

# Ph.D. Student Attrition in the EECS Department at the University of California, Berkeley

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## ABSTRACT

We report on results of a survey conducted to study attrition of Ph.D. graduate students in the Electrical Engineering and Computer Science (EECS) Department at the University of California at Berkeley. We surveyed Berkeley alumni who entered the department between 1981 and 1991 and left the EECS Ph.D. program before obtaining their degree. The respondents returned an extensive questionnaire about their backgrounds, motivations for choosing a Ph.D., and factors that resulted in their leaving. Many also responded to an open-ended question that sought further comments and suggestions for improvement. The most common reasons for leaving the program involved changed career goals and personal reasons. Not far behind were departmental, advisor, and academic concerns, the length of time it takes to obtain the degree and the number of academic as well as emotional “hoops” a student is expected to jump through during the process of earning a Ph.D. More ambiguous concerns were expressed such as not feeling integrated in the department academically. This issue involves problems ranging from finding an advisor or research group to feeling isolated amongst colleagues and in research interests. Even when research compatibility was achieved, lack of guidance from advisors contributed to a number of students’ decision to leave. When we separated respondents by gender, we found little overall difference in response between females and males, but we discuss those areas where differences were observed. We provide recommendations for departmental improvement. These include integrating first year students, continuing evaluation of preliminary exams, rewarding faculty for mentoring, and supporting diversity.

## 1.0 Introduction

Of students who entered the Electrical Engineering and Computer Science (EECS) doctoral program at Berkeley in 1981-1986, 43% of the women and 61% of the men obtained a Ph.D. <sup>\*\*1</sup> What drives talented students from a doctoral program despite their desire to achieve a Ph.D.? It would be easy to attribute attrition to the failure to meet academic requirements, but we found that the reasons are usually much more complex. In 1993, the graduate student group Women in Computer Science and Engineering (WICSE<sup>\*\*\*</sup>) at the University of California at Berkeley sought to identify reasons for Ph.D. attrition rates among graduate students in the EECS department at Berkeley. The goals of the study were to:

- draw attention to the problem of graduate EECS attrition,
- identify the reasons for attrition,
- give feedback to the department encouraging continuation of positive influences and suggesting changes to improve the department,
- determine if women and men leave for different reasons.

Our approach was to survey former Berkeley students who entered the graduate program intending to obtain a Ph.D.

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\*\* For those entering in 1981-83, these rates are 50% from women and 64% from men, and are close to the campus average Ph.D. completion rates of 51% for women and 64% for men.

\*\* \* WICSE is a student-run group for women graduate students in electrical engineering and computer science.

in EECS, but who left without earning the degree. Although the study focuses on one campus, we believe this campus is an important example. In the 1994-95 academic year, Berkeley graduated 79 Ph.D.s in EECS. The program is a significant source of Ph.D.s for both academia and industry. We propose that our results may also apply to other graduate programs, making this work important in ensuring that, nationwide, industry and academia are not denied the talents of potential contributors.

Several factors distinguish our attrition study from previous research. We address student attrition at the Ph.D. level, which receives little attention in the science education literature. Barber et al.<sup>2</sup> address the decision to pursue a Ph.D. in engineering, but they do not follow up on students who eventually leave the Ph.D. program. We consider the problem for EECS Ph.D. students in particular. EECS is different from many other scientific fields, because the master's is a viable terminal degree. Almost all of our respondents received the master's degree, which helped them pursue challenging careers in the field. Most research on student attrition from engineering or science focuses on undergraduates, especially those in the first two years of college.<sup>3,4,5,6,7</sup> These reports study students who remain in school but leave the sciences for other fields. In contrast, most of our respondents left school but remained in the fields of electrical engineering or computer science. Although some respondents did switch fields, about three-quarters are working in related careers.

In the past, most educators attributed attrition from scientific majors to the difficulty of the subject matter. They assumed that students who left these fields lacked the ability or motivation to perform well. We discovered that our respondents did not leave school primarily because of problems with academic performance. These findings are consistent with the results of undergraduate attrition studies. In the last decade, researchers including Tobias, Seymour and Hewitt, and Strenta et al. have studied the large proportion of students who transfer from the sciences into other majors during or following their lower-division pre-requisite courses.<sup>3,4,5,6</sup> Many students leave the sciences because of changes in their career plans, dissatisfaction with classes and teaching, and negative reactions to the prevalent "weeding-out" system. Similarly, our survey found that career choices, opportunities outside of academia, and dissatisfaction with the academic environment influenced the decision to leave graduate school. Problems with academic performance less frequently factored into the respondents' decisions.

The number of women in science and engineering is disproportionately small and decreases in each stage of the academic pipeline.<sup>8,9</sup> To some extent, most researchers discuss the attrition of women from the sciences as a specific sub-problem. Seymour<sup>7,10</sup> and Felder et al.<sup>11</sup> address the attrition of women in more depth and discuss problems women face in adapting to the culture of academic science, mathematics, and engineering. Although we did not specifically set out to investigate the problems women encounter in science, we have compared responses by gender. To our surprise, we found only a few areas of significant difference.

### ***EECS Department Background***

The University of California at Berkeley has a relatively large and prominent department, with about seventy-five combined EE and CS faculty. About 500 students are pursuing Ph.D. degrees at any given time, and about 100 new Ph.D. students enroll each year. The Berkeley campus is a Research University I,<sup>12</sup> highly ranked and with competitive admissions standards. The graduate programs in EE and CS are highly regarded, ranking among the top four in the National Research Council's 1995 report on Research-Doctorate programs in the U.S.<sup>13</sup> Less than one in five applicants to the department are accepted, with the vast majority having GPA's of 3.8 or higher, near perfect GRE quantitative scores, and very good references. For Berkeley EECS graduates, the current mean time to obtain a Ph.D. is 5 and a half years, one of the shortest times to degree compared to other departments at Berkeley and comparable to other top ten universities. Mean times to degree do not appear to differ significantly between women and men. Nationwide, a Ph.D. in EE or CS has traditionally led to industrial research as well as academic positions. Because of the department's reputation, graduates of Berkeley, both those receiving the Ph.D. and those deciding to leave with a master's degree, can be assured of rewarding positions with good salaries. (For 1994-95 graduates, median salaries in EECS were \$40,000 for a B.S. degree, \$48,000 for an M.S. degree, and \$66,500 for a Ph.D.<sup>14</sup>)

## 2.0 Survey Methodology

The survey was sent to former Berkeley EECS students who, according to university records, had marked an intention to get a Ph.D. on their applications and left the department without obtaining one. Despite the length of the survey, 97 out of 190 surveys sent were returned without prompting. This high return rate for a non-follow-up survey suggests that former Ph.D. students had a strong desire to share their opinions of the Berkeley program.

The survey (Appendix A) comprised 141 questions divided into two main sections. The first section addressed the educational background of the respondents and their motivation for pursuing the Ph.D. The second section listed possible reasons, or “factors,” for leaving the Ph.D. program. Respondents were asked to identify each factor as a “major factor,” “a factor,” or “not a factor” in their decision to leave the Ph.D. program. The questions were generated from interviews with a focus group of former Berkeley EECS graduate students who left without attaining a Ph.D., and from commonly-held beliefs about why graduate students leave. The list of factors was quite extensive because we found interviewees reluctant to state a definite response unless the question specifically addressed their concerns. For example, people were reluctant to say they had a “bad advisor match,” but did respond to more specific descriptions such as “lack of guidance from advisor,” or “my advisor did not provide any specific timeline for progress.”

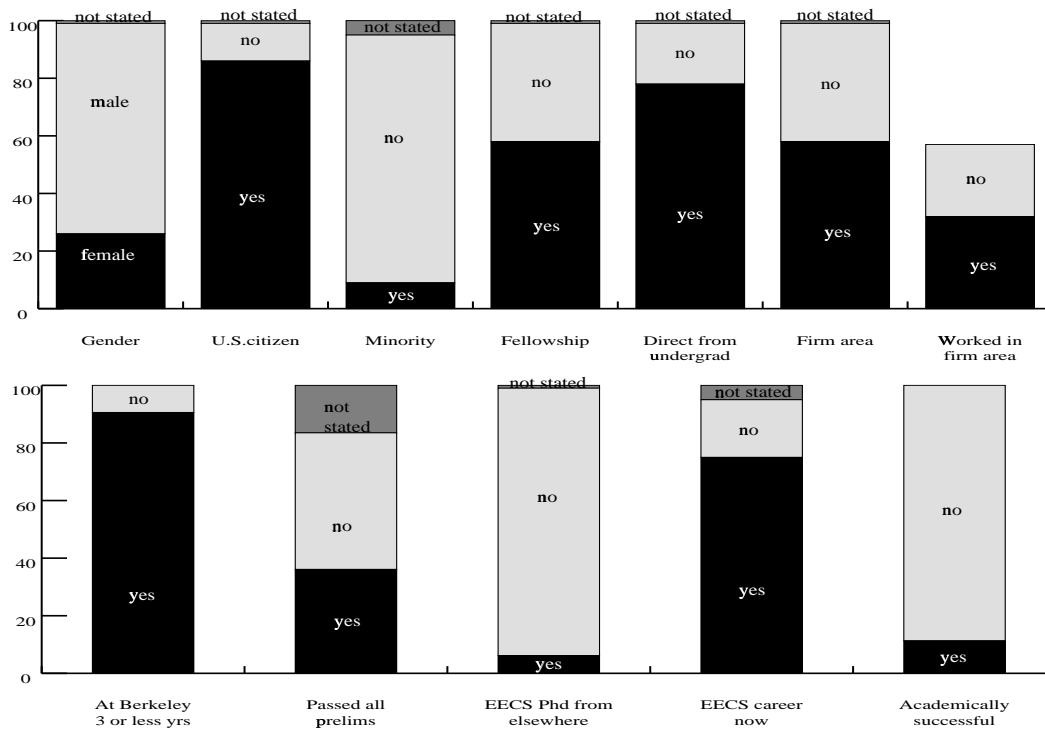
Question responses were analyzed individually and grouped into themes. Individual questions were analyzed in two ways. For each question, or factor, we calculated the percentage of respondents who answered either “a major factor” or “a factor,” and also the percentage of respondents who answered only “a major factor.” In order to understand major trends in our data, we categorized factors into ten groups by general theme; we refer to these as “aggregates.” An affirmative response to an aggregate was recorded if the respondent chose at least one factor in the aggregate as a “major factor”; thus the aggregate groupings are summaries of more strongly held perceptions. Although this method of analysis serves to illuminate general themes, we found that at times it could also mask results within the groupings. Consequently, in our analysis, we refer to results from both the aggregates and individual questions and comments. With this technique, we hope to identify the common reasons for Ph.D. attrition, while also examining reasons that might not be reflected by the majority of the respondent population.

