brown, McCord, Matusovich, & Kajfez, 2015). However, the elements of SDT are also similar to concepts and ideas represented in other frameworks. Therefore, while literature on graduate education broadly may not always be situated in SDT, the concepts of agency, competence or support, and social connection have been widely discussed as critical to doctoral education.

**4.2.2 Autonomy.** Autonomy is described by Deci and Ryan the need to act out of one's own volition consistent with one's interest and/or values (1987). In the doctoral education literature, the concept of autonomy in the student experience has been studied along two lines of inquiry. The first line of inquiry, and by far the most popular, is autonomy in the relationship with the advisor; this is to say whether the advisor is allowing students too little or too much autonomy in the doctoral pursuit. The second line of inquiry is in relation with the broader doctoral experience. The following studies present example of each of these lines of inquiry with relation to the doctoral student experience.

Concerning the advising relationship, Deane, and Peterson (2011) surveyed doctoral students to assess students' academic, personal, and autonomy support as well as their research self-efficacy. The results showed that students with a high research autonomy had a higher

research self-efficacy when advisor support and availability were also high. However, a high autonomy did not lead to a high research self-efficacy when the advisor support and availability were low. Advisor support and availability were characterized beyond research assistance to a friendly and emotionally supportive advisor in the face of research adversities. Conversely, the authors found that student satisfaction with the advisory relationship was not consistent with the degree to which supervisors supported students' autonomy, thus proving that students need a balance of both support and autonomy on their path to becoming independent scholars.

Concerning the broader doctoral experience, O'Meara et al. (2014) conducted a mixed methods study where they examined the ways departments influence science, math, and engineering doctoral students' ability to pursue goals that matter to them or autonomy towards their career advancement. The authors found that departments can enhance student autonomy towards career advancement in multiple ways but particularly by providing structures and opportunities to practices the necessary skills and access to resources and networks that could help students pursue a myriad of careers. By providing structures and networks to help students succeed, they increased students perceived social capital. This social capital helped increase students sense of belonging in the department. The authors exhort departments to take responsibility for the environment they create for students.

Both of these studies demonstrate that not only is autonomy crucial for student motivation but also that too much autonomy must be guided with support for students to be successful.

**4.2.3 Competence.** The need for competence is described by Deci and Ryan as 1) the need to feel effective and capable (1985; Ryan & Deci, 2000) and 2) the existence of support such that one can then feel effective and capable (Deci & Ryan, 1987). It is important to note that

feeling capable does not mean to feel unchallenged, but rather to find that tasks match the preparation of an individual and to perceive growth in the outcome of pursuing its completion.

In doctoral education, this need for competence of support has most commonly been discussed in terms of the role of the advisor. For example, when taking a broader view on doctoral education, a study by Cockrell and Shelley (Cockrell & Shelley, 2011) investigated the relationship between academic support systems and student satisfaction. The authors surveyed doctoral students across four institutions in the US and found that 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. The authors also found that students being involved in learning communities, such as research or study groups, help facilitate the learning experience increasing student satisfaction.

When specifically looking at doctoral student development frameworks, one can build a strong case for the need of competence being particularly crucial at the early stages of the doctorate. Specifically, theoretical work (establishing frameworks) and research studies have argued that doctoral students entering the Ph.D. program do not have an accurate conception of what the doctoral pursuit entails (Lovitts, 2001); frameworks for graduate student development in particular label this 'stage of not knowing' the initial stage of pursuing graduate education (Austin, 2009; Lovitts, 2001; Twale, Weidman, & Bethea, 2016; Weidman et al., 2001) Misconceptions held in this stage can leave students unprepared to take on the important early choices of the Ph.D. warranting support to feel competent in making decision. One particular study by Holbrook et al., (2014) sought to understand the specific misconceptions students hold when entering the doctoral pursuit. The authors found that student possessed negative mismatches between expectation and reality and these forced students to question their

preparation and fit with the doctoral program and not necessarily in a positive way. Therefore, the need for competence needs to be satisfied to promote persistence in the doctoral pursuit.

**4.2.4 Relatedness.** The need for relatedness is described as the need to connect and belong in a social group (Deci & Ryan, 2010). The need refers not only to taking from others but being able to contribute socially. This need can often overlap with the emotional aspects of the doctorate and has been argued to relate to students' sense of belonging (Osterman, 2000). The following examples are studies that studied the concept of relatedness in the advising relationship and the research groups in which doctoral students function.

The first example is work by Curtin, Stewart, and Ostrove (2013) which used a climate survey to examine the role of the advisor in doctoral students' sense of belonging. On a sample of over 300 domestic and international graduate students at a large public institution in the midwestern United States, the results showed that doctoral students' relationships with the advisor had a strong influence in their sense of belonging and academic self-concept. This finding was particularly true for the domestic students who showed a stronger relationship between belonging and their academic self-concept.

In a qualitative study of an intervention, Holley & Caldwell (2012) sought to understand student motivation in association with a mentoring program at a Southern institution in the US. Twelve participants were interviewed to understand what students valued in a mentoring relationship. The authors found that students strongly valued contact with faculty beyond the advisor. More specifically, students found that receiving the same advice regarding graduate school from different people gave them a more holistic view of the graduate experience and increased their self-efficacy in completing the degree. In a similar manner, the study also found that these students valued peer interactions beyond the advising relationship which as these

relationships reinforced their relationship as it helped them overcome impostor syndrome. These findings align with the need for relatedness in the process of completing the Ph.D., in this case via social networks within the doctoral program.

In a smaller study of participants with earned doctoral degrees, Jairam & Kahl (2012) studied how social support aided or hindered doctoral students towards degree completion. The authors found that students benefitted from aligning themselves to a small group of academic friends seeking similar goals as well as having a good rapport with the advisor. The authors also found that seeking assistance from family on certain tasks while education family members on the doctoral student experience helped students create a network of support.

**4.2.5 Literature Summary.** The previous studies have summarized what we know about doctoral students' basic needs and how these needs may vary dependent on their individual background. However, most of these studies focus on the needs of more advanced phases of doctoral education, and not on the initial phases of the doctoral student experience such as the selection of an advisor. And while we know some information of what students value when choosing an advisor (Joy et al., 2015; Nettles & Millett, 2006), we do not have information of how students experience doctoral processes such as choosing an advisor and how these experiences vary across students. This study aims to address this gap by comparing how students in one program experience the selection of an advisor from a basic needs perspective (Deci & Ryan, 1985; Ryan & Deci, 2000). Further, this study's results show how processes that are outwardly neutral can be experienced differently across students.

### **4.3 Methods**

The proposed study is grounded in case study methodology as described by (Yin, 2003) as (1) the nature of the research question is exploratory; (2) the investigator lacks methods to control the site and participants; and (3) the phenomenon being studied is contemporary and the context is real life. These conditions are met as the goal of the study is to describe the ways through which the phenomenon under question is occurring in a single doctoral program, we are unable to control the site or the student participants, and the phenomenon is ongoing as the students are currently either selecting an advisor or being advised by them.

**4.3.1 Case Background.** The study was conducted in accordance with human subjects research ethics as review by the Institutional Review Board. The study took place in a large public institution in the Midwest. This institution is known for its engineering programs and its Chemical Engineering program is ranked in the top 30 in the US. The study focuses on a single institution to understand the variety of student experiences while controlling for institutional and departmental variation (Golde, 2005).

