Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #47157

Doctoral Students Changing Labs Considerations in Engineering Graduate Education

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Persistence Pathways: Changing Research Labs to Persist in Engineering Graduate Education

This full empirical research study investigates the factors contributing to doctoral students changing research labs during their academic programs in engineering graduate education. Recent research has demonstrated over 70% of engineering doctoral students contemplate leaving their programs without a doctoral degree [1]. Depending on the discipline, 40-60% of engineering doctoral students actually depart due to conflicts with advisors and peers, financial or academic difficulties, and personal or family concerns [2]. Some students remain in their doctoral programs by changing research labs, advisors, programs, or even universities [3], [4]. While changing research labs can help retain partially trained and qualified students, the associated individual costs, programmatic barriers, and advisor conflicts complicate the process. Consequently, the early departure of graduate students from their programs poses a major issue in higher education. When these highly skilled, knowledgeable, and talented individuals leave, it results in losses for the workforce, universities, funding agencies, faculty members, and the students themselves [5]. Although this is a widespread issue across all doctoral programs, research indicates that engineering graduate students encounter distinct challenges resulting from higher levels of stress compared to graduate students in other fields [6], [7]. Graduate students with these experiences often report a decline in the quality of their advising relationships over time, which can lead to decisions to switch labs [8], [9].

Background and Literature Review

The advisor-advisee relationship is crucial in shaping doctoral students' experiences and their decisions to change labs [9], [10], [11]. This dynamic considerably affects students' academic satisfaction, emotional well-being, and the decision to remain in or leave their current research environment [12], [13]. This study explores the quality of these relationships, the experiences of sexism, racism, and discrimination, and how these factors influence doctoral students' decision to switch labs to persist in their studies.

The quality of the advisor-advisee relationship is closely connected to student satisfaction and retention [14]. Studies show that attributes like supportiveness, availability, and effective communication in an advisor contribute notably to a fulfilling doctoral experience [15]. On the other hand, unsatisfactory relationships frequently result in frustration and disillusionment, causing students to contemplate changing labs. Craft et al.[16] point out that poor advisor-advisee relationships are a major factor in doctoral student attrition, indicating that when students feel unsupported or undervalued, they may look for alternative environments where they feel a stronger alignment with their advisors [16]. Equally, Studies indicate that positive self-recognition correlates with higher satisfaction in academic settings [17], [18] because students who feel competent are more likely to seek guidance and feedback from their advisors. Moreover, advisors who acknowledge their students' efforts and achievements create a supportive atmosphere that encourages academic growth [18]. This recognition can manifest through constructive feedback, mentorship, and opportunities for professional development. Furthermore, the dynamics of the advisor-advisee relationship can shift over time, influencing students' decisions to change labs. Bryson and Kowalske [8] highlight that these relationships can particularly evolve for students from underrepresented groups in STEM fields, potentially prompting them to reassess their fit within their current lab.

When students face considerable emotional exhaustion because of insufficient support or mismatched expectations with their advisors, they might be more likely to switch labs in pursuit of a healthier and more supportive setting [19], [20]. Additionally, the alignment between a student's research interests and their advisor's expertise is crucial [21]. Wofford et al. [22] highlight that students take into account various factors, such as the mentorship style and professional stability of their principal investigator (PI), advisor, or supervisor when choosing a lab [22]. If students discover that their advisor's research focus diverges from their own interests, they might feel the need to switch labs to better pursue their academic goals [22].
The experiences of doctoral students with sexism, racism, and discrimination heavily influence their decisions to change labs [21], [23], [24]. For example, faculty and administrators from different backgrounds may dismiss or downplay the experiences of doctoral women of color, resulting in feelings of isolation and marginalization [25]. This lack of recognition can create a hostile lab environment, leading students to consider changing labs to find mentors who better understand their experiences and challenges [25]. Additionally, when students feel their contributions are undervalued, or they are subjected to discriminatory practices, they may choose to change labs to escape these negative experiences and seek a more equitable academic environment [26].