We have, in addition, analyzed responses by gender. Among the statistics we have used are the *t*-test for the difference between the sexes in the means and the Chi-square test for the difference between the sexes in proportions. To determine if a statistically significant difference between female and male response existed, we calculated the significance level, referred to here as the “p-value” (probability value). A p-value represents the probability that chance variation would have produced a difference as large or larger than the one observed in the data. In other words, a low p-value means there is a significant difference between the data being compared. A p-value of 0.05 is always considered significant and a value of 0.10 is often considered significant. All data were analyzed through a statistical analysis package, SPSS.<sup>15</sup>

## 3.0 Survey Respondents

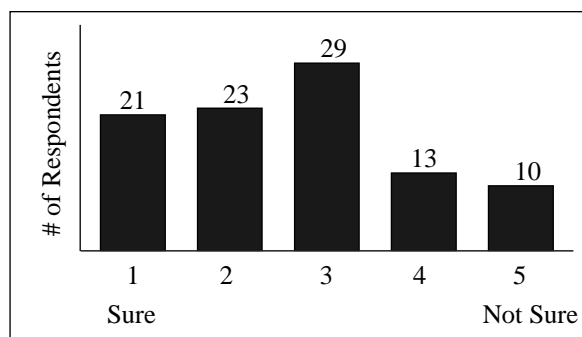
### 3.1 Respondent Demographics.

Respondents entered the EECS department between 1981 and 1991 and left between 1982 and 1994, staying an average of 2.2 years. The respondent breakdown (Fig. 1) introduces many of the issues to be addressed in this paper. Women were better represented in our sample than in the graduate population as a whole. (This will be discussed further in section 5.0.) A large proportion had fellowship support, but the vast majority stayed less than three years, suggesting that a significant amount of fellowship support fails to keep students in school. The minority population of our respondents was relatively small, but comments indicated some disagreement as to what “under-represented” meant in this department. (This is discussed in section 4.5.) Less than a third were able to work in the area of their initial strong interest. Although almost half failed prelims, we will see that fewer than this number considered this the reason they left (see section 4.2). Many of the respondents may not even have attempted prelims. Most of those who left are still doing technical work, some even in an academic or research environment. Six respondents went on to obtain an EECS Ph.D. elsewhere. Respondents were also asked what their current occupations are. About 75% are now pursuing technical careers; two are now professors; nine are conducting industrial or government research, and five others achieved degrees in other professional areas such as law and medicine.



**Figure 1:** Statistics on respondents' backgrounds.

Respondents were asked, regardless of what they stated on their graduate application, how sure they were that they wanted to obtain a Ph.D. in EECS. Figure 2 summarizes their responses, and shows that on a scale from 1 to 5, respondents' certainty is weighted towards being "sure" that they wanted a Ph.D.



**Figure 2:** Survey respondents' certainty of wanting a Ph.D. in EECS upon entrance to the Ph.D. program.

### 3.2 Motivation for choosing a Ph.D. in EECS at Berkeley.

Respondents were asked to rank in order of importance a list of possible reasons to pursue a Ph.D. in EECS (Table 1). The survey listed nine possible reasons. Respondents were allowed to repeat a number if they couldn't decide the order of importance of two choices and they could write in one "other" reason. Respondents were also asked to indi-

cate if a reason did not play any part in their decision by marking it with an “X.” These data are shown in order of average ranking across the respondent population. We chose this method of representing the data because it takes into account respondents’ subsidiary reasons for pursuing the Ph.D. as well as their number one reason. Items marked with an “X” were assigned a ranking of ten. Respondents were also asked to rank a list of eleven reasons for choosing Berkeley for graduate school (Table 2). These data are also shown by average ranking.

**Table 1: Reasons for Pursuing a Ph.D.\***

Overall		Women		Men	
Reason	Mean Rank	Reason	Mean Rank	Reason	Mean Rank
1. Fascinated by subject	3.39	1. Fascinated by subject	4.48	1. Fascinated by subject	2.92
2. Improve career opportunities	4.40	2. Prestige of the Ph.D. degree	4.76	2. Improve career opportunities	4.13
3. Preparation for research in EECS	5.00	3. Improve career opportunities	4.96	3. Preparation for research in EECS	4.80
4. Prestige of the Ph.D. degree	5.74	4. Preparation for research in EECS	5.36	4. Enhance earning potential	5.55
5. Enhance earning potential	5.88	5. Default next step	5.44	5. Prestige of the Ph.D. degree	6.03
6. Default next step	6.07	6. Enhance earning potential	6.64	6. Default next step	6.24
7. Wanted to become a professor	6.84	7. Wanted to become a professor	7.08	7. Wanted to become a professor	6.70
8. Important to my family	7.97	8. Important to my family	7.24	8. Important to my family	8.20
9. Didn’t like work in industry	8.94	9. Didn’t like work in industry	8.68	9. Didn’t like work in industry	9.01

\*. In Tables 1 and 2, mean overall rank is not exactly the weighted average of women and men because one respondent declined to specify gender.

Our findings in Table 1 agree well with a study done by Barber et al.<sup>2</sup> in which graduate students planning on getting the doctorate degree were asked to rank reasons that influenced their decision to pursue the Ph.D. The most important reason cited in Barber’s study pertained to interesting and challenging subject matter and a desire to learn more about the field. Second and third reasons dealt with improving career opportunities and wanting a career in research. Even the fourth and fifth ranked reasons in our study, “prestige of the Ph.D.” and “enhancement of earning potential,” ranked a similar fifth and sixth in the Barber study.

Respondents were asked what their reasons were for choosing the graduate program specifically at Berkeley. Many of these reasons might also generalize to the choice of any EECS graduate program. Clearly Berkeley’s “great reputation” attracts students (Table 2). The gap in mean rank between reputation and the next reason (“best program I was accepted into”) emphasizes how important Berkeley’s reputation is compared to other reasons. Ironically, it is also Berkeley’s reputation that allows students to leave the program without a Ph.D. and find top-notch work. It is interesting to note that choosing Berkeley because it was the best program which accepted them, a natural and obvious reason, was essentially tied in importance with Berkeley’s desirable location in the San Francisco Bay Area. The fourth most important reason, “specific faculty,” combines two elements: those students who actually were acquainted with a member of the faculty who wanted to work with them and those who were attracted by a prominent faculty member, without knowing him or her personally. The importance of personal acquaintance or prominent faculty extends to many EECS programs, but the attraction to particular Berkeley faculty points again to what this department specifically has to offer. The early retirement of some of Berkeley’s well-known faculty does not bode well for Berkeley’s continued ability to attract graduate students in EECS. The other reasons given for the choice of Berkeley ranked too low to draw any specific conclusions. The relative unimportance of financial considerations probably reflects the

nature of EECS education: most EECS students are funded while in graduate school through fellowships or working as a teaching or research assistant. Students can also find outside programming work and well-paid summer jobs in industry. As can be seen in Table 2, the reasons are ranked differently for women and men. We discuss these differences in the section on gender differences (section 5.0)

**Table 2: Reasons for Choosing Berkeley**

Overall		Women		Men	
Reason	Mean Rank	Reason	Mean Rank	Reason	Mean Rank
1. Great Reputation	3.14	1. Great reputation	2.80	1. Great reputation	3.14
2. Best program I was accepted into	5.04	2. Liked the atmosphere	6.44	2. Best program I was accepted into	4.31
3. Liked the Bay Area	5.05	3. Liked the Bay Area	6.48	3. Liked the Bay Area	4.45
4. Specific faculty	7.08	4. Best research facilities	6.64	4. Specific faculty	6.87
5. Best research facilities	7.21	5. Best program I was accepted into	6.84	5. Best research Facilities	7.34
6. Most affordable school/ gave best financial support	7.95	6. Specific faculty	7.48	6. Most affordable school	7.85
7. Liked the atmosphere	8.00	7. Most affordable school	8.08	7. Liked the atmosphere	8.49
8. Wanted a change from my undergraduate school	8.53	8. Wanted a change from my undergraduate school	8.36	8. Wanted a change from my undergraduate school	8.54
9. Geographic area was good for my significant other	10.05	9. Friends recommended it to me	9.36	9. Geographic area was good for my significant other	9.76
10. Friends recommended it to me	10.13	10. Other	10.28	10. It was the only school I applied to /was accepted into	10.11
11. It was the only school I applied to /was accepted into	10.44	11. Geographic area was good for my significant other	10.80	11. Friends recommended it to me	10.38
12. Other	11.05	12. It was the only school I applied to /was accepted into	11.32	12. Other	11.31

## 4.0 Reasons for Leaving the Ph.D. Program

### *Overview*

Respondents were questioned on 90 specific factors and asked, “To what extent did the following affect your decision to leave Berkeley?” They were given three choices of response for each factor: “major factor,” “a factor,” or “not a factor.” About half the respondents chose seven or fewer of the possible factors as a “major factor.” Table 3 lists the reasons that were either a “major factor” or “a factor” for at least 35% of the respondents. We have ranked the reasons for leaving in two ways. The first column shows the percentage of respondents who answered “major factor” or “a factor” for the given reason. The second column shows the percentage who answered “major factor.”