In this doctoral program, students are admitted without an advisor and are funded by the department in the first semester. Students are then invited to participate in a research seminar to become more familiar with the available research projects currently seeking doctoral students in the department. Students are then required to meet with a minimum of three faculty and then submit a form indicating 3 faculty in ranked order, they would like to have as an advisor. The graduate program director compiles these preferences and shares arranges matches between faculty and students. Details of the process have been reported elsewhere (Artiles & Matusovich, 2019).

**4.3.2 Data Collection.** The main unit of analysis in this study is the individual student. The main data source for this study is semi-structured interviews with doctoral students enrolled in a

Chemical Engineering doctoral program. The goal of these interviews was to understand the students' individual experiences in selecting an advisor and their perspective of this program's process. The questions aimed to understand what factors did students consider when selecting an advisor, why did they deem these factors as important, and how they sought to satisfy their basic needs throughout the process of finding an advisor. Questions asked were similar to "How did you find your advisor?", "What information was made available to you during this process?", "What information did you wish you knew in the process of finding an advisor?" among others. Students were also asked contextual questions such as their relationship with their advisor, their research group, as well as their reflection of what they would change if they had to undergo the process of finding an advisor all over again.

**4.3.3 Participant Recruitment.** All doctoral students currently enrolled in the program were invited to participate in the interview via email. 14 participants agreed to participate and their self-reported demographics are summarized below in Table 8. Participants were compensated for their time with a \$20 Amazon gift card. While our sample encompassed multiple demographics including those typically underrepresented in engineering, comparing groups across every single demographic would be a disservice to compare based on these attributes because it could tokenize one single person. Our results did not yield any findings that could lead us to believe that students' experiences in finding an advisor could be different based on the presented demographics; we did not specifically ask about differences in experience based on demographics.

Table 8. Manuscript Three Participant Attributes

<b>Attribute</b>	<b>Sample</b>
Resident Status	7 International 7 Domestic
Gender	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

#### 4.4 Data Analysis

The interviews were analyzed via three phases of coding in the following order: theoretical, evaluative, and attribute coding (Miles et al., 2014). Using an interpretivist worldview (Lincoln & Guba, 1985). In theoretical coding, the interviews were coded using an a priori coding scheme informed by SDT (Ryan & Deci, 2000) for the constructs of autonomy, competence, and relatedness (see Table 9).

Table 9. Theoretical Coding Operationalization

<b>Basic Need</b>	<b>Literature Definition</b>	<b>Operationalization</b>	<b>Sample Excerpt</b>
<b>Autonomy</b>	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>"I believe I had authority over my Ph.D. because I was matched to my first choice".</i>
<b>Competence</b>	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>"I wish I had more time and more information when I was choosing an advisor"</i>
<b>Relatedness</b>	To connect with others and belong socially.	The need to be or seek connection to others in the process of finding an advisor.	<i>"I was more concerned with finding someone I would like to work with than findings a desirable research topic"</i>

The second phase consisted of evaluative coding (Miles et al., 2014) where we classified each instance where students referred to a basic need on whether the students were having the need satisfied or not. For example, if students described feeling prepared to select an advisor those students describe a positive competence experience. Conversely, students that describe not having a choice on their advisor would be described as having a negative autonomy experience. Finally, the third phase consisted of attribute coding (Miles et al., 2014). Here the emerging themes were labeled by the student attributes that students were asked to self-identify or emerged through the data. The attributes described were selected based on what prior literature has demonstrated to influence the doctoral pursuit. A sample table is provided in Table 10.

Table 10. Manuscript Three Coding Operationalization

Sample Excerpt	Basic Needs Theory		Attribute Coding			
	Theoretical Coding	Evaluative Coding	International / Domestic	Direct Ph.D. or MS	Prior Research	Sex
<i>“I believe I had authority over my Ph.D. because I was matched to my first choice”.</i>	Autonomy	+	International	Direct Ph.D.	Yes	M
<i>“I wish I had more time to finding an advisor”</i>	Competence	-	Domestic	Direct Ph.D.	No	M
<i>“I was more concerned with finding someone I would like to work with than findings a desirable research topic”</i>	Relatedness	+	International	Master’s	Yes	F

These coded excerpts were then examined for patterns based on the students’ attributes and experiences prior to attending graduate school. One background experience seemed to differentiate the ways through which students selected advisors and graduate institutions. By studying similarities and differences within and between students, we sought to understand whether certain factors may influence students’ experience through a common doctoral process (such as selecting an advisor). The outcome of this analysis would be to identify the attributes that influence students’ needs in the selection of an advisor.

**4.4.1 Research Quality.** To ensure the quality of our results, we triangulated within each source to ensure that the interpretations were consistent with each individual’s complete account (Tracy, 2010). Once the analysis was completed, it was externally reviewed by two researchers to ensure appropriate interpretation (Creswell, 2013).

**4.4.2 Limitations.** As with any study, this research has some limitations. First, our interview protocol did not fully evaluate all aspects of the student's prior participation in research. Therefore, 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 for the selection task. Second, our sample is predominantly composed of students in later phases of the Ph.D. Future work could take a comparative approach between students in earlier phases of the degree and evaluate how being in a different stage of graduate student development (Lovitts, 2001; Weidman et al., 2001) influences their perspective on their advisor selection experience. At the same time, we recognize that students early in the process may not have the full benefit of reflective hindsight to know what did and did not work about their process. Finally, our findings were obtained from a sample hailing from a single institution. We do not aim to generalize beyond this institution but recommend future work looks at how institutional variations on the advisor selection process (Artiles & Matusovich, 2019) may affect student satisfaction of basic needs.

## **4.5 Results**

To understand the process through which students found an advisor in terms of Self-Determination theory (Deci & Ryan, 1985), we divide the results into three sections. Our results showed that students who had research experience prior to pursuing the Ph.D. had a stronger competence and a better understanding of their need for relatedness when they selected their advisor than students who did not have this prior research experience. When referring to prior research experience, these students had participated in over a year of part time research during their undergraduate degree or pursued a research Master's degree prior to commencing the Ph.D.

The following sections discuss each of the basic needs (autonomy, competence, and relatedness) and how students differentiated in their pursuit of satisfying such needs in the process of finding an advisor.

**4.5.1 Autonomy.** Out of the 14 students interviewed, 12 had been matched to work with their first choice for an advisor. When asked if they felt they had authority over their advisor selection process most students responded similar to the quote below:

*“Yeah. I mean it gave you enough of a choice that it felt like you could pick what you wanted. I got my first option so it wasn't a big deal. [...] It gave me enough of a choice in the selection process that I was comfortable with it.”*  
[Participant 1, no research experience prior to the Ph.D.]

*“It's hard to say, because I got my first choice. In a certain sense, I would probably say yes, but that's because I got my choice. I've talked to plenty of students who didn't get their first choice, and they were like, ‘This isn't what I wanted,’ right?”*  
[Participant 2, no research experience prior to the Ph.D.]

Regardless of receiving the first choice, some students still felt that they lacked autonomy in the process:

*“It was just a preference system. So 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. Like, if the timing matches, the funding matches. Quite a few variables”*  
[Participant 4, no research experience prior to the Ph.D.]