The intersectionality of race and gender further complicates the experiences of doctoral students [12], [27]. The everyday experiences of racism and sexism can push students to their breaking point, making them feel compelled to resist these experiences by seeking a different academic environment [10], [28]. This persistence often serves as an approach by students to reclaim their agency and find environments that affirm their identities and contributions [10]. Other studies indicate that doctoral students, such as Black women, Latina/Hispanic, and Asian, Middle Eastern/North African (MENA) women, employ a range of tactics to stay motivated despite facing racism and sexism [29], [30].

When these strategies fall short in countering the negative impacts of discrimination, students might view changing labs as their best chance to reach their academic and professional objectives [29]. Moreover, experiences of burnout and dissatisfaction with supervision can be intensified by encounters with discrimination [23], [28]. A lack of satisfaction with supervision, combined with experiences of inequality within the research community, can also result in heightened burnout and a greater likelihood of attrition among doctoral students [3], [31], [32]. This suggests that when students perceive their lab environment as discriminatory or unwelcoming, they are more likely to consider leaving for a more supportive environment [33]. Positive advisor-advisee relationships enhance satisfaction and retention, whereas negative experiences with sexism, racism, and discrimination can lead to feelings of isolation, burnout, and dissatisfaction. These adverse experiences may prompt students to seek more inclusive and supportive environments.

Research Questions
This research is part of a larger mixed-methods project that examines the persistence pathways of doctoral engineering students as they change research labs to continue their graduate education. The goal of this analysis is to investigate how common changing labs is amongst engineering doctoral students and to identify the factors that influence those who are seriously considering changing labs (serious considerers), those who have taken steps towards changing labs, such as talking to potential advisors or school administrators (planners) and those who have already changed labs (changers). The following are the research questions for this study:

Research Question 1: How common is changing labs amongst engineering doctoral students?
Research Question 2: How do advisor relationships affect doctoral students' changing lab considerations?

Methods

This study is part of a larger mixed-method longitudinal research project aimed at better understanding engineering doctoral students' experiences and behaviors related to changing labs. A self-report survey administered to these students examines the frequency, predictors, and outcomes of lab changes, as well as their persistence in their academic programs.

Recruitment

The American Society for Engineering Education (ASEE) 2022 edition of "Engineering and Engineering Technology by the Numbers [34] was used to select the top 50 institutions awarding engineering doctoral degrees. Emails were sent to 448 engineering graduate program directors, coordinators, or heads of departments, inviting them to send information about the study to their doctoral students. Doctoral student participants volunteered to take part in this study through a survey on the Qualtrics online survey platform. Participants could register for a compensation drawing of $10. Ten participants were selected and emailed an Amazon gift card. This was expected to be about 1% of the participants.

Participants

Our sample includes participants from 26 highly ranked universities in the U.S. and 17 engineering doctoral disciplines (e.g., materials, electrical, mechanical). 51.7% were domestic students, while 48.3% were international students. Women are underrepresented in engineering (n = 108, 46.2%) compared to men (n = 113, 48.3%), and Gender non-conforming (n = 13, 5.5%), reflecting a common trend for men’s overrepresentation in engineering disciplines [35], [36]. White students (37.3%) are underrepresented, while Asian students (41.9%) are well-represented. Additionally, there is some representation from Black/African American (4.6%), Middle Eastern or North African (7.8%), and Hispanic, Latino/Latina/Latinx, or Spanish origin (6.5%) students.

Measures

Participants answered a series of questions on changing lab experiences, changing lab behaviors, and advisor relationships. The first item asked, Have you considered leaving graduate school within the last month? with eight response options: 1. Yes, I have often seriously considered leaving my PhD program with no degree, 2. I have changed my research lab since starting my PhD program, 3. I have changed my university since starting my PhD program, 4. Yes, I have often seriously considered leaving my PhD program by taking a master’s degree, 5. I sometimes consider leaving my PhD program either with or without a master degree, 6. I rarely consider leaving my PhD, 7. I have never considered leaving, 8. Another statement describes my experience. The responses were recoded with responses 1, 4, 5 into consider (1) and responses 2, 3, 6, 7, 8 into not consider (0).

