# AC 2012-5574: TRENDS IN DOCTORAL EDUCATION: ENGINEERING STUDENTS' PERSPECTIVES ON FACULTY ADVISING

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# Trends in Doctoral Education: Engineering Students' Perspectives on Faculty Advising

Given the value of graduate education to the nation's economy and global standing, it is imperative for institutions of higher education to examine ways to improve the retention and advancement of doctoral students and to diversify the professoriate in science and engineering. A 2010 report by the Council of Graduate Schools and Educational Testing Services called upon universities to improve completion rates, clarify career pathways for doctoral students, and prepare future faculty and professionals[1]. Presently, the ten-year completion rate for engineering doctoral students is only 63%, with 65% of men and 56% of women graduating[2]. In addition to the gender disparity in completion probabilities, women are underrepresented in the composition of engineering doctorates and faculties. Only 23.1% of doctorates and 6.4% of senior faculty in engineering are women across universities in the United States[3].

Doctoral completion rates are affected by factors such as level of financial aid, faculty composition, student preparation, and doctoral program requirements[4-8]. The advisor-advisee relationship, however, may be one of the most critical factors in determining the experiences and success of doctoral students[9,10]. After all, "the [advisor] influences how the student comes to understand the discipline and the roles and responsibilities of academic professionals, their socialization as a teacher and researcher, the selection of dissertation topic, the quality of the dissertation, and the subsequent job placement.[9]" Given the importance of the advisor-advisee relationship, changes in advising practices have the potential for meaningful improvements in student educational and employment outcomes[11]. In fields with higher proportions of male faculty and students, same gender mentorship is commonly proposed as a method for increasing the retention and advancement of female students. Theory suggests that female faculty advisors may encourage the persistence of female students through psychosocial functions[12-17]. Yet, there are limited empirical studies on the impact of same gender mentorship on the graduation probabilities and other educational outcomes of female graduate students. Furthermore, the results from these studies tend to be mixed, suggesting that there may be variation in the impact of same gender mentorship by department and context[18-20].

This study examines trends in engineering doctoral student's perspectives and experiences regarding faculty advising to identify correlates with graduation probability and academic career trajectory. Particular attention is given to differences in advising experiences between students working with female faculty and students working with male faculty. Research findings will help higher education institutions develop programs and policies to improve the experiences of doctoral students and to address the gender disparity in engineering.

The research questions are as follows:

- Are female doctoral students more likely to work with female faculty advisors?
- What reasons do students provide for "selecting" their faculty advisor?
- Do differences in advising experiences and academic career aspirations exist between students advised by male faculty and students advised by female faculty?

## Data

The data on engineering doctoral students come from a selective four-year research institution in the Northeast United States. The departments include Civil and Environmental, Mechanical, Electrical, and Chemical Engineering. The dataset consists of student-level administrative records, as well as individual responses to an online survey focusing on advising experiences in the doctoral program. The online survey was administered in January 2010 to current students and to doctorates who graduated between 2003 and 2009. Of the 640 individuals invited to participate, 370 individuals completed the survey resulting in a 58% response rate.

Table 1 summarizes the characteristics of the respondents versus non-respondents. There is no statistically significant difference between survey respondents and non-respondents on GRE verbal score, GRE quantitative score, proportion of U.S. citizens, age at the start of the doctoral program, or in the proportion of non-white U.S. citizens. The non-white U.S. citizen variable includes American Indian, Asian American, African American, Hispanic, and multicultural students. Given the relatively small number of members in each of these groups, the data is aggregated. Current students were more likely to respond than recent PhDs; 70% of respondents and 41% of non-respondents were current students. Women were also more likely to participate in the survey; 25% of the respondents were women versus 16% of the non-respondents.