For the two students who did not get their first preference, their responses described a lack of autonomy based on the fact they had not been able to work for who they originally preferred:

*“I was kind of disappointed, because it was my third choice. And I was kind of like “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 research experience prior to the Ph.D.]

While no clear pattern emerged from those students that were matched to their first choice versus those that were not, it is important to note that the two students who did not match with their first choice did not possess prior research experience.

**4.5.2 Competence.** Where autonomy was mainly discussed in terms of having been matched to their first choice, competence was discussed in terms of being prepared to list their preferred advisor. We were able to identify a clear pattern in our data when contrasting between students who had pursued significant research experiences prior to commencing their doctoral studies (both at the undergraduate level and/or master's) and students who had not participated in research prior to pursuing their doctoral education. The following quote describes how a student who had no prior research experience underwent the process of 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 all three of these were in the biology realm. And then my third choice ... I didn't really understand what his research was super much.”*

[Participant 3, no research experience prior to the Ph.D.]

When looking at commonalities across these students who had no prior research experience, most of these students had selected doctoral programs prior to considering who they may be working for. The following quotes describe the factors they considered when choosing the doctoral program in which they would apply to and ultimately enroll:

*“I didn't want to go super far away. I'm originally from [the Midwest], so I wanted to stay generally in the area, and all of those schools had ... or I knew that they had a good engineering school.”*

[Participant 3, no research experience prior to the Ph.D.]

*“Oh, I just Googled ‘Chemical Engineering grad programs, top 25’”.*

[Participant 5, no research experience prior to the Ph.D.]

*“I was pretty concentrated to the Big 10. I’m from [Midwest], so that was what I was very familiar with.”*

[Participant 6, one summer REU experience]

*“I grew up in [institution’s city]. I was familiar with it. It was the best school that I applied to, and I got accepted to it, so that was primarily it. [...] I had no idea what advisor I would work with going into it.”*

[Participant 2, no research experience prior to the Ph.D.]

Conversely, peers who had undertaken longer research experiences typically over one year, either during their undergraduate degree or while pursuing a research master’s, had a clearer idea of the factors relevant to selecting an advisor and by consequence described a more thorough process to select the institution in which they would ultimately pursue the Ph.D. The following quote shows one student’s process when selecting institutions:

*“When the time came to apply for grad school I asked my advisor, where do you recommend me looking at? He gave me a list of people he knew in our field across the US. I went some digging around [...] It turns out I found the person who is now my advisor, and I went back to my undergrad advisor and said, do you know this lady? He said, yeah. She was my student. He encouraged me to apply for her. He said she’d make a great advisor. She’s very kind and creative. I went ahead with that after he said, yeah, you should apply for her.”*

[Participant 7, undergrad research for two years]

In this quote we can observe how the student had a specific idea of what research topic they wanted to pursue and only applied to institutions that had professors working in that type of research. When the time came to choose between programs, this student had already filtered for the research topic first. The following quote shows a peer who similarly had already narrowed down the institution but had multiple options for selecting a faculty for whom to work for:

*“Okay. I think during the summer, I had already had a pretty good idea of who I wanted to work for, because I had talked to other professors within my department at [undergraduate institution]. To be honest, I liked the research that the PI that I work for now was doing. [...] I was a little bit nervous about him being a new professor, because there's always a risk with having a new professor [...] because it's their first time on something like this. I had talked to a few professors in my department, [...] I had pretty much committed and decided, okay, I want to work for this professor during the summer. In fact, I was pretty confident that I was going to work for him, so I talked to him as well, got a little bit more convinced before I accepted. [...] I have been awarded two years of fellowships here, so pretty much is what the new professor said, I can basically work for whoever I wanted to work, because I was a free student. [...] I pretty much knew that I was going to work for this PI, and he had shown interest in me as well, so I knew that it was going to be this pairing.”*

[Participant 8, undergraduate research for two years]

This quote exemplifies how students who had research experience had a broader and clearer understanding on the things that mattered in the advising relationship and sought this information before arriving on campus and used their own sources of information often outside of the Ph.D. department.

Not only did these students understand what to look for in an advisor, but they also knew what factors could be negotiable. In the following quote we see how another student kept his options open strategically when selecting an advisor:

*“I knew that there was a matching process, and [...] I knew that I knew the risk that there's always a possibility of not being able to work with somebody, but like I was saying 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 three years and master's]

This same student also understood that to get their first choice of advisor, they would need to convince the professor to vouch for him in the matching process. This student decided to take pre-emptive actions beyond what the program required so he could all but guarantee that he would be able to work for his preferred advisor:

*“Okay. I sent an email to [Advisor] a month before I intended to move and expressed my interest. I asked her if it's okay for me to get a feel for the lab even before the program starts. [...] I just kind of 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 crew meetings, and she knew 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 master's]

In sum, students that have research experience demonstrated a more thorough understanding of the role and the advisor and what characteristics the advisor needed to possess to help the student be successful in the doctoral pursuit. The majority of these students first selected specific advisors they would like to work with and from there decided the schools they wanted to apply for admission. Contrariwise, students without research experience tended to prioritize institutional factors such as ranking and geography in their selection of where to attend. Once they had selected an institution, they then considered who to work with based on the availability at that institution and typically based only on the research topics the faculty were working on.

**4.5.3 Relatedness.** Relatedness was typically described as feeling connected to others. For this need we were able to distinguish across students in the way they chose their advisor. Students without prior research experience described their process of finding an advisor as considering a research topic and a facilitator for conducting such research. Most of these participants did not describe considering relatedness in the process of choosing an advisor.

*“One of [advisor]'s students, gave me advice that someone else gave him [...] and it's that you should work with an advisor that you get along with and that you have good chemistry 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. Yeah, unfortunately I can't say whether or not ... I did take that advice. 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, basically.”*

[Participant 2, no research experience prior to the Ph.D.]

While the majority of these participants did not describe considering relatedness when selecting an advisor, at the time of the interview they discussed realizing this need as important over the course of their Ph.D. When asked what would they change about the process, they all indicated their desire to have participated in rotations to test how labs and advisors work:

*“I think that rotations are a good idea, and I understand why they don't do them, because it delays everything. I think that getting to work for a couple weeks and seeing what's actually going on in the lab would be helpful. I feel like it's impossible to make a completely informed decision. Because you know the general research area of the advisor but you don't know exactly where a project is going to lead, or really what a project entails.”*

[Participant 3, no research experience prior to the Ph.D.]

Students with prior research experiences had a clearer understanding of the role of relatedness in conducting research under an advisor. When one student asked what did they attribute their success in graduate school to, one student responded:

*“It was mostly talking to the students that he had in his lab for the year before. I talked to them, basically I wanted to make sure how the interaction between the PI and his students were. I wanted to see how in the lab he was, [...] the amount of work he was giving [...] their opinions on the publications that he would write and the way that he thought about new ideas and stuff like this”.*

[Participant 8, undergraduate research for two years]

*“I think maybe the good relationship with the professors [...] a good relation means you have a better communication. You can get the information correctly. You know what's the professor wants. You know how should you pursue your goal. 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 about all your data and results.”*

[Participant 10, research master's at different institution]

These students also concurred about adding rotations to the existing process. However, they also recognized that for students who have a clear idea on who they would like to work with, forced rotation could be a waste of time:

*“One of the universities that I got accepted to had rotations every year. [...] It's hard to tailor. This could be nice for the people that don't necessarily know who their advisor would want to be, but I could also see why that could be a waste of time for people who are very sure of what they want.”*

[Participant 8, undergraduate research for two years]

In sum, we can observe by evaluating student's description of their process for finding an advisor that students who have substantial experience in research (be it during undergraduate or through Master's) have more accurate mental models of the what the doctoral process is and are better positioned to making an educated selection. This statement does not mean that only such students will make a better selection, but that they are better equipped to undergo the decision process as designed and supported by the doctoral program. While we evaluated students experiences across 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.