The second question on changing lab behaviors asked: have you ever done any of the following related to changing research labs or universities? And had six response options: discussed changing with an advisor, discussed changing with program administration, searched for

program information about changing labs, searched for graduate college information, or discussed changing with a potential new advisor.

The third set of questions on the advisor relationship scale had nine items, and the following instruction was provided: Please indicate how strongly you disagree or agree with the following statements about your advisor: My advisor has clearly stated their expectations for satisfactory participation in the program, My advisor values my work, My advisor provides advice in a timely manner, My advisor is easy to approach, My advisor is knowledgeable about my research, My advisor encourages and supports my research ideas, My advisor is also my mentor, I can balance the needs of my advisor with my own needs, Overall, my relationship with my advisor is good. Participants indicated their agreement with the items on a scale from Strongly Disagree (1) to Strongly Agree (5) on a series of questions on advisor relationships. The mean of these items is used as the advisor relationship variable. The scale demonstrated strong internal reliability (Cronbach's alpha = .94).

The demographic questions included: "How do you describe your gender identity?" with the options: Woman, Man, Genderqueer, Agender, Transgender, Cisgender, Non-binary/third gender, Prefer not to say, and a text write-in option. Race/ethnicity was collected with the question, "With which racial and ethnic group(s) do you identify?" The options included American Indian or Alaska Native, Asian, Black or African American, Hispanic, Latino/Latina/Latinx, or Spanish origin, Middle Eastern or North African, Native Hawaiian or Other Pacific Islander, White, and Another race or ethnicity not listed above with a text write-in option.

Analysis

Participants who did not complete at least 70% of the survey were excluded from the analysis. We used SPSS 30.0 for these analyses. First, we conducted a descriptive analysis of the frequencies of changing lab experiences and changing lab behaviors among doctoral engineering students to examine the distribution of engineering disciplines and demographics, specifically gender and race. Next, we conducted a binary logistic regression to identify how the advisor relationship predicted students' consideration of leaving the doctoral program.

Results

Frequency of Changing Labs and Considerations

In answer to our first research question about the frequency of changing lab experiences and behaviors, descriptive analyses of how often students experience changing lab are reported in Table 1 and the behaviors they engage in when seriously considering changing research labs are reported in Table 2. Overall, the majority of students have never considered leaving their PhD programs, a smaller percentage often seriously consider leaving by taking a master's degree (Table 1). A few have seriously considered leaving with no degree. Some students provided another response indicating they had considered leaving in the past, and examples include "there was a phase where I very often considered leaving the PhD program but not anymore," "Considered switching to my second-choice school to complete a PhD there, but only rarely" Next, we examined different lab change considerations based on gender and race.

Changing Lab Experiences and Gender

Some notable differences were identified between women and men in lab change considerations (Table 1). Among women, a considerable proportion have never considered leaving their PhD programs, while some rarely consider leaving. In contrast, men show a higher tendency to never consider leaving, followed by those who rarely consider leaving. However, both men and women have similar proportions of individuals who often seriously consider leaving for a master's degree, though this is slightly lower for women.

Changing Lab Experiences and Race/ethnicity

Similarly, notable differences were identified for race/ethnicity groups (Table 1). A considerable portion of Asian students have never considered leaving their PhD programs, although some often seriously consider leaving with a master's degree. Black or African American students show a strong tendency to never consider leaving, with a notable number rarely considering it. Hispanic or Latino students have diverse experiences, with a mix of rarely considering leaving. Most Middle Eastern or North African students have never considered leaving, while White students show a relatively higher tendency of never considering leaving. Students from other races or ethnicities, while fewer in number, display diverse experiences, with half never considering leaving and half sometimes considering leaving. Next, we looked at the different behaviors of students as they change labs.