A cursory glance at Table 3 shows that the most frequently stated factors for leaving the program are related to career choices, being tired of school, the time commitment of the degree, and problems with research advisors. This underscores the fact that attrition is not due simply to the difficulty of the subject matter, which would be reflected by aca-

ademic performance problems, such as finding classes too difficult or failing prelims. This result agrees with the findings of Barber et al.<sup>2</sup> regarding graduate students who did not intend to get a Ph.D. The reasons these students most frequently gave for stopping at the master’s degree were “not interested in a job as a professor,” “takes too long to get a doctorate,” and “a doctorate will not help me to do the work I want to do.” Low in the list of reasons were “didn’t think I could handle doctoral level work,” and “I have been discouraged for academic reasons from getting the Ph.D.”

**Table 3: Most Common Factors for leaving**

“To what extent did the following affect your decision to leave Berkeley?”	% responding major factor or a factor	% responding major factor
Realized that I didn’t need a Ph.D. in EECS for the career I wanted	74%	48%
Wanted to get on with my life	69	37
Degree took too long	63	30
Realized I didn’t want an academic career	60	35
Wanted a break from school	60	25
Lack of guidance from advisor	54	29
Wanted to get work experience	54	28
Too many hoops to jump through to get the Ph.D.	52	22
Was unexcited by my research topic	51	23
Impersonal atmosphere	45	16
Outside activities more interesting and rewarding	44	19
Didn’t have enough confidence	42	13
Constant pressure	42	12
My advisor didn’t provide any specific timeline for progress	39	19
Unencouraging treatment of students by faculty	39	15
Tired of taking classes	37	13
Prelims were intimidating	37	13
Couldn’t decide on a general research area	36	11
Felt like an outsider in my research group	36	8

***Respondents’ certainty of wanting a Ph.D.***

How sure were our respondents that they wanted a Ph.D.? To analyze our data (Fig. 2), we separated those who were initially more sure of wanting a Ph.D. (circled 1 or 2) from those who were less sure (circled 3, 4, or 5). Both groups ranked “realized I did not need a Ph.D.” as the highest reason for leaving; however, 57% of the “less sure” group marked this as a “major factor,” versus 39% of the “more sure” group. The p-value of this difference was 0.08. Other than realizations of not needing or wanting a Ph.D., the “more sure” people tended to select specific reasons related to the mechanics of the Ph.D. process more frequently than the unsure people. These include advisor-related, research, and research-matching reasons. For instance, “lack of guidance from advisor” ranked third in importance for the “more sure” group, but only sixth for the entire respondent population.

### *Aggregate results*

Table 4 shows both female and male responses to the ten aggregates that represent the main themes into which respondents' reasons for leaving were grouped. This aggregating technique was used to study the relative importance among these ten themes. Also shown in Table 4 is the p-value that indicates if there is a statistically significant difference between female and male responses. A lower p-value reflects more difference in response between genders.

**Table 4: Ranking of Response to Aggregate Themes**

Aggregate Major Factors	% of all respondents	% of female respondents	% of male respondents	P-value of difference
Career and personal reasons	79%	80%	79%	1.00
Degree requirements	64	52	68	0.25
No research match	53	68	48	0.13
Advisor-related reasons	41	44	39	0.87
Department atmosphere	39	36	39	0.95
Confidence	26	24	27	1.00
Guidance	20	16	21	0.77
Academic performance	16	20	14	0.53
Treatment of minorities	4	4	4	1.00
Treatment of women	3	8	1	0.17

We summarize some of the more notable results of the aggregate data. About 80% of both genders cited what we have defined as “career and personal reasons” as major factors for leaving; more than 60% objected to degree requirements; and over half could not find a clear research fit with the department. Only a few aggregates elicited discrepant responses between males and females. Four respondents (4% of the sample) cited as a major factor in their decision to leave problems with a perceived bias against minorities in the department, some naming particular professors and administrators. Although this is a small proportion of the total population, we believe that it is a large proportion of the minorities who responded. Two women (of 25 in the sample) and one man (out of 71) found problems with the status of women in the department to be a major factor in their leaving. Unfortunately the sample size of under-represented minorities was too small to draw any statistically significant conclusions; however, the comments from minority respondents clearly indicate a problem. We discuss this in section 4.5.

In the following sections, we examine the six aggregates that elicited the most response from respondents and also explore the differences in response between males and females. We also look at responses to the individual questions that made up the aggregates. As we noted previously, respondents typically chose several “major” factors that contributed to their decision to leave. Thus, even when career or personal reasons were a major factor, respondents often had department-specific frustrations that were major factors in their decisions to leave.

#### **4.1 Career and Personal Reasons Most Important**

The “career and personal” aggregate received responses from about 80% of those surveyed. Factors within this aggregate can be grouped into four broad categories: didn't need the Ph.D.; school burn out; outside enticements; and other reasons. We list the reasons that garnered the most responses within the categories in Table 5 in order to illustrate the range of career and personal concerns to which people responded.

**Table 5: Selected factors in the “career and personal” aggregate**

Factors	% responding major factor or a factor	% responding major factor
<b><i>Didn't need the Ph.D.:</i></b>		
Realized that I didn't need a Ph.D. in EECS for the career I wanted	74%	48%
Realized I didn't want an academic career	60	35
The economy improved, so I could get a job in industry	6	3
<b><i>School burn out:</i></b>		
Wanted to get on with my life	69	37
Wanted to get work experience	54	28
Wanted a break from school	60	25
Disliked being split between an outside job and school	11	5
<b><i>Outside enticements:</i></b>		
Outside activities were more interesting and rewarding	44	19
Summer/co-op job led to work much more exciting or cutting-edge than my research	24	11
Saw friends leave, who then made much more money and had more personal time	24	11
<b><i>Other reasons:</i></b>		
Had trouble balancing personal and school life	28	10
Socially isolated in personal life	19	7
Problems with housing	13	7

The highest-ranked reason for leaving was “realized I didn't need a Ph.D. in EECS for the career I wanted” (Table 3). It is generally agreed that the main reasons a Ph.D. is necessary are to become a professor and to pursue a career in research. If we look at the top three reasons respondents chose to pursue a Ph.D. -- they were fascinated by the subject, they wanted to improve their career opportunities, and they wanted to prepare for research in EECS (Table 1) -- a master's degree at Berkeley can address these goals. A master's degree is sufficient to provide experience in a particular subject area and also substantially improves one's marketability at graduation. And since Berkeley has a combined master's and Ph.D. program in EECS, master's students conduct an abbreviated research project alongside Ph.D. students. This may have convinced some master's students that they didn't want a research career. Considering that “wanted to become a professor” ranked seventh in reasons for choosing to pursue a Ph.D., and that the process of earning a Ph.D. is not a trivial undertaking, we conclude that many people left when they realized their reasons for pursuing the Ph.D. no longer corresponded with their career goals. The Ph.D. degree wasn't worth the effort.

The large commitment of time and effort discouraged many from pursuing a Ph.D. Ranked second and third in respondents' reasons for leaving (Table 3) were “wanted to get on with my life” and “the degree took too long.” In written comments, respondents described feelings of “burn out” and frustration with having to postpone starting their careers. One student considered the possibility that a Ph.D. could take up to seven years and decided “I wasn't prepared to put my life on hold that long.” Another respondent commented, “a doctoral degree really requires a long commitment that I was not willing to make.” Accordingly, three factors in the “school burn out” category (Table 5) were cited by over half the respondents. In addition, 63% felt that the “degree took too long” and 37% were “tired of

taking classes” (see section 4.2).

“Realized I didn’t want an academic career” was also ranked highly (fourth) by respondents as a reason for leaving. For some, this realization was simply a change in career choice; however, for others the decision to leave academia was a negative reaction to experiences that turned them away from academic or research careers. One respondent remarked “I was very turned off by the competitiveness, combativeness, egotism, and self-aggrandizement I saw in academic computer science as a whole.” The student also indicated that this negative atmosphere was experienced at conferences as well as within the department. Another respondent observed “if the idea was to select only people who thrived in an atmosphere of intellectual hostility, I figured I didn’t want to be a part of it.” This remark suggests an unsettling, inherent self-elimination process in present-day academics, and we submit that these comments reflect problems with the structure and atmosphere of academics today.

The EECS department at Berkeley seems to be able to support most students adequately, with only 10% of respondents marking “not enough financial support” as a major factor and another 16% considering it a contributing factor. “Always had to TA to support myself” was a major factor for 5% and a contributing factor for another 6%. Although the percentage of respondents who considered funding to be a major factor was relatively low, we acknowledge that for those who had funding problems, the impact on their lives was pervasive. Although the two department funding factors are not part of the “career and personal” aggregate, we mention them here because they pertain to financially-related career decisions.