#### **4.6 Discussion**

The goal of this study was to examine how Chemical Engineering doctoral students' satisfaction of basic needs in the process of selecting an advisor were met. This study also aimed to examine how the meeting of these needs differed based on students' attributes and prior experiences. Our findings showed that despite the Chemical Engineering process of finding an advisor being a highly structured process when compared to other engineering disciplines (Artiles et al., 2019), most students in this program still felt that they possessed autonomy to select who they wanted to work with. However, our findings also showed that, overall, students with prior research experiences had a lower need for competence because this prior research

experience resulted in them possessing a better understanding of what they were looking for in an advisor. This difference results in students with prior experience having a higher likelihood of having all of their basic needs met.

When looking at all three basic needs, we see that in this context, these needs act as rungs of a ladder where students first satisfy their autonomy, then their competence, and lastly their relatedness (model reflected in Figure 13 adapted from Kajfez & Matusovich (2017)). In this case, all students begin on equal footing as the department is granting them autonomy over their advisor decision. However, students that have prior research experience tend to have a more accurate idea of what they should be looking for in an advisor while students who did not have such experiences only relied on the knowledge and experiences that the department is providing them. Thus, students with experience begin one rung higher in the ladder than students without.

The problem with this disparity across students is that the process is both designed and practiced in such a way that students without experience are not made aware of what they should be assessing in their selection of an advisor. Students without research experience begin ‘climbing the ladder’ of meeting their basic needs on the autonomy rung and can see the competence rung or what the program is advising them to look for which is interest in a research topic. However, students with prior research experience understand what they need to look for beyond what the program is advising, so they are on the competence rung on the ladder and have a better viewpoint of understanding that relatedness to their advisor is also relevant, so they seek this characteristic throughout their selection process. Thus, students that select an advisor strictly based on research topic are at a higher risk of positioning themselves in advising relationships that may not meet their basic needs for relatedness. 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 (Bair & Haworth, 2004; Lovitts, 2001; Zhao et al., 2007).

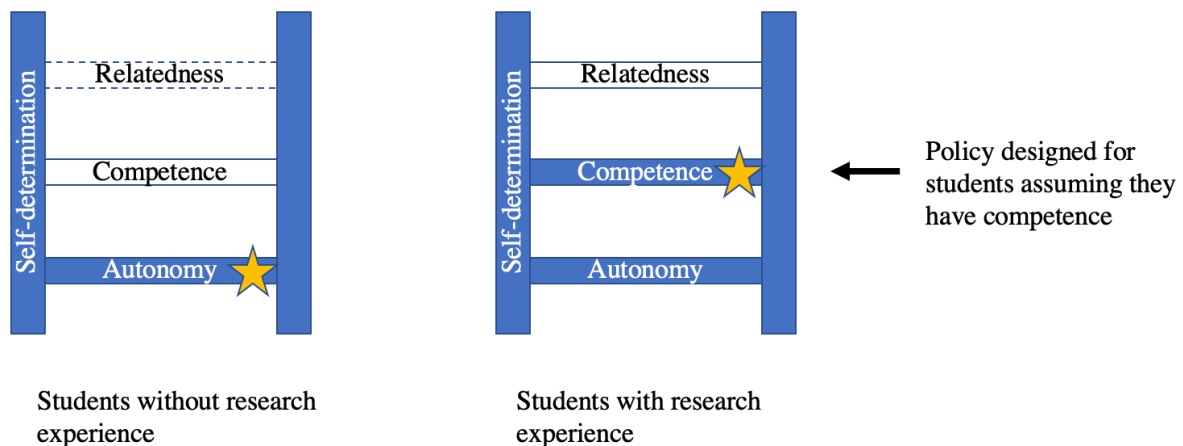


Figure 13. Ladder Rungs in Self Determination Theory

Deci & Ryan (2000) 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” ( p. 58). However, Ryan and Deci (2000) 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. When we place these theoretical propositions in our context, we can observe that they align with our findings. Students that lacked competence questioned their autonomy, and students that lacked autonomy were not motivated to work with their assigned advisor. Therefore, people must experience both competence and autonomy to be self-determined and intrinsically motivated. In these explanations, the need for autonomy can be defined as a person's need for independence and the ability to make their own choices. The need for competence is a person's need to be successful and competent in the social world (which as defined above can be

encouraged via structures). Ryan & Deci (2000) go on to indicate that the degree of satisfaction of our need for autonomy distinguishes whether we simply enjoy the activity because we are being externally motivated to do so (also referred to in SDT as introjected motivation) or because we have developed internal motivation towards the task (also referred to in SDT as identified or integrated motivation). Therefore, our findings align with prior studies that state autonomy and competence complement each other in the pursuit of intrinsic motivation; a high competence structure needs a high autonomy to match (O'Meara et al., 2014; Overall et al., 2011).

This 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 students that are interested in such projects. However, the goal of obtaining a Ph.D. (and from the faculty standpoint, training a Ph.D. student) is not necessarily furthering work existing under an existing research project (such as funded grant work) but learning how to conduct independent research (Gardner & Mendoza, 2010), a process that requires internal motivation (Mason, 2012). Therefore, students who do not have research experience could be assisted in understanding the multiple and often competing tasks that they may face and what they may need from their advisor throughout the doctoral process. This awareness will help students have a fuller understanding of the characteristics they should be looking for in an advisor rather than their research topic, funding availability, and whether they make their students work on weekends.

Another important implication of this research 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 preferences for relatedness. 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 who they preferred to work with. These findings align with prior research that has suggested a positive research group environment as a motivator for doctoral students (Golde, 2005; Jairam & Kahl, 2012).

#### **4.7 Conclusion**

In conclusion, this study provides two significant contributions to engineering doctoral education. The first contribution of this study is that it provides empirical evidence of student stratification in the process of selecting an advisor along the lines of those who have research experience and those who do not. This study shows that the process of finding an advisor in Chemical Engineering as practiced in most institutions (Artiles et al., 2019; Artiles & Matusovich, 2019) does not provide the preferred support for students who have not participated in research activities; thus, limiting their ability to make a decision in selecting an advisor that can help them satisfy all of their basic needs. The second contribution of this study is the expansion of the analytical generalizability of SDT in doctoral education processes. This study provides a template on how to use SDT as a framework to not only understand an individual's needs in a setting but also specific interactions with conventional processes in higher education.

Future work could extend to applying a similar approach to other advisor selection practices as a way to determine how students' need are being satisfied (Kajfez & Matusovich, 2017). Another recommendation for future work is to examine students' experience through a longitudinal approach to determine if there is any relationship with students' prior experiences, how they choose an advisor, and students' satisfaction in the advising relationship over time. Similarly, future research work could look into how other areas of the doctoral pursuit are

influenced by students' prior participation in research, which specific aspects of research participation influence researcher development positively towards doctoral degree success, and how programs can help level the playing field for all students.