Changing Lab Behaviors and Gender

Lab change behaviors also differed based on gender (Table 2). Among women, there is a noticeable pattern where no individuals discussed changing with their advisors. However, some discussed changing with the program administrator, or searched for graduate college information. A smaller number discussed changing with a potential new advisor. In contrast, among men, some discussed changing with their advisor, while a lower number discussed changing with the program administrator. Similar to women, some men searched for program information about changing labs and discussed changing with a potential new advisor. Most participants who identified as gender non-conform searched for graduate college information about changing labs.

Changing Lab Behaviors and Race/Ethnicity

Some differences in lab change behaviors were identified for race/ethnicity (Table 2). Among Asian students, a considerable portion searched for program information about changing labs and some discussed changing with a potential new advisor. All Black or African American students reported taking other actions in preparation for changing labs. For instance, "I discuss with others who changed programs, university or lab as well as those who left with a masters." Hispanic or Latino students also show a reliance on other actions similar to Black or African American students. Middle Eastern or North African students display a different pattern, with half discussing changing with the program administrator and the other half searching for graduate college information. White students discussed changing with the program administrator or searched for graduate college information. Overall, a small number of students discussed changing with their advisor, and a slightly larger group discussed changing with the program administrator. The largest proportion of students searched for program or graduate college information about changing labs.

Table 1. Percentage of students Lab Change Experiences by gender and race/ethnicity

Changing Lab Experiences	1. I have often seriously considered leaving my PhD program with no degree	2. I have changed my research lab	3. I have changed my university	4. Yes, I have often seriously considered leaving my PhD program by taking a master's degree	5. I sometimes consider leaving my PhD program either with or without a master degree	6. I rarely consider leaving my PhD	7. I have never considered leaving	8. Another Statement
Overall	1.60%	0.50%	0.50%	10.10%	15.90%	28.00%	39.20%	4.20%
Gender								
Women	1.20%	0.00%	1.20%	9.50%	20.20%	23.80%	39.30%	4.80%
Men	1.00%	0.00%	0.00%	11.50%	11.50%	30.20%	41.70%	4.20%
Gender non-conforming	20.00%	0.00%	0.00%	0.00%	20.00%	40.00%	20.00%	0.00%
Race/Ethnicity								
Black or African Americans	0.00%	0.00%	0.00%	0.00%	16.70%	33.30%	50.00%	0.00%
Asian	1.30%	0.00%	1.30%	13.00%	14.30%	26.00%	42.90%	1.30%
Hispanic, Latino/Latina/ Latinx, or Spanish	11.10%	0.00%	0.00%	0.00%	11.10%	33.30%	22.20%	22.20%
Middle Eastern or North African	0.00%	6.70%	0.00%	6.70%	6.70%	20.00%	53.30%	6.70%
White	1.50%	0%	0%	10.80%	18.50%	27.70%	36.90%	4.60%
Another race or ethnicity	0%	0%	0%	0%	50.00%	0%	50.00%	0%

Table 2

Percentage of students Lab Change Behaviors by gender and race/ethnicity

Changing Lab Behaviors	1. Discussed with an advisor	2. Discussed with program administration	3. Searched for program information about changing labs	4. Searched for graduate college information	5. Discussed with a potential new advisor	6. Another Statement
Overall	8.30%	11.10%	16.70%	13.90%	11.10%	38.90%
Gender						
Women	0.00%	16.70%	16.70%	16.70%	5.60%	44.40%
Men	17.60%	5.90%	17.60%	5.90%	17.60%	35.30%
Gender non-conforming	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%
Race/Ethnicity						
Black or African Americans	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Asian	12.50%	6.30%	25.00%	12.50%	18.80%	25.00%
Hispanic, Latino/Latina/Latinx, or Spanish	0.00%	0.00%	25.00%	0.00%	0.00%	75.00%
Middle Eastern or North African	0.00%	50.00%	0%	50.00%	0.00%	0.00%
White	11.10%	22.20%	11.10%	22.20%	0.00%	33.30%