Table 1: Survey Respondents versus Non-Respondents

| | Respondents | Non-Respondents | | |
|---|---|---|---|---|
| | Mean | Mean | Difference | T-stat |
| GRE Verbal | 562.63 | 544.55 | 18.09 | (-1.88) |
| GRE Quantitative | 771.37 | 766.69 | 4.682 | (-1.24) |
| US Citizen | 47.84% | 44.97% | 0.0287 | (-0.76) |
| Age | 24.33 | 24.38 | 0.0549 | (0.23) |
| Non-White US Citizen | 15% | 13% | 0.0239 | (-0.91) |
| **Female** | 25% | 16% | 0.0862** | (-2.85) |
| **Student** (at time of survey) | 70% | 41% | 0.289*** | (-8.07) |
| *Observations* | 370 | 270 | | |

*p<0.05, **p<0.01, ***p<0.001

## Methods and Theoretical Framework

The Graduate School in this study requires PhD students to form a dissertation committee consisting of a faculty chair and at least two additional faculty members. Students typically select a faculty chair within the first semester and the two additional members by the end of the third semester. Dissertation committee formation is a mutual process that requires the agreement

of both student and faculty member to work together, and is therefore subject to many nuances arising from programmatic requirements, funding opportunities, advisor availability, and other considerations. Role model and social cognitive theories whereby individuals seek role models who are similar to them and then envision potential career trajectories based on the attributes, experiences, and successes of the selected role models predict that female doctoral students will be more likely to select female advisors[12-15]. Likewise, based on social identity theory, female faculty may be more likely to work with female graduate students due to same group membership and the desire to help and promote members of the group[16,17]. Logit regression is used to test the likelihood that female graduate students will match with female faculty. The explanatory variable indicates whether the student is female or male. Control variables include GRE quantitative score, department, and the proportion of female faculty in the department, as well as whether the student is international or a non-white US citizen.

Inasmuch as it is possible to "select" an advisor, the survey asked respondents to indicate reasons for selecting the faculty chair. In most cases, the faculty chair serves as the primary research advisor. Reasons include faculty member (1) conducts interesting research, (2) has a good research reputation, (3) has a good reputation as a classroom instructor, (4) has a reputation for being a good dissertation advisor, (5) is knowledgeable in techniques and methods of interest, (6) fosters a desirable working environment, (7) makes respondent feel comfortable, (8) has a good reputation for helping place students in academic positions, and (9) was assigned. Each of these variables is dichotomous with "0" indicating not a reason for selecting chair and "1" indicating a major reason for selecting the chair. T-tests are used to determine whether there are differences between female students advised by male faculty and female students advised by female faculty, as well whether there are differences between male students advised by male faculty and male students advised by female faculty.

Since discovering correlates with graduation probabilities and academic career aspirations are of primary concern, the survey includes questions on student perspectives on faculty advising in these areas. Respondents indicated whether their faculty advisor encouraged them to finish the dissertation as quickly as possible; to polish the dissertation, even if it delays completing the degree; or to publish the results of their dissertation studies in peer-reviewed journals, even if it delays completing the degree. Some responded that their faculty advisor did not exhibit a preference in regard to dissertation completion. Survey participants also reported whether they considered applying for a tenure-track faculty position while still a graduate student. In regard to the faculty advisor's influence on career trajectories, respondents provided the extent to which their faculty chair encouraged them to pursue an academic career on a scale of 1 to 5, where 1 is "discouraged" and 5 is "strongly encouraged." The faculty advisor's level of influence on career aspirations is measured on a scale of 1 to 5 where 1 equals "very little influence" and 5 equals "a lot of influence." Differences in student perspectives on faculty advising and career aspirations are estimated using t-tests.

**Results**

Faculty Advisor Selection

Consistent with role model and social cognitive theories, estimates from the logit regression show that female students are more likely than male students to match with a female faculty advisor (Table 2). All else equal, women are 5 percentage points more likely than men to pair with a female dissertation chair ($p<0.10$). The proportion of female faculty in the department at the start of the doctoral program is positively associated with the probability of pairing with a female advisor. The other student characteristics included in the model, GRE Quantitative score, U.S. citizenship, and Non-White U.S. citizenship do not influence the likelihood of working with a female faculty advisor.