#### **4.8 Acknowledgements**

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

## Chapter 5. Implications & Conclusion

### 5.1 Introduction

A doctoral advisor is a central component of the doctoral pursuit and one of the main influences in a student's decision to persist in the Ph.D. (Bair & Haworth, 2004; Barnes & Austin, 2009; Hilmer & Hilmer, 2007; Joy et al., 2015; Paglis, Green, & Bauer, 2006; Zhao et al., 2007). However, students choose their advisor in the early phases of the Ph.D. when they still possess a very limited understanding of the doctoral journey in which they are about to commence (Lovitts, 2002). When students make this decision without properly understanding the role of the advisor and what characteristics would best serve them in their doctoral pursuit, there is a risk of students and faculty ending in a working relationship where the expectations held for each other are mismatched (Baker et al., 2014; Devos et al., 2016). Numerous research studies have argued that those students that remain in less than satisfactory conditions are more likely to lose satisfaction with the doctoral pursuit as a whole (Baker et al., 2014; Pyhältö, Vekkaile, & Keskinen, 2015; Zhao et al., 2007), more likely to develop mental health issues (Levecque, Anseel, De Beuckelaer, Van der Heyden, & Gisle, 2017), more likely to take a longer time to degree (Bair & Haworth, 2004), and risk not completing the doctorate (Lovitts, 2001).

Yet, knowing how important the advisor selection can be to the doctoral journey, little research has addressed how students and advisor pairings occur or are facilitated by the department. Prior work has shown that this process is both highly contextual and highly individual to the student (Golde, 2005; Nettles & Millett, 2006; E. Zhou & Okahana, 2016). While some research has addressed the doctoral advising relationship formation process (Joy et al., 2015), to our knowledge, it typically has not been addressed in depth and the nuances of

disciplines within science, math, and engineering are often conflated. This lack of detail in existing research neglects important factors that can affect student persistence, faculty satisfaction, and the further improvement of doctoral program processes and practices (Gardner, 2010; E. Zhou & Okahana, 2016). Thus, with every new incoming cohort of doctoral students, academic programs continue to perpetuate practices of which there is little research on how they affect the students and faculty that participate in such.

To enlighten the faculty and student experience in such a commonplace academic processes, this dissertation sought to understand the process through which doctoral students find advisors across three different factors shown to influence the doctoral process: field of study (Gardner, 2009b; Golde, 2005; Knight et al., 2018), institution or department (Gardner, 2010; Golde, 2005; E. Zhou & Okahana, 2016), and student characteristics (Gilmore et al., 2015; Le & Gardner, 2010; Sowell et al., 2015). Specifically, through three studies, this dissertation takes a comparative approach in examining how advisor-advisee matching processes vary across fields of study and their disciplines, the programs within a discipline, and multiple students within a single program to evaluate the various experiences that could occur during this important part of the doctoral process (see Figure 14).

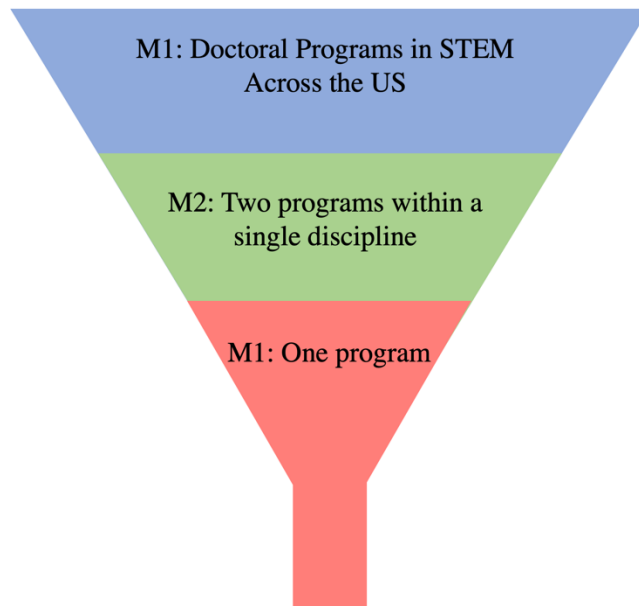


Figure 14. Reducing Scope of Manuscripts

To achieve this, we addressed the following overarching research questions:

- **What are the processes for doctoral students to find advisors in engineering, science, and math?**
- **How is this process experienced by faculty and students in Chemical Engineering?**

To address such questions, this dissertation was divided into three studies that allowed us to examine factors shown to influence the advisor selection process individually. The preceding three chapters addressed the following aims respectively:

1. Identify and describe the types of advisor-advisee selection processes that exist in engineering, science, and math and examine trends and patterns across disciplines
2. Compare how two Chemical Engineering programs practice the advisor selection process and examine how faculty and graduate program directors negotiate agency in the process.

3. Explore how students experience the satisfaction of their basic needs in the advisor selection process of one Chemical Engineering program and examine which student attributes influence this satisfaction of needs.

The research questions and key findings for each of the previously described manuscripts are summarized in Table 11.

Table 11. Summary of Manuscript Purpose and Research Questions

Manuscript	Purpose Statement	RQ	Data Sources	Key Findings
1	Identify and describe the types of advisor-advisee selection processes that exist in engineering, science, and math and examine trends and patterns across disciplines.	<p>What advisor selection process exists across doctoral programs in science, math, and engineering?</p> <p>How do these processes advisor selection processes vary by fields of study?</p>	<p>Graduate Student Handbook</p> <p>Interviews with Doctoral Program Leaders</p>	<p>Participants described <b>four main types of processes through which students can find advisors</b>: advisors and students self-select, advisor-advisee matching, temporary advisors prior to the permanent advisor, and funding dependent process.</p> <p><b>Engineering doctoral programs structure</b> the advisor selection process less than Science and Math programs because advisor selections are made earlier and fewer information systems and required tasks can be implemented.</p>
2	<p>Compare how two Chemical Engineering programs practice the advisor selection process.</p> <p>Examine how faculty and graduate program directors negotiate agency in the process.</p>	<p>How do two Chemical Engineering doctoral program compare in how they manage the advisor-advisee matching process?</p> <p>How do faculty negotiate agency with the doctoral program director in the advisor-advisee matching process in such programs?</p>	<p>Graduate Student Handbook</p> <p>Interviews with Doctoral Program Leaders</p> <p>Interviews with Faculty</p>	<p><b>Both programs practice a fairly similar matching process</b> - the processes are connected to admissions and both face the same challenges in managing student's evolving research interest and the faculty's research needs.</p> <p>How agency is negotiated between the program director and the other faculty was different and ultimately impacted faculty satisfaction. <b>Faculty value having agency over the matches.</b></p>
3	<p>Explore how students experience satisfaction of their basic needs in the advisor selection process of one Chemical Engineering program.</p> <p>Examine which student attributes influence this satisfaction of needs.</p>	<p>How are student's basic needs satisfied in the process of selecting a doctoral advisor in a Chemical Engineering program?</p> <p>What student attributes impact the satisfaction of basic needs in selecting a doctoral advisor?</p>	<p>Graduate Student Handbook</p> <p>Interviews with Doctoral Students</p>	<p>Overall, <b>students with prior research experiences had a high satisfaction of competence</b> because this prior experience resulted in them possessing a better understanding of what they were looking for in an advisor. This difference results in <b>students with prior research experience having a higher likelihood of having all of their basic needs met when choosing an advisor.</b></p>