One factor that evoked surprisingly different responses between women and men was “problems with housing.” Not a single woman cited this as a reason for leaving, while 10% of men considered it a “major factor,” and another 8% considered it a contributing factor. This suggests some bias against men in the housing market. In recent years, the department has developed relationships with local landlords and posted housing opportunities to EECS graduate students by email, possibly alleviating some of these problems. Nevertheless, this issue should be looked into further among recently admitted students to see if this is still a problem.

## **4.2 Academic Factors: Degree Requirements and Academic Performance**

The aggregates listed in Table 4 include two academic categories. The “degree requirements” aggregate covers frustrations with the objective requirements for the Ph.D. degree. In contrast, the “academic performance” aggregate consists of both self-perceived and objective academic problems. In this section we will describe academic requirements and then discuss survey responses to degree requirements and academic performance. Because prelims are the biggest initial hurdle for graduate students, we discuss them in detail.

The doctoral program in EECS has many academic requirements, including a relatively heavy courseload and preliminary exams (“prelims”). Students take about 8-12 graduate and upper division courses, including breadth requirements, a major emphasis, and minors both within and outside of the College of Engineering. Prelims include an oral component and are normally taken in the first and second year of graduate school. They test both general background and preparation in the proposed research area. Studying for and taking prelims is time-consuming and usually stressful. Concurrently with taking courses and preparing for prelims, the typical doctoral student also has a substantial time commitment to a research project or thesis for the master’s degree. The qualifying examination (“quals”) is an oral exam normally taken after the third year of graduate school. It covers a student’s dissertation research.

### ***Factors Related to Degree Requirements***

Degree requirements caused more respondents to leave than actual academic performance problems. Table 6 details the factors in the requirements aggregate. Nine reasons for leaving dealt with the requirements of the Ph.D. program. This group ranked second among the ten aggregates with 64% of respondents considering requirements a major factor in their decision to leave the program. These data demonstrate the students’ frustration with the length of the doctoral program and their subjective response to its requirements. Specific, more objective complaints about coursework were much less frequent. As section 4.4 will discuss, respondents commonly complained that their research advisors failed to provide sufficient guidance (54%) or a specific timeline for progress (39%) (Table 3). Considering this, the frustrations that so many students felt with the program’s requirements may reflect as much on their

desire for more guidance in progressing through the Ph.D. as on their evaluation of the specific requirements.

**Table 6: Factors in the “degree requirements” aggregate**

Factors	% responding major factor or a factor	% responding major factor
Degree took too long	63%	30%
Too many hoops to jump through to get the Ph.D.	52	22
Prelims were intimidating	37	13
Tired of taking classes	37	13
Process of finding an advisor difficult	33	14
Disliked work hanging over my head	31	12
Better research possibilities in industry without all the requirements	28	12
Too many classes required	22	6
Classes too difficult/too much work	18	5

Men and women show some differences in their attitudes towards degree requirements. In general, men more frequently cited factors in the degree requirements group as major reasons for their leaving (68% of men vs. 52% of women). As major factors for leaving, the “degree requirements” aggregate was second only to the “career or personal” aggregate for men, but it ranked third for women (problems finding a research match ranked second). When we consider problems with degree requirements as either major or contributing reasons, women tended to cite the degree requirements factors more frequently than men. One large difference was for “prelims were intimidating,” a major or contributing factor for 54% of the women who answered the question, but only 34% of the men (p-value of 0.10). Among those who answered the question, another factor received a larger response from the men (35% of men vs. 13% of women, p-value not usable due to small sample size): “I could have the same or better research possibilities in industry without all the other requirements (prelims, etc.).” Why did women choose this reason so much less frequently than men? Their response may indicate not so much a willingness to put up with requirements as a belief that their research opportunities in industry will be weaker without a Ph.D.

*Academic Performance and Attrition*

**Table 7: Factors in the “academic performance” aggregate**

Factors	% responding major factor or a factor	% responding major factor
Did not pass prelims	24%	11%
Classes were too difficult or too much work	18	5
My G.P.A. wasn’t high enough to continue for the Ph.D.	7	1
Did not pass the qualifying exam	2	1

Few respondents left the program primarily because of problems with their academic performance, but almost all

who left for academic reasons had problems with prelims. Not passing prelims was a “major factor” for 12% of those who responded to the question and “a factor” for another 13%. Because of the wording of the questionnaire, it is not clear whether all of these individuals actually failed prelims; some may have left without attempting all of the prelim requirement. Low grades were a major factor for only one individual (1% of those who answered the question) and a contributing factor for six others (6%). Two individuals cited not passing the qualifying exam as a factor in their leaving, one as a major factor and one as a factor.

### ***Prelims***

EECS graduate students commonly perceive preliminary exams as a “weeding” process or a rite of passage. Although the structure and content of the exams have changed over the years, prelims have always demanded a considerable time commitment and are generally a stressful experience. Prelims eliminate students from the program in two ways. Some students fail prelims and are not allowed to continue past the master’s degree. Other students are discouraged by prelims; they decide not to attempt the exams or do not put forth enough effort to pass all required exams.

More than one-third of the people responding to our survey passed all of their prelim requirements before leaving the program. In unsolicited comments, nineteen respondents (20%) told us either that they did not try to take prelims or that they passed all that they attempted, but had not attempted all of the exams. Unfortunately, we do not know how many of the rest attempted prelims unsuccessfully and how many did not seriously try. Relatively few people in the sample left the program largely because they did not pass prelims; only 11% of respondents gave this as a major reason, and an additional 12% said it was a secondary factor. Of these, we do not know how many actually attempted all the exams and failed. Somewhat more students found prelims intimidating; 13% gave this as a major factor in their leaving and 24% considered it a secondary factor. When respondents described prelims as intimidating, we interpreted this to indicate frustration with the requirements of the Ph.D., rather than academic problems. One student viewed prelims as “1 or 2 years of garbage to get out of the way,” and another was “not sufficiently motivated to pass prelims.” Others described feeling stressed or demoralized.

If prelims are used to “weed” students from the Ph.D. program, who is being weeded out? Among the eleven individuals who left the program largely because they failed prelims, four achieved a Ph.D. at a different university (two at Stanford). Ten out of the eleven are currently working in an EECS-related field, with six pursuing careers in industrial research or teaching. Some may consider that prelims succeed in discouraging candidates who are less qualified academically, yet it is questionable whether prelims are an accurate measure of potential success. (Seymour argues that similar “weeding-out” systems in undergraduate engineering, science, and mathematics rest on untested theories about attrition and do not, in practice, eliminate the less capable students.<sup>4</sup>)

## **4.3 No Research Match**

The “no research match” aggregate received responses from 53% of respondents. It is composed of the twelve factors listed in Table 8. We use the term “matching” to refer to a respondent’s perception that she or he did not fit into the EECS department *academically*, meaning that either the faculty, their peers, or their preferred research topic did not match.

The “no research match” aggregate provoked the greatest difference in responses from women and men, with a p-value of 0.13. Results showed that 68% of women cited matching as a problem, whereas 48% of the men did so. From the magnitude of these numbers this was clearly an important problem for both sexes. We hypothesized that women had more problems with matching themselves to an advisor and group. Three factors seemed most important in this respect, but no statistically significant difference was found between genders for these factors. When the aggregate was broken down into its constituents, two other factors seemed to account for the difference: of those who answered the question, 36% of women, but only 20% of men (p-value of difference 0.10), cited “unexcited by my research topic” as a “major factor” and, probably related to this finding, 17% of women, but only 7% of men, cited as a major factor “focus of research group shifted to area of little interest.” (P-value not usable due to small sample size.)

**Table 8: Factors in the “no research match” aggregate**

Factors	% responding major factor or a factor	% responding major factor
Was unexcited by my research topic	51%	23%
Couldn't decide on a general research area	36	11
I felt like an outsider in my research group	36	8
Could not find a research project	33	14
Process of finding an advisor difficult	33	14
No peers to discuss my work with	33	12
My research area was marginal to my advisor's core interest	33	8
Could not find a match on the faculty for my research interests	30	18
Changing research group/project was too difficult	30	12
Couldn't get into the research group doing the work I was interested in	22	10
The focus of my research group shifted to an area of little interest to me	20	9
My advisor left or didn't get tenure	4	3

The dissertation is a formidable undertaking. Barber et al.<sup>2</sup> found that the dissertation requirement discouraged many engineering graduate students from pursuing a Ph.D. Among their respondents, about two-thirds of those who opted to leave with a master's degree cited the dissertation as a discouraging factor. Although our survey does not ask directly about the dissertation requirement, many of the research match factors indicate problems with beginning the thesis. Finding an enjoyable topic in an appropriate group with an advisor who will accept you into the group requires many steps, any of which require compromise. To alleviate these problems, we encourage the department to continue efforts in its research seminars to give new students an idea of what research is being done and by whom.

#### 4.4 Advisor-related Factors

Advisor-related issues (Table 9) ranked prominently among the factors affecting respondents' decisions to leave, with 41% of respondents expressing a problem with advising as a major factor in leaving. This is not surprising, since the research advisor plays an important role in the professional development of a graduate student. “Lack of guidance from advisor” was a highly ranked factor affecting respondents' decision to leave (Table 3). Before analyzing advisor-related factors, we briefly examine what roles an advisor plays and how these fit into the Ph.D. process.