Table 2: Likelihood of Working with a Female Faculty Advisor
Logit Regression Marginal Effects

| Variable | Coefficient | Std. Err. |
|---|---|---|
| Female Student | 0.0513+ | 0.0309 |
| GRE Quantitative | 0.0005 | 0.0004 |
| International | -0.0244 | 0.0306 |
| Non-White US Citizen | -0.0225 | 0.0432 |
| Proportion of Female Faculty | 0.1012+ | 0.0529 |
| *Observations* | 622 | |
| Pseudo R-squared | 0.04 | |

+p<0.10, *p<0.05, **p<0.01, ***p<0.001
Note: Departments not shown

Table 3 summarizes student characteristics by student and advisor gender. The sample includes 436 male students advised by male faculty (MM), 59 male students advised by female faculty (MF), 106 female students advised by male faculty (FM), and 23 female students advised by female faculty (FF). Among students working with a female advisor, 18% are female and 12% are male. These percentages are roughly proportional to the representation of female faculty. In 2009, the percentage of female faculty in the sample departments ranged from 9.5% to 16%. There is no difference between FM and FF on the characteristics tested (GRE scores, U.S. citizenship, non-white U.S. citizenship, and age at start of doctoral program). Although the two groups are similar on other measures, MF, on average, have higher GRE verbal scores than MM.

Table 3: Student Characteristics

| | *Male Students* | | | |
|---|---|---|---|---|
| | Male Advisor | Female Advisor | | |
| | Mean | Mean | Diff | T-stat |
| GRE Verbal | 550 | 586 | -36.1* | (-2.11) |
| GRE Quantitative | 772 | 777 | -5.1 | (-0.81) |
| US Citizen | 0.46 | 0.44 | 0.02 | (0.26) |
| Non-White US Citizen | 0.15 | 0.10 | 0.05 | (0.97) |
| Age | 24.3 | 23.8 | 0.5 | (1.38) |
| *Observations* | 436 | 59 | | |

| | *Female Students* | | | |
|---|---|---|---|---|
| | Male Advisor | Female Advisor | | |
| | Mean | Mean | Diff | T-stat |
| GRE Verbal | 568 | 555 | 13.2 | (0.48) |
| GRE Quantitative | 758 | 775 | -17.7 | (-1.38) |
| US Citizen | 0.44 | 0.61 | -0.17 | (-1.44) |
| Non-White US Citizen | 0.13 | 0.22 | -0.09 | (-1.04) |
| Age | 24.0 | 23.6 | 0.4 | (0.63) |
| *Observations* | 106 | 23 | | |

*p<0.05, **p<0.01, ***p<0.001

Reasons for Selecting Faculty Advisor

The reasons students provided for selecting his or her faculty advisor is summarized in Table 4. Over 86% of respondents selected faculty advisors based on research interests. Thereafter, respondents considered the faculty member's reputation as a good researcher, knowledge in techniques and methods of interest, and ability to foster a desirable work environment. Relatively few respondents chose advisors based on the faculty member's reputation as a good classroom instructor or reputation for helping students obtain academic positions. A relatively small proportion of students were administratively assigned to a faculty advisor. In general, MM and MF provided similar reasons for selecting the faculty advisor. The exception is a difference in the proportion of male students who chose an advisor based on faculty member's knowledge in techniques and methods of interest - 69% of MM versus 47% of MF. Meanwhile, 25% and 22% of FM indicated reputation as a good classroom instructor and reputation for placing students in academic jobs as major reasons for choosing a faculty member, respectively. In contrast, none of the FF respondents considered either of these as a major reason for advisor selection.

Table 4: Reasons for Selecting Faculty Advisor

| | *Male Students* | | | |
|---|---|---|---|---|
| | Male Advisor Proportion | Female Advisor Proportion | Diff | T-stat |
| Conducts Interesting Research | 0.89 | 0.86 | 0.0321 | -0.57 |
| Good Research Reputation | 0.67 | 0.72 | -0.0556 | (-0.66) |
| Knowledge in Techniques of Interest | 0.69 | 0.47 | 0.213* | -2.53 |
| Fosters Desirable Work Environment | 0.57 | 0.69 | -0.127 | (-1.44) |
| Comfort | 0.54 | 0.61 | -0.0723 | (-0.81) |
| Reputation as a Good Advisor | 0.39 | 0.47 | -0.0863 | (-0.98) |
| Reputation as a Good Classroom Instructor | 0.20 | 0.11 | 0.0932 | -1.32 |
| Advisee Placement in Academic Jobs | 0.20 | 0.17 | 0.0298 | -0.42 |
| Assigned | 0.06 | 0.08 | -0.023 | (-0.52) |
| Observations | 232 | 36 | | |