The first study examines the existing processes through which students find advisors in science, engineering, and math doctoral programs. After evaluating over 50 doctoral programs in the US through a PAT lens (Eisenhardt, 1989), the results showed that engineering doctoral programs follow advisor selection practices differently than those observed in the science and math doctoral programs. While science and math tend to provide students with more time, information and required tasks to make a proper selection, engineering programs follow a more laissez faire approach and only provide students with a selection date that is typically before they start doctoral studies or very early in the process. These trends speak to the allocation of students inherent to each discipline due to teaching needs and doctoral funding mechanisms. Math and science programs tend to have more teaching positions available that can help in funding students until they commit to an advisor, while engineering programs may not. Within engineering, a notable exception was doctoral programs in Chemical Engineering. These programs practiced a hybrid process with characteristics that match those held in both engineering and science doctoral programs. Chemical Engineering made students interview a number of faculty, submit their top advisor choice to the graduate program director, and this person would then match all doctoral students to a faculty member using their preferences and resource availability among other information to conduct such matches (faculty input on such matches varied by program). The findings relating to this process became the impetus for studying Chemical Engineering programs as the main sample in the subsequent studies (manuscripts two and three).

The second study (Manuscript 2) focused on understanding the variations in advisor matching within a single discipline and their effect on faculty satisfaction. Using the faculty perspective, this study compared how the advisor matching process was practiced in two separate

doctoral programs through a PAT lens (Eisenhardt, 1989). The results showed that while the process was mostly similar across programs, minor variations in the process can lead to large effects on faculty satisfaction and agency. Also, faculty were willing to trust their individual agency to the administration in order to benefit the student. However, this trust could quickly waiver when they perceived to be making a continuous sacrifice for the larger good of the department without reaping the benefit in terms of recruiting students over multiple doctoral cohorts. The findings also showed that faculty criteria for recruiting doctoral students originated in a way that to the process but the criteria became refined as they gained more experience in advising students. This understanding served as a rationale for studying the variations in the student experiences in the third study of this dissertation which takes one of such programs and examines the student experience.

The third study examined how students experienced the advisor matching process through a self-determination theory lens (Deci & Ryan, 1985; Ryan & Deci, 2000) and it evaluated whether certain attributes made them better prepared to go through the process. Findings showed that not all students enter the doctoral process with an equal level of knowledge regarding the purpose and the dynamics of doctoral research and that this disparity has an effect on their decision-making process when finding an advisor. Specifically, students who had a significant background in conducting research (either as an undergraduate or master's) possessed richer criteria on what they sought in an advisor. Conversely, students who had not conducted research defaulted to the criteria suggested by the department which was mainly finding a match regarding research topic. The analysis demonstrated that in the process of finding an advisor, students were granted autonomy in the selection of an advisor. However, the process did not work in favor of students who did not have a research background as these often expressed

desiring more support in terms of what to seek in an advisor or more time before they had to declare their preferences. These students also and to not have considered the social aspects of being able to work with such advisor in the moment of listing their preferences. Thus, while the design of the process for finding an advisor works well for students who have prior research experience, it may not be properly guiding students who enter the doctoral pursuit without prior research experience in finding a satisfactory advisor match.

## **5.2 Implications for Practice**

The first study demonstrated that doctoral programs in math and science have significantly more practices in place to help students become familiar with the faculty, their research, their current doctoral students, and their working styles before committing to working with them. Science and Math programs also allowed students a longer time before having them commit to an advisor than engineering programs. These notable distinctions create some specific implications for engineering programs. First, engineering programs should consider their processes as a whole, particularly the type of support they are offering their incoming doctoral students and whether it meets their needs (Zhou & Okahana, 2016). For most engineering programs in our sample, students did not have support in the selection of an advisor. This lack of support could likely be due to the fact that in many of these programs' students select an advisor before stepping foot on campus; placing the onus of the advisor selection research on the student. It could be that a program's incoming cohort of doctoral students is well established in research experience and does not need additional support. However, it may also be that the students entering a particular program may need more support than that which is offered. The same implication should be considered in science and math programs. It may be that an excess of

support and processes to help students select an advisor is keeping students from making degree progress. As no single recommendation can effectively improve all programs, programs should consider the specific needs of their incoming students to design an advisor selection process that best works for their context.

In the second study, comparing how the advisor matching process was practiced across two Chemical Engineering departments revealed that the processes were practiced in relatively similar as it connected to the admissions process and matching student interest. However, a difference in how agency was negotiated between faculty and the graduate program director was observed. This difference had a direct impact on faculty satisfaction; faculty who perceived having agency were satisfied and more likely to participate in the matching process as facilitated by the program. Faculty who did not perceive they had agency, were circumventing the process by recruiting students of other doctoral programs or by directly hiring students into their groups. Doctoral programs should consider not only how their processes are being practiced but also how these practices may impact their faculty (Joy et al., 2015). For example, if faculty are satisfied with quality of the doctoral students entering the program, they could be more likely to be more satisfied with the matching results and less likely to have a need to exert their agency to decline a match. Conversely, if faculty are not satisfied with the quality of the incoming students, they are more likely to decline a match or look for students elsewhere. Therefore, programs should evaluate how is their advisor selection process being perceived beyond the student experience, what is influencing these perceptions, and how could they maximize the satisfaction of not just students but also their faculty in the matching process.

The second study also showed that junior faculty possessed limited criteria for determining how they would like to recruit students in comparison to established faculty. This

limited criterion was assessing students strictly on research topic. While further research is needed, it may be that by developing richer processes for matching students to advisors that include both parties getting to know each other's workstyles and management of the research group, junior faculty can learn holistic and better criteria for recruiting students. An implication of this finding is for departments to engage in conversation with their junior faculty regarding their needs (Campbell & O'Meara, 2014), specifically those regarding recruiting students and whether matching students based on research interest is working for them in each department's context. While being prioritized in the matching process can be advantageous for junior faculty, it may also be that they get matched with students who may not have as great an interest in their research. Knowing that the level of agency given to faculty in each department's advisor selection process varies, program directors and junior faculty should continually assess whether the practice of each program is working satisfactorily for those involved.

The third study showed that within a single department, the process of finding an advisor was individual to each student. However, a clear divide existed between students who had research experience prior to the doctoral pursuit versus students who had no such research experience. Students who had prior research experience had clearer criteria of what they were looking for in an advisor and valued being able to relate to the advisor and their research group. Conversely, students who did not have such experience mainly looked for what the program process prioritized which is a research topic match. These findings suggest that programs could take a critical look at how they support students in the early phases of the Ph.D. (Holbrook et al., 2014). Clearly, not all students will enter the Ph.D. with equal knowledge on the doctoral process and which needs they will have as doctoral students (Gilmore et al., 2015). Thus, programs could consider implementing student support structures, such as information bridging activities (refer

to Artiles, Knight, & Matusovich (2019) for examples), that help level the playing field across incoming students and help them make an informed decision in selecting an advisor and beyond. Similarly, programs should look at how all of their processes may benefit students with certain experiences over others. Not considering how processes may be experienced by students without certain key experiences or knowledge may lead to the unintentional exclusion of such. These recommendations should be considered for each program individually (Gardner, 2009). It may be that for a certain program, most of the incoming doctoral students have a clear understanding of what research they want to work on or with which faculty they want to work. In this case, implementing processes that help them choose an advisor may be unnecessary; keeping students from research and making progress towards degree completion. However, in programs such as the one studied in in the third study, students may both need and want information bridging systems and find those available insufficient. Therefore, all programs should consider the specific needs of their students and determine which process works best for their context. Similar to the prior recommendation for faculty, programs need to continually assess their processes and verify if the systems in place are indeed working for their population.