Advisor Relationship and Lab Change Consideration

We conducted a regression analysis to answer our second research question: How do advisor relationships affect doctoral students' changing lab considerations? The binary logistic regression demonstrated advisor relationship score predicted students considering leaving the doctoral program ($\beta = -0.83(1)$, $p < .001$). Students who had not or rarely considered leaving the doctoral program had higher advisor relationship scores ($m = 4.31$, S.D. = 0.82) than those who had considered leaving ($m = 3.56$, S.D. = 1.03).

Discussion

Engineering doctoral students go through different lab change experiences. We found that students with supportive advisor relationships are less likely to change labs or leave their Ph.D. program, with a majority having never considered leaving their PhD. This reflects positively on the advisor-student relationship, which is critical in shaping students' experiences and decisions to remain in their programs. This finding corroborates with other studies indicating that a supportive advisor relationship is critical for doctoral persistence [15] and academic commitment [9] and facilitates the success of minoritized groups in PhD programs [8], [37]. Students who feel that their advisors are invested in their academic and professional development are more likely to remain committed to their programs. Moreover, students who feel comfortable discussing their challenges and aspirations with their advisors are more likely to stay committed to their programs [4], [38]. Advisors who take an active and supportive role in their students' academic journeys tend to foster greater levels of engagement and satisfaction. On the other hand, those who maintain a more detached approach may unintentionally contribute to feelings of isolation and disconnection among their students [15].

We also found that the decision to switch labs is often fraught with emotional and logistical challenges, making potential lab changers uncertain about their choices. This explains why students engage in a variety of preparatory actions before making a lab change. We observed that discussing lab changes with a current advisor is the least common preparatory action (8.3%) among students before changing labs. This can be attributed to advisor relationships [8], [31]. Students may feel hesitant to approach their current advisors due to concerns about potential negative repercussions [13], such as damaging their relationship or receiving discouragement [9]. This apprehension can lead students to prioritize other preparatory actions, such as seeking information independently or discussing their options with peers or potential advisors rather than their current advisors. Moreover, the nature of the advisor's advising style can also impact these discussions. If students perceive their current advisor as less supportive or engaged, they may be less inclined to initiate discussions about changing labs [3], contributing to the lower percentage of students who report discussing their plans with their current advisors. Additionally, the competitive nature of academic environments, particularly in STEM fields, may further discourage open communication between students and advisors [11]. Students might fear that discussing their desire to change labs could be interpreted as a lack of commitment or dissatisfaction with their current research group, leading them to avoid such conversations [33].

While both women and men engage in a variety of lab change behaviors, women did not report discussing with advisors or program administrators, while men did. Related research has shown that women often prefer indirect communication methods and may feel less comfortable initiating discussions with authority figures, such as advisors. This tendency can lead to a

reliance on alternative actions rather than direct conversations about lab changes. For instance, Wang and Houdyshell [39] found that female students tended to favor remote academic advising over in-person interactions, suggesting a preference for less direct forms of communication. This preference may stem from a desire to avoid potential confrontations or negative feedback, which can be more pronounced in male-dominated STEM disciplines [40].

Moreover, gender discrimination by advisors can impact female students' willingness to engage in discussions about their academic paths [41]. If female students perceive their advisors as less supportive or more critical, they may be less inclined to seek their guidance, thereby contributing to the observed disparity in communication behaviors. Additionally, the identity and background of the advisor can influence the comfort level of students when discussing sensitive topics [42]. This dynamic can create a feedback loop in which men feel more supported and are thus more likely to engage in discussions, while women may feel less inclined to do so due to perceived barriers.