“...the two main things that make graduate school hard are the unstructured nature of the process, and the lack of information about what you should spend your time on.” So writes desJardins,<sup>16</sup> a Berkeley EECS Ph.D. now conducting industrial research. She goes on to list the roles of an advisor, including: “guiding students' research; getting them involved in the wider research community; finding financial support; and finding a position after graduation.” Since 78% of respondents came to graduate school straight from an undergraduate program, they were left with coursework, summer jobs, and undergraduate research experiences as a basis from which to embark on a Ph.D. research project. An advisor clearly has a great impact on students' choice of research topic and research progress, especially in the first few years of graduate school.

Considering that a primary role of the advisor is guidance, the basic expectations listed by desJardins should be met for all students. 31% of respondents cited “my advisor was uncaring about students' professional development” as at

least “a factor” in leaving. We propose that the advisor’s concern and involvement in students’ professional development is really a minimal expectation, and as such any response should be looked upon critically. On two questionnaires, however, respondents attempted to soften their responses with comments such as “uncaring is too strong--unaware would be more accurate.” We suggest the department should publicize to both students and faculty the expected roles of an advisor. A quarter of respondents listed “my advisor never encouraged me or complimented me” as at least “a factor.” These respondents expected some form of encouragement from their advisor, and the lack of it contributed to their decision to leave.

**Table 9: Factors in the “advisor” aggregate**

Factors	% a factor or major factor	% major factor
Lack of guidance from advisor	54%	29%
My advisor didn’t provide any specific timeline for progress	39	19
My research area was marginal to my advisor’s core interest	33	8
My advisor was uncaring about student’s professional development	31	8
My advisor never encouraged me or complimented me	25	9
My advisor was hard to work with	23	7
My advisor expected too much grunt work	18	3
My advisor and I didn’t get along	13	5
My advisor didn’t treat me with respect	8	2
My advisor left or didn’t get tenure	4	3
My advisor discouraged me from getting a Ph.D.	3	1

In looking only at “major factors,” there is a distinct gap between the first two responses “lack of guidance from advisor” and “my advisor didn’t provide a timeline for progress” (29% and 19%, respectively), and the rest of the advisor-related reasons (9% or less). The factors that could be viewed as specific to a particular advisor’s personality, such as “my advisor was hard to work with” were much lower in response frequency as major factors, indicating that most major advisor problems were in basic bottom-line student expectations that were not being met.

Of course, the advisor-student relationship is a two-way street, with students bearing part of the responsibility for making it work. desJardins<sup>16</sup> provides advice to graduate students for finding the right advisor, urging students to read research summaries of a potential advisor and talk to other graduate students of the group. Other considerations include average time to degree and the dropout rate for their students, and how long they have been on the faculty. As desJardins points out “the most important thing is to ask for (i.e. politely demand) what you need.”

***Respondents’ suggestions for improving advisor effectiveness***

A few respondents listed very specific suggestions for improving the advisor relationship. Two relevant responses to the survey question “Do you have suggestions for how to improve the environment for graduate students in the EECS department?” are listed below.

“I think making the process of finding an advisor more structured would help. Admitting students with a better match with available research opportunities would make the process easier. The Ph.D. program is too long already. If finding an advisor takes 1-2 years, there is no way anyone can be expected to finish in 4 years, which to me seems like the right amount of time for a doctorate degree.”

“The single most important factor is for the advisors to act as managers and play a major role in moving their students through the program. I think there are some profs that do this well, others that do it poorly. I

firmly believe the ‘sink or swim’ approach is counterproductive to all. The cost to UCB of accepting a promising candidate and having them suffer for 3, 4, or 5 years before deciding to leave must be very high, not to mention the cost to the student. Some ideas for improvement:

1. recognition to professors who
  - a) have a high rate of Ph.D. successes
  - b) get students through the program in normative time or less
2. compensation e.g. a bonus
  - a) for each Ph.D. earned
  - b) for exceptional performance in getting students through

“Getting the Ph.D. is a matter of perseverance. This requires support and encouragement through the inevitable difficult times. This in turn requires that advisors take a more active role in actually managing the students. The way to get professors to devote energy to this management process is to a) train them; b) recognize them; c) reward them....”

## 4.5 Department Atmosphere

**Table 10: Top Factors in the “department atmosphere” aggregate**

Factors	major or a factor	major factor
Impersonal atmosphere	45%	16%
Unencouraging treatment of students by faculty	39	15
Little or no respect from faculty	33	13
Competitive environment	33	10
Senior grads seemed bitter and unhappy	31	10
Professor encouraged a pressure-filled atmosphere	28	8
Disliked having to prove myself all the time	26	8
Students encouraged a competitive atmosphere	23	4
Hostile atmosphere	19	8
Combative discussion style	18	7

The factors listed in Table 10 are part of an aggregate of eighteen questions concerning the perception that the departmental climate was impersonal or hostile. Table 10 shows the ten factors that elicited the most response. Respondents listed these factors much more frequently as secondary rather than as primary reasons for leaving. In other words, many former students had complaints about the social climate in the department, but these complaints were not the major reasons that they left the Ph.D. program. The atmosphere in the Berkeley EECS department is probably common to competitive departments in the sciences and engineering, which often encourage processes to “weed out” some of the students who are initially admitted to their programs. Tobias believes that similar problems with the academic and social climate discourages capable undergraduates from continuing in science.<sup>3</sup> Her subjects specifically cite problems with a discouraging rather than encouraging atmosphere, the lack of “community,” and competitiveness.

Men and women responded similarly to the aggregate of eighteen factors as a whole. Although there were some differences in the relative ranking of factors within the aggregate, the differences are not statistically significant for our sample size.

### ***Diversity and Belonging***

The most important problem with the department's atmosphere, as can be seen from Table 10, was its perceived impersonal nature. This quality may help explain the surprising and disquieting finding that a large number of students felt like they did not belong. In addition to the "department atmosphere" aggregate, feeling like an outsider in one's research group was mentioned by 36% of the respondents, and 33% complained of isolation in their research.

Several students experienced problems related to the diversity of students and faculty in the department. Some experienced discrimination on the basis of ethnicity or sex, while others felt excluded or had problems adjusting to a population that includes many international students. The survey asked, "Are you in an ethnic/racial group under-represented in EECS?" without specifying which groups are under-represented or asking respondents to state their race or ethnicity. Because several respondents volunteered their ethnicity, inconsistencies in the self-definition of minority status became apparent. White and Asian students, both male and female, described themselves as under-represented minorities, while others of the same groups stated they were not minorities.

The University of California defines under-represented minorities as members of the following groups: African-American, Filipino-American, Mexican-American, Native American, Pacific Islander, and Puerto Rican. University-wide, Asian Americans, Latinos, and women are also considered to be minorities in disciplines in which they are under-represented. Among the eight respondents who potentially fit the department's definition of ethnic minorities, three considered "bias against racial or ethnic minorities" to be "a major factor" in leaving, with one respondent considering it "a factor." An additional non-minority respondent also cited bias a "major factor." This is an unacceptably large proportion, even though taken from a small sample. A few surveys contained specific comments about minorities and discrimination, the mildest of which states, "I could have the same or better research possibilities in industry without all the discrimination." Other comments named specific professors and support programs as condescending, unhelpful, or antagonistic towards minorities. According to one respondent, "Other grad students I spoke to shared this view. We were usually quiet since there were too many other things to worry about. I think the students would have been much better off without such questionable help." Because the number of minorities in the sample is so small, it is difficult to draw statistically significant conclusions about the differences between minorities and non-minorities. However, the responses indicate some strong feelings about discrimination that the department should investigate.

Several non-minority respondents commented on problems with ethnicity and belonging that affected their working relationships with faculty and with other students. One student said, "... I felt a large cultural and generational gap between [my advisor] and myself. He seemed to get more excited and involved when working with [students of his nationality] (in fact they often spoke [a language other than English] when discussing research.)" Another student felt excluded from study groups dominated by international students. A third student responded to the question of whether he was a minority by stating "No, but I am gay, which is not under-represented, but it is more closeted in CS..." Comments such as these, and the inconsistent responses to the question about minority status, indicate unresolved problems about ethnicity and belonging in the department. These problems are not unique to our department, however. Tobias interprets the "weeding-out" process as a mechanism that selects new scientists who can assimilate into the existing "in-group" of scientists.<sup>3</sup> Including more women and minorities will, she claims, require expanding the notion of good scientist material to include those previously in the "out-groups."

Problems with impersonal treatment or a competitive atmosphere are felt by many students. Although these problems may not on their own determine whether people stay or go, they affect the quality of life in the department and the feelings that people take with them after leaving. Helping new students become integrated into the department with better orientation programs is one way to improve the atmosphere. The administration must also take a leadership role in increasing the sensitivity of faculty and students towards problems related to ethnic, racial, and sexual diversity.

## **4.6 Confidence**

Eight factors listed in the questionnaire (Table 11) covered the topic of self-confidence. About one-quarter of all respondents cited at least one of these eight as a major factor in the decision to leave the Ph.D. program.

Data for the “confidence” aggregate as a whole show no statistically significant difference between men and women, but this result is misleading. A closer examination of the components of the aggregate reveals that the confidence problems differ both qualitatively and quantitatively between the sexes. The women’s problems with self confidence tend to be more general and pervasive than the men’s. The men are typically more self-assured, but their confidence falls in response to a specific, objective academic problem.