### **5.3 Implications for Research and Future Work**

Findings from this dissertation revealed a number of implications for research within each manuscript and some overarching implications for research. In the first study the different organizational behaviors across the fields of science, math, and engineering imply that for certain phenomena it is unwise to combine or generalize over all of science, math, and engineering as in research it can be counterproductive. Researchers need to consider which nuances are being lost by the conflation of the fields of study and adjust their claims accordingly. Future research

should look at further differences in these fields of study to better determine how these disciplines compare in terms of organizational behavior and educational practices. Similarly, the results demonstrated that different levels of support were offered to students across both disciplines and fields of study. Thus, the individual context in which a doctoral student develops, be it disciplinary or institutional, has an effect on the doctoral student experience (Gardner, 2009; Golde, 2005).

The second study demonstrated that the satisfaction of faculty is indeed influenced by their perception of their individual agency. One of the research findings from this study is the notion that faculty exist in relationships where reciprocity is expected but sacrifice for the larger good is not uncommon. Future work could observe whether this willingness to sacrifice extends to other parts of faculty employment and how its presence (or lack thereof) may impact departmental culture. While the study sample was limited, the findings hinted at institutional ranking possibly having some influence on the faculty satisfaction with the process and the outcome of matches. Because the study sample only consists of two programs, it is not possible to draw any conclusions to this regard but further study into more departments could help clarify this possible connection and the intersection of institutional prestige with doctoral education (Morrison et al., 2011). Similarly, previous literature has demonstrated the role of demographics in differing faculty experiences (Callister, 2006; Ong et al., 2011). While the study data did not show any indication to this effect, further study with a larger and more diverse sample could clarify this notion. This study also showed that faculty learn to recruit doctoral students over time. Future research could take a longitudinal approach to understand how faculty learn to advise doctoral students and the existing structures and incentives that could promote better advising relationships. Finally, this study justifies future and further work into unquestioned and

commonplace processes in doctoral education. Understanding the nuances that exist across programs could help us understand why some programs may perform better than others and further in terms of recruitment and retention.

The third study demonstrated that the advisor-advisee matching process is not experienced in the same way across all students. The findings show that processes do encompass assumptions about students' knowledge that did not necessarily meet the preparation students actually possessed. Using, SDT helped us understand both where and how the advisor selection process fell short and how to improve the process. A research implication of this study is that motivation theories from educational psychology can indeed be used to study everyday processes in doctoral education or workplace type of settings (Deci and Ryan, 2000). They can also help us design processes that support students from a myriad of backgrounds and experiences.

Our research also pointed to connections between the preparation students had before entering graduate school and the experiences they bring in to the doctorate. Further study could look into the rationale for why do students pursue a Ph.D., how they select institutions, and what factors do they prioritize in the search. Finally, while we know these results to be true for the context they were obtained from, future work could study if such a divide in students is also present in other institutions of varying levels of prestige and varying student demographics (Morrison et al., 2011).

#### **5.4 Summative Implications**

When connecting across the multiple findings from each study, summative implications are revealed. First, as a whole, this dissertation demonstrated a way to use economic and motivation theories in qualitative educational research. Economic theories, particularly those

related to behavioral economics, aim to predict human behavior. In the case of this study, PAT helped us characterize the existing interactions between faculty, students, and departments. Much of the research in education takes a motivational theory approach to understand the rationale behind human behavior. This approach suffices for a number of conditions including but not limited to the desire to pursue a degree and learning throughout the process of obtaining such. However, under certain conditions, motivational frameworks can be insufficient to understand human behavior as they tend to focus on the individual and not the interactions across individuals in a group. This study showed that, when combined, theories from economics and motivation can support each other towards a deeper understanding of why people act the way they do and how departments can foster environments that help maximize their satisfaction and competence within a system (Gagné & Deci, 2005).

Additionally, by examining multiple perspectives, this dissertation shows how the behaviors faculty and programs promoted in the first two studies yield the kinds of reactions by students observed in the third. While extrapolating from the findings to all of engineering is unadvisable, the results begin to paint a picture of what it means to select an advisor in Chemical Engineering. Per most of our sample in the first study, engineering programs outside of Chemical Engineering do not have structured processes for helping students find an advisor. However, in Chemical Engineering, we interviewed students that are mostly happy to receive a structure for choosing an advisor and faculty are happy to share their agency to help students own this selection. As observed in our manuscript two data, faculty did not complain about students leading the decision and in manuscript three we observed that most students did indeed get to work with their first choice. While this process works is somewhat at odds with the larger

engineering practices, it still satisfies those who participate in it as long as they were able to maintain their volition, or the ability to act in a way consistent to what they believe.

So, should every program design and execute a process for the least prepared student? Absolutely not. The appropriate advisor selection process for each program will ultimately depend on each institution's individual needs. But doctoral programs need to consider who is being admitted into their doctoral programs and how the practices they have either restrict or support students. It may be that in certain institutions no support structures are needed as the student that is traditionally admitted knows both with whom and on what they want to work on. But it may be also be that the students entering a different institution could strongly benefit from a solid support structure that helps them make a good advisor decision.

A way to assess the needs of students is through holistic admissions practices (Kent & McCarthy, 2016). By evaluating the full range of experiences that students entering doctoral programs possess, faculty and administrators can have a more thorough understanding of what assistance they need to provide. Particularly for those students that do not possess knowledge about the research process when entering graduate school, programs and administrators should consider how to make this information available to them. Graduate student development frameworks suggest that departmental interactions with faculty and students in later phases of the degree tend help incoming students learn the informal rules of the doctoral pursuit. (Lovitts 2001; Weidman et al., 2001). Thus, faculty and administrators should consider how to best facilitate communication within departments, particularly between students in the early stages of the doctorate and students in later phases that may have a clearer understanding of the doctoral process. Regardless of which practices are ultimately implemented, all institutions should evaluate whether the processes in place support those admitted students' needs. Policies and

processes should not impede the progress of those ready to take on the task but they should be able to meet and support those unprepared for the task where they are.

## **5.5 Role of the Researcher**

An essential component of qualitative study is the role of the researcher. The researcher not only designs the research question and the methods to address such but also interprets the findings and offers conclusions based on these (Patton & Patton, 2002). However, the researcher is not bias-free. The researcher brings in their worldviews and interpretations into the findings. In this section, I state my intersections with the research topic and present my bias on such and the strategies I took to minimize its impact on the analysis.