The moderately positive relationship between advisor relationships and changing lab experiences reinforces these findings. Healthy advisor relationships are associated with less frequent experiences and behaviors of changing labs among PhD students. The findings align with existing literature on the impact of advisor-student relationships on academic outcomes. Studies by Devine and Hunter [19] and Mansson and Myers [14] highlight that supportive advisor relationships enhance student satisfaction and retention, reducing the likelihood of students contemplating lab changes or program attrition.

Limitations

Though the research questions for this study were answered, they focused on advisor relationships. However, varying factors, including personal motivations, institutional support, career change, and the nature of the academic environment, can affect the lab change experiences and lab change behaviors of doctoral engineering students, influencing varying persistence pathways. Moreover, changing labs can be a sensitive topic for students, and some may be reluctant to participate or share their true experiences due to fear of repercussions from their current advisors or departments or for cultural reasons. This further limited the sample size for this study. Moreover, this study did not study participants who identify as first-generation in their families. It is the understanding of the researchers that research-based degrees often do not prioritize first-generation status for admissions but instead on a high level of academic and professional preparation. This preparation may not be easily accessible to those who are the first in their family to pursue research-based degrees. Nevertheless, we recognize that a study focusing on this group could yield valuable insights into how they navigate lab decision-making processes differently, which was not included in this study. Additionally, advisor-student relationships can be highly variable and influenced by numerous factors, such as personality, cultural background, and departmental policies. This variability made it challenging to isolate the specific impact of advisor relationships on lab-changing experiences. Understanding these dynamics requires careful consideration of the unique interactions and circumstances that characterize each relationship beyond the scope of this study.

Future Work

Future studies should seek to explore how personal motivations, institutional support, career change, and the nature of the academic environment affect the lab-change experiences and behaviors of engineering students in specific engineering disciplines across multiple institutions,

multiple disciplines across a single institution, or multiple disciplines across multiple institutions. Further, future studies could also investigate how advisor relationships affect students in different fields—engineering, sciences, and humanities—to see if field-specific dynamics are at play. Examining these relationships across various disciplines could uncover unique challenges and opportunities specific to each field while providing evidence for general, more common systemic issues in multiple disciplines. Equally, comparing the experiences of doctoral students with positive and negative advisor relationships can provide valuable insights into successful mentoring practices. Moreover, future studies could also consider lab change and funding policies at participating institutions to clarify the support available for students who wish to change advisors. This clarity may reveal important insights into other factors influencing students' decisions to change advisors, particularly when comparing institutions with well-defined funding or lab change policies to those without such provisions. These findings could lead to adopting best practices and recommendations for advisors and support for PhD students, including training programs, mentorship guidelines, and institutional policies that promote effective mentoring.

Conclusion

This study investigates the persistence pathways of engineering doctoral students as they change research labs to continue their graduate education. Initially, we examined the frequency of lab changes among these students and found that this frequency is influenced by their experiences. Behaviors such as searching for programs online, discussing with potential advisors, and consulting with departments were identified as common among students who changed labs. Additionally, we explored how advisor relationships influenced students' lab-changing experiences. The findings indicated that factors such as sexism, racism, financial support, and lab cultures impacted students' decisions to change labs. These insights highlight the complexity of advisor-student dynamics and the various challenges that doctoral engineering students face in their academic journeys. Switching labs can disrupt research progress and increase the burden of recruiting and training new students to continue the research endeavor. Consequently, a substantial investment in the faculty-student relationship can positively influence new research directions, leading to technological and engineering breakthroughs and fostering lifelong relationships that benefit the faculty, the student, the department, the institution, and the nation. This impact can attract talented students to the research lab, department, and engineering program. Understanding how faculty can best support graduate students remains a considerable issue.

Acknowledgments

We acknowledge the National Science Foundation (NSF) for funding this project (#EEC2404797), and we express our gratitude to the graduate students who participated in the study.

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