**Table 11: Factors in the “confidence” aggregate**

Factors	major or a factor	major factor
Didn’t have enough confidence	42%	13%
Lost confidence as graduate school progressed	30	7
Felt inadequate to PhD standards	27	14
I wasn’t creative enough	24	8
Felt my academic background was too weak	21	4
Didn’t have the broad background I thought a doctoral student should have before entering graduate school	19	6
I was too shy	19	4
Failing prelims shook my confidence	14	7

Fifty-six percent of the female respondents cited “did not have enough confidence” as either a major or a secondary factor, ranking it in a tie for fifth place among the women. However, only sixteen percent of the women cited this as a major factor. Thus the aggregate, which counts only major factors, seriously underestimates confidence problems among women. In comparison, only 38% of the men selected this factor, ranking it in a tie for fourteenth place among the men. Men (13%) were almost as likely as women (16%) to cite this reason as a major factor. However, women (40%) were more likely than men (25%) to cite this reason as a secondary factor. Our results are consistent with the findings of other researchers, which show that women students tend to have more problems with self-confidence than men, even when their academic performance and preparation are comparable to, or better than, men’s. For example, Strenta et al.<sup>6</sup> found women in the sciences were significantly less confident and more depressed about their academic progress than their male peers, even when their grades were the same as the men’s. (See also the review by Kimball.<sup>17</sup>)

The question of prelims and confidence reveals an interesting difference between the sexes. Although the numbers are relatively small, men were more likely than women to agree that “failing prelims shook my confidence.” Over one-third of the men counted in the “confidence” aggregate considered this a major factor in their leaving. For the men there is a strong and highly significant correlation (correlation coefficient of 0.66, p-value of less than 0.001) between the factors “did not pass prelims” and “failing prelims shook my confidence.” For the women, there is no significant correlation between these two factors. Because the men generally have more confidence, an academic problem such as failing prelims may be more of a blow to their self-esteem. Alternatively, men who fail prelims may focus on prelims as the specific reason for lost confidence, while women view the entire graduate school experience as a cause for lost confidence.

## 5.0 Gender Differences

During the first six years covered by this survey, the attrition rate for women EECS Ph.D. students was 57%, compared with 39% for the men. (More recent statistics are not yet available due to the potential length of a student’s Ph.D. studies.) Considering both the large difference in the attrition rates and the historical under-representation of women in EECS, we expected to find significant gender differences in reasons for leaving graduate school without

the Ph.D. Our results surprised us. We found few strong, statistically significant differences in how women and men explained their decisions to abandon Ph.D. studies. We did find that women and men were, at the outset, equally sure that they wanted the Ph.D. Women and men were also equally likely to think that their academic preparation for graduate school was as good as their peers'. It seems that although women leave the program in greater proportions than men, they leave for approximately the same reasons. We suggest that gender problems are now seldom overt; this does not mean that subtle or specific issues do not exist. This section discusses the differences that we did find.

During the ten-year period examined by this study, women represented between 8% and 17% of the EECS Ph.D. graduate student population. Because of the higher attrition rates for women, we estimate that women constituted 11% to 23% of the survey's target population. Our response pool had proportionately more women (26%, with one person declining to state).

Here we summarize our most important gender-related findings within the aggregates. Out of the ten aggregates, two aggregates -- "no research match" and "degree requirements"-- suggested some gender differences. We also look at differences in the order that women and men ranked individual factors. Finally, we explore gender differences in responses to rankings of reasons to pursue a Ph.D. and reasons to choose Berkeley.

The "no research match" aggregate provoked the most strikingly different responses from women and men. Two factors within that group seemed to account for the difference: of those who answered the question, significantly more women than men cited "unexcited by my research topic" as a "major factor," and more women cited "focus of my research group shifted to area of little interest" as a major factor.

In general, men more frequently cited factors in the "degree requirements" aggregate as major reasons for leaving. When contributing factors are included, differences are less obvious. However, there were two statistically significant differences. Women were much more likely to say "prelims were intimidating." Men ascribed more importance to the factor "I could have the same or better research possibilities in industry without all the other requirements (prelims, etc.)."

A comparison of the ranking of factors for women and men uncovers gender differences that were not made apparent by our previous analysis. Table 12 shows the ten most commonly cited factors for leaving, ordered separately for women and men. As noted in the previous section, "didn't have enough confidence" was ranked highly by women, but not by men; however, men were much more likely to lose confidence as a result of failing prelims. Men, unexpectedly, disliked the "impersonal atmosphere." This was their tenth most-commonly cited factor, but for women it was in a nine-way tie for twenty-first place. "Realized I didn't want a career in academics" and "unexcited by my research topic" both ranked among the top seven for men, compared with the top sixteen for women.

If we look at only the three most common factors in Table 12, we notice a subtle difference in the reasons given by women and men. For the men, the two most frequently cited reasons are clearly career-related -- deciding that they did not care for an academic career; thus, the Ph.D. was not needed. The two reasons tied for third speak of some degree of "burn out" for the men, expressing a dislike for the time commitment necessary to obtain the degree. For women the most prominent reason is "wanted to get on with my life," while career-related choices ranked a close second and third.

A possible interpretation of this result is that women may be unconsciously more pressed by societal constraints in terms of a life timeline. Some may choose to view this pressure as a "biological clock," but we would like to expand the concept beyond that of having children and suggest that women require more integration of their career and life goals. Thus, career choices must fit into a larger picture. For men, it is more acceptable to segregate the two. Seymour observed this same phenomenon in a study of undergraduates<sup>10</sup>: "young men... are more willing to place career goals above considerations of personal satisfaction. By contrast, young women show a greater concern to make their education, their career goals, and their personal priorities, fit coherently together." Another important concept is the idea of the science "mold." If there are no role-models, no women faculty within the academic mold that appear to enjoy the life graduate student women aspire to achieve, women will seek a career option in which it is easier to integrate career

and personal goals.

**Table 12: Most common factors in leaving for women and men**

Women			Men		
Factors	major or a factor	major	Factors	major or a factor	major
1. Wanted to get on with my life	80%	48%	1. Realized I didn't need the Ph.D.	77%	49%
2. Realized I didn't need the Ph.D.	68	48	2. Realized I didn't want a career in academics	66	37
3. Wanted work experience	64	36	3. Degree took too long 3. Wanted to get on with my life	66 66	34 34
4. Wanted a break from school	64	20			
5. Lack of guidance from advisor	56	32	5. Wanted a break from school	59	27
6. Degree took too long	56	20	6. Lack of guidance from advisor	54	28
7. Didn't have enough confidence	56	16	7. Unexcited by my research topic	54	20
8. Outside activities more rewarding	52	28	8. Too many hoops to jump through	52	25
9. Constant pressure	52	16	9. Wanted work experience	51	25
10. Prelims were intimidating	52	12	10. Impersonal atmosphere	49	17
10. Too many hoops to jump through	52	12			

Women and men differed in the reasons they chose to pursue the Ph.D. (Table 1) and why they chose the program at Berkeley (Table 2). Both sexes said their main reason for pursuing a Ph.D. was fascination with the subject of EECS, though the men's average ranking of this reason was significantly higher than the women's. The means for the women's reasons were clustered more tightly, suggesting that women tended to find the reasons closer in importance than the men. At least two possible reasons for the women's higher ranking of prestige seem plausible: perhaps women tend to perceive the prestige of their graduate program as more important in ensuring that they will find interesting work afterwards, or perhaps women value more highly the recognition of their accomplishments that a prestigious degree confers.

Both women and men chose Berkeley primarily because it "has a great reputation" (Table 2). However, this is the only reason the women substantially agreed upon. For women, there is a large gap in the mean rankings between the first reason and all the others (from 2.80 to 6.44). Men were more evenly split between their top three reasons (from 3.14 to 4.45): the reputation; their belief that it was the best program they were accepted into; and their liking the Bay Area. Women agreed less among themselves about reasons besides the reputation, and their rankings differed from the men's. Women cited liking the atmosphere of the EECS department at Berkeley as their second most important reasons for choosing the school. The department atmosphere influenced the men much less; they ranked it seventh in importance. Since women found their initial impressions of the department atmosphere so important as a reason to choose Berkeley, we conjectured that later finding the atmosphere hostile might have been an important reason they left. Contrary to our conjecture, we found no correlation between initially liking and valuing the atmosphere and later finding it hostile. From this we conclude that women who found the atmosphere pleasant in the beginning continued to find it acceptable and did not leave because of it. If we compare valuing the good atmosphere initially with finding it hostile later, gender blind, we find that there is a correlation between not initially caring about the atmosphere and finding it hostile later, though the correlation is not particularly strong or significant. Similar to the men, women cited liking the Bay Area as their third reason for choosing Berkeley, but they also cited "wanting to live elsewhere" more frequently (28% vs. 8%) as a reason for leaving.

## 6.0 Conclusions

The decision to pursue a doctoral degree is a personal choice that must match with one's ultimate career and life goals. We have found that a large number of EECS students leave the Ph.D. program because they find that their career goals can be achieved without a Ph.D. The object of this survey and the following recommendations (section 7.0) is to address the possibility that students are driven away from the doctoral program despite their desire to achieve a Ph.D. because of departmental factors or the present structure of academia.

It is encouraging to see from our survey results that the most commonly given reasons graduate students leave the Ph.D. program at Berkeley can be described as career and personal reasons. Seventy-four percent of respondents indicated that they left the Ph.D. program because they realized that they no longer needed a Ph.D. for their chosen career. This suggests that the compelling reasons that students leave the department are because they have simply altered or more finely focused their goals after entering the Ph.D. program. However, respondents also indicate that departmental factors do play a definite role in students' decision to leave. Furthermore, several respondents indicated in their comments that their experience in the program soured them on academia.