| | *Female Students* | | | |
|---|---|---|---|---|
| | Male Advisor Proportion | Female Advisor Proportion | Diff | T-stat |
| Conducts Interesting Research | 0.90 | 0.94 | -0.0459 | (-0.59) |
| Good Research Reputation | 0.65 | 0.61 | 0.0411 | -0.32 |
| Knowledge in Techniques of Interest | 0.65 | 0.72 | -0.07 | (-0.56) |
| Fosters Desirable Work Environment | 0.66 | 0.65 | 0.0101 | -0.08 |
| Comfort | 0.67 | 0.47 | 0.196 | -1.5 |
| Reputation as a Good Advisor | 0.52 | 0.40 | 0.122 | -0.85 |
| Reputation as a Good Classroom Instructor | 0.25 | 0.00 | 0.250* | -2.21 |
| Advisee Placement in Academic Jobs | 0.22 | 0.00 | 0.217* | -2.02 |
| Assigned | 0.09 | 0.06 | 0.0257 | -0.33 |
| Observations | 69 | 18 | | |

*p<0.05, **p<0.01, ***p<0.001

Perspectives on Faculty Advising and Academic Career Aspirations

Do differences in advising experiences and academic career aspirations exist between students advised by male faculty and students advised by female faculty? In regard to their perspective on the faculty advisor's attitude toward dissertation completion, FM and FF did not differ in the proportion who responded that their advisor encouraged them to finish quickly, to polish the dissertation, or to publish the dissertation (Table 5). A greater proportion of MM than MF, however, reported that their advisor encouraged them to finish quickly, while a greater

proportion of MF than MM indicated that their advisor encouraged them to publish the dissertation.

Table 5: Advisor Attitude Toward Dissertation Completion

| | *Male Students* | | | |
|---|---|---|---|---|
| | Male Advisor Proportion | Female Advisor Proportion | Diff | T-stat |
| Publish Dissertation | 0.21 | 0.42 | -0.210* | (-2.80) |
| Polish Dissertation | 0.14 | 0.17 | -0.023 | (-0.37) |
| Finish Quickly | 0.11 | 0 | 0.114* | (2.14) |
| *Observations* | 237 | 36 | | |

| | *Female Students* | | | |
|---|---|---|---|---|
| | Male Advisor Proportion | Female Advisor Proportion | Diff | T-stat |
| Publish Dissertation | 0.26 | 0.22 | 0.038 | (0.33) |
| Polish Dissertation | 0.115 | 0.111 | 0.004 | (0.06) |
| Finish Quickly | 0.13 | 0.11 | 0.019 | (0.22) |
| *Observations* | 69 | 18 | | |

*p<0.05, **p<0.01, ***p<0.001

Role model and social cognitive theories predict that individuals will seek individuals who are similar and subsequently, follow similar career trajectories. Given that female students are more likely to work with female faculty, are FF also more likely to have an interest in pursuing a faculty position? Further, based on social identity theory, are female advisors more likely to encourage their female advisees to pursue academic careers? The trends presented in Table 6 show that academic career aspirations, encouragement to pursue academic careers, and level of faculty advisor's influence on career aspirations are similar between FF and FM, as well as between MM and MF. Although not statistically significant, FF are more likely than FM to indicate that their advisor more strongly influenced their career goals. Further, 66% of MF and 70% of MM considered applying for a faculty job compared to 60% of FF and FM.