At the time of this research, I, the primary author, was actively pursuing a Ph.D. in Engineering Education. Through the course of these study's design and execution, I was employed by the NSF funded project 'The Dissertation Institute' where we developed workshops for underrepresented minorities in doctoral engineering programs on how to persist in the doctoral pursuit. I co-lead the research component of this project, granting me access not just to doctoral students but students that are actively struggling in their doctorate. Besides from these activities, I was actively involved in multiple research projects at Virginia Tech using institutional data to understand the experiences of doctoral students further. Overall, my experience in pursuing the doctorate has been very positive. I have met most of the goals I have set for myself, have a positive relationship with my advisor and my committee, and plan to complete this degree in the timeline I had devised upon my arrival to the program.

Despite this positive experience, it is important to note that ten years before the submission of this dissertation, I began to pursue a Ph.D. in Mechanical Engineering at a

different institution. I ultimately departed from the program at the Master's level. My experience with this masters-level departure inspired my decision to work on the previously mentioned project. Ten years of hindsight have revealed to me that at the time, I had not selected a research topic I enjoyed. Further, I was adjusting to living and studying in a completely different environment, both culturally and academic, to that of my undergraduate institution. Despite enjoying working with the team, I did not enjoy the work I was doing. From a summative standpoint, my personal experiences in graduate school have been overall neutral. This neutrality has helped me be able to argue for multiple interpretations in my data regarding the student experience.

However, being still a graduate student, I do not possess the vantage point of the faculty and administrators in my sample. While this separation proved useful in creating a barrier from my own experiences in graduate education, I had to continuously verify that my interpretations aligned with their experiences and that they were not misinterpreted from not having lived the role of faculty or administrator. I also had to verify that my interpretations did not advocate for certain groups over others.

To address the biases stated above, I took several approaches to reduce my bias. The first was to be reflexive throughout all steps of my project (Guillemin & Gillam, 2004). This practice meant that in every stage of my study, I made sure to ask myself questions relating to how am I, my experiences, and my actions influencing this study. Having many shared experiences, particularly with the student community in my research, I had to ensure that I was allowing the data to speak for itself. To achieve this, I took three specific strategies. One strategy that I used in the early phases of my project was to journal my thoughts, feelings, and reactions through my review of the literature and pilot data collections (Ahern, 1999). This strategy allowed me to

verify my initial interpretations of the existing work and understand specifically where did my own experiences intersect with my participants. Once the data was collected, I consulted both my analytical approaches and interpretation with researchers both inside and outside the project (Tracy, 2010). This strategy of bringing in ‘critical friends’ helped in challenging my assertions by people with multiple perspectives different than my own, particularly when understanding the faculty and administrator perspective. I also reduced the impact of my personal bias by using multiple data sources and triangulating my findings across various points of the data throughout the three manuscripts (Hesse-Biber & Leavy, 2011). This strategy allowed me to ensure that my interpretations did not rely on any single source. The third strategy I used was continuously drawing on the literature to build my interpretations and arguments. Knowing that being a student may influence how I advocate for students, I continuously had to ensure that the both the arguments and the language I used were not my own opinions but rather those reflected in what prior literature had argued. Similarly, for the portions of this study that focused on the faculty perspective, I ensured that my interpretations of the data were done through the lens of prior work in the faculty space and not my opinion as a graduate student. My experience in graduate education will always be inextricably connected to who I am and how I conduct research. And while they bring richness into the way I see the phenomena I study, I also have to be aware of how to reduce its impact.

## **5.6 Concluding Remarks**

The doctoral process offers agency to the people involved in such at many different points. This dissertation showed that concerning one of those points, the selection of an advisor, science, math, and engineering doctoral programs have largely varying levels of designed to help

students make an informed decision; but, many of these structures were not present in engineering. It also showed that how faculty negotiate agency among themselves in a doctoral program influences their satisfaction and that recruiting students is something that is learned and refined over time. Finally, this dissertation demonstrated a trend that while autonomy is valued, people need structure to help them make decisions. Faculty may not know initially how to recruit and experience leads them to learn better. Students may not know initially how to choose an advisor, but after some time working with one, they learn what they truly need from the relationship. People need autonomy to be satisfied, but autonomy without support, or 'competence', can be detrimental for the self determination of people. Rather than develop policies and processes intending to meet the highest level possible of autonomy, we need to take a critical look at these to understand who is at a disadvantage, who is benefitting, and how we can make the playing field equal.

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## Appendix A. Principal-Agent Theory Propositions

<b>PAT Propositions</b> (Eisenhardt, 1989)	<b>Behavior-based Policy:</b> e.g. “required activities before selection”	<b>Outcomes-based Policy:</b> e.g. “pick an advisor by certain date”
<b>Proposition 1:</b> <i>“When the contract between the principal and agent is outcome based, the agent is more likely to behave in the interests of the principal.”</i>	Students will undergo activities before selecting an advisor.	Student will select an advisor by a certain date.
<b>Proposition 2:</b> <i>“When the principal has information to verify agent behavior, the agent is more likely to behave in the interests of the principal.”</i>	Programs require students to actively seek information before selecting an advisor.	Programs do not have information on students’ selection process.
<b>Proposition 3:</b> <i>“Information systems are positively related to behavior-based contracts and negatively related to outcome-based contracts.”</i>	Required activities such as seminars and interviews are a way for programs to ensure students are seeking information.	Programs without activities can not ensure student’s selection process was properly informed.
<b>Proposition 4:</b> <i>“Outcome uncertainty is positively related to behavior-based contracts and negatively related to outcome-based contracts.”</i>	Program assumes student may not know all of the factors that matter in selecting an advisor. Requires activities that can help them select an advisor.	Programs assume students have the necessary knowledge on how to select an advisor and only enforce a deadline.
<b>Proposition 5:</b> <i>“The risk aversion of the agent is positively related to behavior-based contracts and negatively related to outcome-based contracts.”</i>	Students go through the process and minimize risk as they gain information and possibly time before selecting an advisor.	Students assume more risk as they are fully in charge of the entire selection.
<b>Proposition 6:</b> <i>“The risk aversion of the principal is negatively related to behavior-based co tracts and positively related to outcome based contracts.”</i>	Programs run a risk as the specified behavior may not be enough for students to make an adequate selection and often programs provides funding through this selection period.	Program places more risk on the student. by making them select before arrival or not providing information systems that could help the selection.
<b>Proposition 7:</b> <i>“The goal conflict between principal and agent is negatively related to behavior based contracts and positively related to outcome-based contracts.”</i>	Requiring activities assumes students and programs may have differing ideas on how to make a good selection.	Not requiring activities assumes both students and programs have the same knowledge on how to select an advisor.
<b>Proposition 8:</b> <i>“Task programmability is positively related to behavior-based contracts and negatively related to outcome-based contracts.”</i>	All students need to go through predetermined activities that will help them make a good choice.	Students can select an advisor as they please as long as they make a selection by a certain date.
<b>Proposition 9:</b> <i>“Outcome measurability is negatively related to behavior-based contracts and positively related to outcome-based contracts.”</i>	Program recognize that a ‘knowledgeable selection’ is not measurable so they require student to participate in information activities to help the selection.	Programs do not require activities so the contract assumes a selection (regardless of how it was done) is a positive outcome.
<b>Proposition 10:</b> <i>“The length of the agency relationship is positively related to behavior-based contracts and negatively related to outcome based contracts.”</i>	Programs with a longer time to selection required more tasks of students prior to selection.	Programs with shorter time to selection require less, if any, tasks of students prior to selection