We propose that one major cause of attrition is a lack of integration. Students who fit into the academic "culture" are more likely to stay in the program, while those who do not, have a higher probability of leaving despite their continued interest in the subject matter. One's personal perception of not fitting into the culture of academics can originate from many sources, and has emotional as well as professional ramifications. The main sources expressed by the respondents of this survey concerned dissatisfaction with the structure of the Ph.D. program and the nature of academics as seen in this department. Specific problems with the program included the length of time it takes to obtain the degree (63% of respondents thought the "degree took too long"); the number of academic as well as emotional "hoops" a student is expected to jump through during the process of becoming a Ph.D. candidate (52% indicated "too many hoops to jump through to get the Ph.D."); and the stressful and combative nature of preliminary exams (37% thought "prelims were intimidating"). Others indicated concerns such as not feeling integrated in the department academically. This issue involves problems ranging from finding an advisor or research group to feeling isolated amongst colleagues and in research interests. A third of respondents had trouble finding a research project and found the process of finding an advisor to be difficult. Others said they felt like an outsider in their research group or felt they had no peers with whom to discuss their work. Other students were able to find a research group, but advisor-related problems contributed to their decision to leave. For instance, 54% of respondents indicated a "lack of guidance" from their advisor. Respondents also found unencouraging treatment in an impersonal, competitive, and pressure-filled atmosphere to be factors in their decision to leave.

A student who is well-integrated in the system, who understands the academic progression through graduate school, who has a good relationship with a mentor/advisor and sufficient guidance in research, will develop the necessary sense of belonging to persevere and pursue the Ph.D. The remaining students are left to flounder and are made to feel inadequate because they do not fit into the academic mold. They are not mentored, guided, or encouraged, and do not recognize the steps necessary to fit the mold. They conclude that they do not belong. And if they perceive that other environments, such as industry, will provide guidance and reward for their efforts, they will probably leave academics and go where they do feel integrated and appreciated.

We also suggest that minorities and women are less likely to fit the academic mold. Responses indicate under-represented minorities had strong feelings about discrimination that should be looked into further by the department (section 4.5). Several non-minority respondents commented on problems with ethnicity and belonging that affected their working relationship with students and other faculty. Surprisingly, when we compared the response from female and male respondents, we found few strong differences in their responses. Because of this unexpected result, it is interesting to note those aggregates and factors that did elicit different responses: a higher percentage of women reported difficulty finding a research match between themselves and the department, and men had more complaints about the department requirements.

Because of the similarity between female and male responses to our questionnaire, the reasons behind the higher attrition statistic for women remain unexplained. Seymour<sup>10</sup> offers a theory that explains the difficulty some women have

fitting into the academic culture. She views the weeding-out process as a typically male rite-of-passage. Men, she suggests, recognize from their previous socialization that they must prove themselves before being accepted into the “fraternity” where they will receive the mentorship and reward that they need. Women do not tend to recognize the weeding process for what it is; they become discouraged and tend to blame themselves for the hardships that the process imposes. Seymour points out that, “As studies of graduate and professional women in science have indicated, women who successfully decode the meaning of the undergraduate testing process do not automatically receive this reward. They are not accepted into the fraternity, except as tokens, and are not mentored by it.” Tobias<sup>3</sup> also discusses the sociology of weeding and hypothesizes that science “selects students for fitting into the ‘culture of science,’” resulting in a survival of the most similar, rather than of the fittest.

We have identified problems with the graduate student experience for those who left the program. These same problems may also affect the productivity and well-being of those who remain. For future work, we suggest that a similar survey be performed on graduate students who do attain the Ph.D. to compare differences between the two groups. What are the differences between students who persist and those who leave? Are the differences in personality, background, or simply situation? We have noted that women students have been less likely to complete the Ph.D. than men, but the survey results do not explain this difference. Comparing students who stay with those who leave may give us more insight into this issue.

## 7.0 Recommendations

We realize that attrition in Ph.D. programs is a difficult issue to address. There is obviously no comprehensive solution to the problem because individuals are involved, and every student’s background, goals, needs, concerns, and personality is unique. The path to a Ph.D. is an arduous one that is a unique process for each individual. Because of this, we would like to underscore desJardins’ characterization of the “unstructured” nature of getting the Ph.D. Although there is no recipe for obtaining a Ph.D., there exists amongst students a perceived timeline of progress regarding a suitable number of publications, amount of research progress, and number of conferences attended. We would like to strongly encourage the administration, professors, and even senior graduate students to help graduate students progress, but through encouragement, rather than the threat of being “behind” in a perceived imaginary timeline. *We must find ways other than a sequence of traumatic checkpoints to provide direction and a sense of progress to students.* One respondent commented, “The process seems oriented to keeping people from succeeding, rather than helping them succeed.”

***Integrate first year students: finding a research group.*** Help students find an advisor and research group. Although the department has made an effort to create research presentations for first year students to help them choose an advisor, the process can still be an intimidating. *Programs such as voluntary, short-term research rotations in labs would give students a more accurate taste of the work done by specific groups.* Indeed, incoming students are often more anxious to find any group and advisor who will take them and do not consider that funding and the type of work involved in a project will have a profound effect on them. All efforts to integrate new students in other ways should also be greatly encouraged and continued. Some existing examples at Berkeley are academic advising from more advanced graduate students, and prelim practice and study sessions. Recent suggestions have also been made at student feedback sessions to distribute a list of “tips” for both new students and for advisors regarding the types of issues that should be discussed between student and advisor before they choose to work together. These include funding, the amount of research activity expected of a student who is TA-ing or taking classes, and the nature of current and anticipated projects in the group.

***Evaluate prelims:*** The department has also made changes to the preliminary exam in recent years. *A continued look at the preliminary exam would be beneficial to evaluate its accuracy in predicting the ability of a student to obtain a Ph.D.* We must evaluate if these “weeding” techniques are really valid methods of predicting academic success or if they are simply driving away talented students. Four out of eleven respondents who considered failing prelims a “major factor” in leaving went on to obtain Ph.D.’s in other graduate engineering programs, including three in EECS. Others who failed prelims went on to successful careers in industrial research.

**Guide students in the dissertation topic choice.** With the large response to having “no research match,” we must also acknowledge the difficulty of finding a research project for the Ph.D. dissertation. Since the research project requires a substantial commitment of a student’s time while obtaining the degree, it is disturbing to see the large number of students who were unexcited by their research topic or couldn’t find a research project or match on the faculty for their research interests. Even if advisors believe that students should find their own projects, they can help guide them through the *process* of finding a dissertation topic. Some ideas suggested by desJardins<sup>16</sup> are: to encourage students to read papers and point out interesting articles to them, to help students to break down projects into smaller goals so the prospect of finding a project is not so daunting, to work with all students -- not just those who are working on pet projects, or those with whom the advisor is comfortable. The department can also help students by continuing with materials such as the research summary of all projects in the department. This gives students a realistic view of projects that are actually in existence, since a professor’s research interests can sound a lot broader than they actually are. The department can also support student sponsored seminars. For example WICSE, a department-supported organization, has started seminars giving students advice on how to begin the Ph.D. project.

**Reward faculty for mentoring.** *Faculty must be reminded of the influence they have on students both emotionally and professionally.* Students do not enter with the ability to perform independent research. An essential element of graduate school is learning the research process. Many advisors make a concerted effort to initiate students to the method of research, aid students in finding a research project of interest, make themselves available for students, and have concern professionally for their students in terms of encouraging publications, getting their students out in a reasonable amount of time, and helping them to find jobs. These advisors should be rewarded for their efforts. The Computer Science Division at Berkeley is currently setting up a system of feedback for advisors. The feedback will also give the department a basis on which to evaluate and distinguish those professors who are putting extra effort into mentoring students. These evaluations should also be made available to new students who are deciding on a research group. This will aid them in choosing a research group not only for the project, but also for best fitting their work style and personality.

**Interacting with students.** Pinpointing the causes of attrition is exceedingly difficult largely because a great deal of the graduate experience depends on individual interaction between students and faculty, in particular the interaction between students and their advisors. It is essential for advisors to realize that each student is unique and has a different communication and work style. Thus, it is helpful for advisors to gear their mentoring approaches towards individuals. Advisors should differentiate between undergraduate, beginning graduate, and senior graduate students. Their needs and required amount of mentoring are very different. We reiterate desJardins’ suggestion that advisors should make an effort to work with *all* students, not just those with whom they are most comfortable.

**Provide structure before quals.** The electrical engineering department at Berkeley has made a recent effort to restructure its qualifying exams, encouraging students to take them earlier in the graduate program so that the exam is more of a research proposal rather than a dissertation defense. This is believed to reduce the time to degree by getting students to think seriously about their research project earlier. The intent is to match students up with faculty members other than their research advisor so that throughout their academic career they have a committee of professors who are knowledgeable about their research to whom they can turn for advice. The motivation is admirable and necessary, since it is earlier in the academic career that students need more direction and guidance with their research; however, there are other, less confrontational methods of achieving the same goal. While the process of preparing for the qualifying exam is valuable in forcing a student to generate a research plan and giving them more direction, the burden of ensuring steady progress in research should not fall solely upon the students’ shoulders. We believe adequate mentoring and guidance from the faculty greatly aids students in reducing their time to degree. Without guidance from faculty, students are apt to flounder and become discouraged.