Table 6: Career Aspirations and Faculty Influence

| | *Male Students* | | | |
|---|---|---|---|---|
| | Male Advisor Mean | Female Advisor Mean | Diff | T-stat |
| Desire Faculty Job | 0.70 | 0.66 | 0.048 | (0.58) |
| Advisor Encouraged Academe~ | 3.53 | 3.77 | -0.237 | (-1.29) |
| Advisor Influenced Career Goals* | 3.96 | 4.11 | -0.159 | (-0.79) |
| *Observations* | 224 | 35 | | |

| | *Female Students* | | | |
|---|---|---|---|---|
| | Male Advisor Mean | Female Advisor Mean | Diff | T-stat |
| Desire Faculty Job | 0.60 | 0.60 | 0.003 | (0.02) |
| Advisor Encouraged Academe~ | 3.63 | 4.00 | -0.365 | (-1.23) |
| Advisor Influenced Career Goals* | 3.67 | 4.29 | -0.614 | (-1.56) |
| *Observations* | 63 | 15 | | |

*p<0.05, **p<0.01, ***p<0.001

~ On a scale from 1 to 5 (1=Discouraged and 5=Strongly Encouraged)

* On a scale from 1 to 5 (1=Very Little Influence and 5=A Lot of Influence)

**Discussion and Conclusion**

While there have been great strides in improving the representation, persistence, and experiences of women, the composition of doctoral students and faculty members in engineering is still disproportionately male. Often, same gender mentorship is proposed as a method for enhancing the experiences and success of female students. There are, however, limited empirical studies on the impact of same gender mentorship on the educational and employment outcomes of doctoral students. This study examines the role faculty advising plays in graduation probabilities and the career trajectories of engineering doctoral students. As predicted by role model and social cognitive theories, female doctoral students in engineering are more likely than male doctoral students to work with female faculty advisors. The proportion of female faculty is also positively associated with the likelihood of students pairing with a female faculty advisor. Together, these findings lend some support to programs and initiatives, such as the National Science Foundation's ADVANCE program[21], which are aimed at increasing the number of women faculty in science and engineering fields. Hiring more female faculty may increase the opportunities for female graduate students to find mentors.

A student's primary reason for selecting an advisor is correlated with the likelihood of completing the PhD[9]. Selecting an advisor based on closeness of intellectual interest is

associated with completing the PhD. In contrast, being administratively assigned to an advisor is correlated with lower probabilities of graduation. Approximately 90% of respondents indicated research interest as a major reason for selecting the faculty advisor, whereas only a small proportion of respondents were assigned to a faculty advisor. Since students, regardless of their faculty advisor's gender, responded fairly similarly regarding their reasons for selecting an advisor, the reasons investigated do not appear to be a source of variation in graduation probabilities. Respondents' perceptions of the advisor's attitude toward dissertation completion did not vary between female students matched with female faculty and female students paired with male faculty. Male students advised by male faculty were more likely than male students advised by female faculty to report that their advisor encouraged them to finish the dissertation quickly. Compared to male students advised by male faculty, a greater proportion of male students advised by female faculty reported being encouraged to publish the dissertation. The faculty advisor's attitude toward dissertation completion has implications for research productivity, time to degree, and academic job placement[11]. Relatively shorter program durations and higher number of publications are associated with greater probability of employment in a tenure-track faculty position[11].

In regard to career trajectories, students advised by male faculty and students advised by female faculty do not appear to differ in the variables measured: academic career aspirations, faculty encouragement to pursue academic careers, and level of faculty advisor's influence on career aspirations. These trends, however, may be influenced by the absence of students who have withdrawn from the doctoral program in the survey sample. The proportion of male students who considered an academic career is higher than that of female students. Approximately 6 to 10% more men than women considered applying for a faculty position while in graduate school, providing some evidence for the National Research Council's finding that the gender disparity in STEM fields is partially due to the lower probability of women applying for tenure-track faculty positions at research universities[22]. This difference is consistent with previous findings that 60.1% of women compared to 67.3% of men in the humanities, social sciences, and biological and physical sciences are interested in becoming faculty members[23].

This study provides some evidence that increasing the number of female faculty may increase the opportunities for female graduate students to find mentors, and that the lower representation of women in the faculty may be associated with the relatively smaller proportion of female doctoral students desiring faculty positions. Future work will include additional data collection to create a larger sample size test the impact of same gender mentorship on student graduation probabilities. Additionally, further research will explore why women may be less likely to desire a faculty position taking into account factors such as motherhood and work-life balance. Research findings will be useful to higher education institutions and stakeholders in improving the completion rates of doctoral students and in diversifying the composition of engineering doctoral students and faculty.

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