**Break the academic mold -- promote diversity.** The “sink or swim” attitude is often professed to be the desired method of finding the star students who, in Tobias’ words, “rise to the top like cream.”<sup>3</sup> We support Tobias’ view that this process allows only a certain type of student to flourish while other equally capable students are simply turned off by the competitive climate. In effectively ostracizing these “other” students from the field, we lose valuable intellect that can only expand and further the field. *To enlarge the definition of a successful Ph.D. student, we urge the administration to take a leadership role to increase faculty and peer sensitivity of minority and women’s issues.* Henes et

al.<sup>18</sup> suggest workshops for faculty led by student panels to heighten faculty awareness and sensitivity. Such workshops were held at the University of California at Davis and among faculty responses, “60% were surprised by the information presented, and 72% felt their views had changed as a result of attending.”<sup>18</sup> We would also like to comment that these “other” students are not only women and minorities. Indeed, the lack of statistically significant differences between women and men in our results indicates that men who leave are equally dissatisfied with the current academic culture. A heightened sensitivity and acceptance of all cultures, genders, and personalities would be beneficial to all. Faculty must be reminded that there is more than one way to approach research, and just because a student differs in her or his approach, does not mean she or he is not equally likely of success.

**Conduct exit interviews.** We also suggest that as a constant source of feedback to the department, graduating students be asked to fill out exit interviews or surveys. In hindsight perhaps these students will be able to identify the attributes of their experience that helped them to persevere. With these suggestions, the department can better improve policies to create a productive environment for all types of students.

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## Appendix A: Text of the survey

**Please answer every item. If you think an item is ambiguous, feel free to write in what you mean by your answer. Some questions may appear redundant; they seek to distinguish details.**

### I. Background Information:

Please list undergraduate and graduate institutions you attended. If this format is not appropriate, please describe your background.

Institution	Years attended	Degrees (if any)	Date of degree	Major area

Regardless of what you said on your graduate school application, how sure were you that you wanted a Ph.D. when you started at Berkeley?			
When did you enter Berkeley for the graduate program?	_____		
When did you leave?	_____		
If there were gaps in your stay at Berkeley, please list the months and years you were here.	_____		
Did you obtain a graduate degree from Berkeley before you left?		yes	no
How many years did you take off between undergraduate and graduate school?	_____		
Are you male or female?		M	F
Are you in an ethnic/racial group under-represented in EECS?		yes	no
Were you an international student?		yes	no
If yes, did your visa allow you to get a job in the U.S.?		yes	no

Was your undergraduate school significantly different from Berkeley in style? (i.e. small, rural, single-sex)	yes	no
Do you believe your preparation for graduate school was non-traditional?	yes	no
Do you think that you were as well-prepared academically for EECS graduate school as the other people who started with you?	yes	no
While you were in EECS graduate school, were you married or in a long-term relationship? If yes, for how many years of graduate school? _____	yes	no
Did you have fellowship support? Number of years _____	yes	no
Did you have parenting responsibility while at Berkeley? If yes, who had the primary responsibility for the children's care? (circle one)	yes	no
Did you have a specific, firm area of research interest when you started? If yes, did you end up working in that area?	yes yes	no no
Did you pass all of your prelim requirement?	yes	no
Are your present career goals related to EECS research and/or teaching?	yes	no
What is your career now? _____		
Have you received a Ph.D. in EECS elsewhere?	yes	no
If not, do you still intend to get a Ph.D. in EECS?	yes	no
Have you pursued an advanced degree in another field after leaving Berkeley EECS?	yes	no
Are you happy with your decision to leave the Ph.D. program at Berkeley?	yes	no
Who was your advisor? (optional) _____		

**Please rank all reasons that apply with "1" being the most important reason. If an item does not apply, mark it with an "X." You may duplicate a number if you can't decide between two choices.**

My main reasons for deciding to pursue an EECS Ph.D. were:

fascinated by the subject	
important to my family	
wanted to be a professor	
prestige of the Ph.D. degree	
wanted to prepare myself for research in EECS	
default next step after undergraduate school	
to enhance my earning potential	

to improve my career opportunities	
didn't like work in industry	
other _____	

My main reasons for choosing Berkeley were:

it was the best program I was accepted into	
it had faculty with whom I wanted to work	
it has a great reputation	
geographic area was good for my significant other	
it was the only school I applied to/was accepted into	
liked the Bay Area	
liked the atmosphere of the EECS department at Berkeley	
wanted a change from my undergraduate school	
friends recommended it to me	
it was the most affordable school I got into/gave the best financial support	
it had the best research facilities	
other _____	

**To what extent did the following affect your decision to leave Berkeley? (Please rank from 1 to 3 where 1 means it was a major factor, 2 means it was a contributing factor, and 3 means it was not a factor.) Indicate the most important factor by circling the item.**

**II. Berkeley environment:**

	major factor	a factor	not a factor
did not pass prelims	1	2	3
did not pass qualifying exam	1	2	3
my G.P.A. wasn't high enough to continue for the Ph.D	1	2	3
prelims were intimidating	1	2	3
process of finding an advisor difficult at Berkeley	1	2	3
too many hoops to jump through to get the Ph.D	1	2	3
degree took too long	1	2	3
too many classes required	1	2	3
classes were too difficult or too much work	1	2	3

	major factor	a factor	not a factor
frustrating trying to get credit for classes I took at other schools or in other areas	1	2	3
changing research group/project to improve the situation was too difficult	1	2	3
not enough financial support	1	2	3
always had to TA to support myself	1	2	3
problems getting integrated in first year (no office/copy card/workstation)	1	2	3
no one to help students to clarify requirements and deadlines	1	2	3
little or no respect from other students	1	2	3
little or no respect from faculty	1	2	3
little or no respect from staff	1	2	3
a particular professor made my life miserable	1	2	3
a faculty member discouraged me from getting a Ph.D.	1	2	3
unencouraging treatment of students by faculty	1	2	3
hostile atmosphere	1	2	3
competitive environment	1	2	3
impersonal atmosphere	1	2	3
combative discussion style	1	2	3
professors encouraged a pressure-filled atmosphere	1	2	3
students encouraged a competitive atmosphere	1	2	3
disliked having to prove myself all the time	1	2	3
bad office situation	1	2	3
friends in other EECS Ph.D. programs were treated much better	1	2	3
bias against racial/ethnic minorities	1	2	3
EECS department was unsupportive/unaware of issues of women students	1	2	3
uncomfortable with skewed ratio of men to women	1	2	3
senior grads seemed bitter and unhappy	1	2	3
few good role models among the more senior students	1	2	3
didn't see senior students get jobs I would be interested in	1	2	3
problems with housing	1	2	3
problems with transportation/parking	1	2	3

	major factor	a factor	not a factor
problems with crime and safety	1	2	3
other _____	1	2	3

### III. Research/Advisor:

	major factor	a factor	not a factor
could not find a research project	1	2	3
couldn't get into the research group doing the work I was interested in	1	2	3
could not find a match on the faculty for my research interests	1	2	3
was unexcited by my research topic	1	2	3
the focus of my research group shifted to an area of little interest to me	1	2	3
lack of guidance from advisor	1	2	3
my advisor didn't provide any specific timeline for progress	1	2	3
my advisor was uncaring about students' professional development	1	2	3
my advisor expected too much grunt work (not enough research content in the work)	1	2	3
my research area was marginal to my advisor's core interest	1	2	3
my advisor and I didn't get along	1	2	3
my advisor was hard to work with	1	2	3
my advisor never encouraged me or complimented me	1	2	3
my advisor discouraged me from getting a Ph.D.	1	2	3
my advisor didn't treat me with respect	1	2	3
my advisor left or didn't get tenure	1	2	3
I felt like an outsider in my research group	1	2	3
no peers to discuss my work with	1	2	3
pressure to publish	1	2	3
other _____	1	2	3

#### IV. Personal:

	major factor	a factor	not a factor
I realized that I didn't need a Ph.D. in EECS for the career I wanted	1	2	3
realized I didn't want an academic career	1	2	3
wanted to get work experience	1	2	3
summer/coop job led to work much more exciting or cutting-edge than my Berkeley research	1	2	3
the economy improved, so I could get a job in industry	1	2	3
I could have the same or better research possibilities in industry without all the other requirements (prelims etc.)	1	2	3
saw friends leave, who then made much more money and had more personal time	1	2	3
couldn't decide on a general research area	1	2	3
outside activities were more interesting and rewarding	1	2	3
wanted to get on with my life	1	2	3
disliked being split between an outside job and school	1	2	3
had trouble balancing personal and school life	1	2	3
wanted to be near family elsewhere	1	2	3
I was homesick	1	2	3
difficult to manage a long-distance relationship with my significant other	1	2	3
wanted to live elsewhere	1	2	3
disliked work hanging over my head and having no time off	1	2	3
tired of taking classes	1	2	3
constant pressure	1	2	3
wanted a break from school	1	2	3
didn't have the broad background I thought a doctoral student should have before entering graduate school	1	2	3
felt my academic background was too weak	1	2	3
didn't have enough confidence	1	2	3
I was too shy	1	2	3
felt inadequate to Ph.D. standards	1	2	3
failing prelims shook my confidence	1	2	3

	major factor	a factor	not a factor
lost confidence as graduate school progressed	1	2	3
I wasn't creative enough	1	2	3
no home support for being in grad school	1	2	3
no emotional support from family, friends, and others	1	2	3
socially isolated in personal life	1	2	3
health problems	1	2	3
other _____	1	2	3

**Thank you for taking the time to complete this survey. Please write any final thoughts or comments below or on the back of this sheet. Do you have suggestions for how to improve the environment for graduate students in the EECS department?**