

**Organizational Practices and Gender Diversity: Factors Contributing to
Differential Participation in Computer Science and Engineering
Doctoral Programs**

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Abstract

The present study examines the sources of variation in gendered outcomes among Computer Science and Engineering (CSE) doctoral programs. The data was collected in 2003 for a project funded through the Computing Research Association by a grant from the National Science Foundation. Joanne M. Cohoon was Principal Investigator and contact. Survey data from a nationally representative sample of 48 CSE departments are examined to identify gender gaps in enrollment, thoughts of leaving the program, and reports of academic and social support from within the department. Responses from faculty are used to construct measures of department characteristics, and responses from graduate students and chairpersons are used to construct measures of outcomes. Factors tested in a logistic regression model for gendered effects in the admissions process are gender stereotyping, criteria representing a CSE occupational schema, formality of criteria, diversity practices, and attitudes towards increasing diversity. Results show that criteria representing a CSE occupational schema predict a lower enrollment of women, while consideration of minority status in admissions decisions predicts a higher enrollment of women. Preliminary evidence indicates that formalized criteria mediate unfavorable effects of gender stereotyping, and that attitudes supportive of increasing diversity mediate effects of diversity practices in expected directions. Factors tested for gendered effects in program participation using hierarchical linear modeling include gender stereotyping, diversity attitudes, diversity practices, faculty support of students, and faculty promotion of a competitive versus helping ethic towards students. Results show that research orientation (a control variable), diversity attitudes, a certain type of

faculty-student support, and formalizing the flow of information predict gender differences in participation. The findings contribute to understanding how interactional and structural mechanisms operate together in organizations to influence differential outcomes. The discussion draws on the literature on gender and science, gender and occupations, and diversity and organizations.

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Dedication

I dedicate this dissertation to Steve Nock, exceptional teacher, motivator, role model, and friend. He had a clarity of thought which will always inspire me.

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CHAPTER ONE: Introduction

Despite the ideals of meritocracy embodied in the scientific endeavor, gender equality often eludes it in practice. Sex segregation persists within many technical and scientific fields (Seymour and Hewitt 1996). Because of the incongruity between science's ethic of intellectual objectivity and the evidence of particularism in who practices science, Long and Fox (1995) argue that science is a strategic site for examining gender inequality in society. This study focuses on one particular field, Computer Science and Engineering (CSE), as a case in point: CSE graduate programs in the US are sparsely populated by women, with their representation at the doctoral level persistently below 25%.¹ While some observers see such statistics as inevitable, the big picture is one of variance. Certain scientific fields have had great increases in gender diversity while others have lagged (Kulis, Sicotte, and Collins 2002); some foreign universities graduate women scientists at a high rate while others graduate a token few (Charles and Bradley 2002). The situation calls out for a sociological explanation.

What social factors are involved? Research on how individuals choose their field of study provides some clues, but it can also unwittingly reinforce the logic of inevitable gendered career paths. This approach begs the question of how social context shapes outcomes. Do gender stereotypes influence women's participation in science, technology, engineering and math (STEM) fields? Are assessments of students' potential to succeed in science gender biased? Do majority-male environments socially exclude outsiders? Such questions are intriguing but difficult to measure. Discussions of the social context of STEM fields are often limited to theoretical analyses of a culture or climate inhospitable

¹ Calculated with data from Webcaspar.

to women, or to empirical exploration of one institution. The need to examine concrete contexts of science, test specific mechanisms of gender bias, and provide generalizable findings is evident. This study is an attempt to fill the gap. To do this I focus on individuals pursuing the highest degree in CSE, and examine the department: the day-to-day social context most relevant to their career outcomes.

The present data comes from a nationally representative sample of 48 CSE departments in the US. The purpose of the project was to examine the recruitment and retention of women graduate students, and was funded by the Computing Research Association. In the Fall of 2003, chairpersons, faculty and students were asked to complete web surveys. The responses of ? faculty and ? students provide an uncommon opportunity for measuring environmental effects. Contextual factors are measured by faculty responses to questions about their attitudes and practices regarding graduate students. Besides providing an atypically direct view of specific attitudes and social behavior within real settings, the number of responses provide the possibility for quantification of their effects. The data set allows for a broader, more clearly specified examination of hypotheses than is generally done on gender inequality in STEM fields.

Inspiration for the identification of specific factors involved in gendered outcomes within departments comes from the literature on gender and work. In the past decade, researchers in this area have identified the need for more research on the context of work, a need that parallels the present deficiency within gender and science research. Recent empirical examination implicates particular mechanisms that contribute to gender differences in career progress. Two sorts of mechanisms, interactive and structural, can be discerned among the factors identified in the literature. When cognitive processes such

as gender stereotypes influence individuals' interactions, cognitive mechanisms are at work. When practices characteristic of the way a particular organization functions have differing effects on men and women, structural practices are at work. I draw on these findings from gender and work and use department averages of faculty responses to measure specific mechanisms within departments. Two main questions summarize this study. First, do the interactive and structural mechanisms identified as relevant in other settings predict gendered participation in CSE graduate programs? Secondly, do other interactive and structural mechanisms contribute to gendered participation in these programs?

This study contributes to the existent body of research in several ways. First, I build on the understanding of how specific mechanisms already identified contribute to gendered outcomes by measuring and testing them in the academic setting of one STEM field. Secondly, I expand upon and test contextual factors that are not well-tested in the literature. For example, I examine the role of occupational schemas, and I test theoretical claims that organizations can reduce gendered outcomes through practices promoting social inclusion. While findings of practices in graduate programs will reflect the particular setting of academic CSE, I discuss why focusing on particular settings is useful and relevant in answering broader questions about sources of occupational gender inequality. Thirdly, this study is distinctive in its examination of a number of contextual factors simultaneously in real settings, rather than in isolation from each other. This inclusive analysis serves as a step towards a more complex understanding of the relative impact of factors. Finally, the findings here have practical implications. Organizations

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have been said to be sites of the most proximate causes of ascriptive bias; as such, they can also be a source of change (Reskin 2000).

In the following chapters, interactional and structural mechanisms are used to predict three outcomes: women's entry into graduate departments, thoughts of leaving the graduate program, and graduate students' reported levels of social support. I focus on two different processes within departments that relate respectively to the dependent variables: the admissions process and how it relates to the proportion of women PhD students, and the retention process and how it relates to gendered thoughts of leaving and gendered social support. I draw on different theoretical literatures, including gender and work, social capital, gender and technology, and diversity in organizations. Together, the beliefs, attitudes, and practices tested in this study for their impact on gendered outcomes constitute a useful step towards defining and materializing the concepts involved in the critiques of science and its enduring gender inequalities.

The organization of this study is as follows. The first section examines how the admissions process contributes to women's representation in graduate programs. Faculty agreement with a gender stereotype and with support for diversity, as well as admissions practices that mediate gendered beliefs' effects, are used to measure interactive mechanisms. Faculty emphasis placed on various admissions criteria hypothesized to have gendered effects are used to measure structural mechanisms. They are combined in a model predicting women's proportion of PhD students. Interactions between admissions criteria and faculty beliefs are explored. In the second section on the retention process, the outcome measures are thoughts of leaving, and students' reports of social support from advisors, faculty, and students. The gendered distribution of these measures

are presented, and then predicted by individual-level variables. Finally, multi-level analysis is presented which models department-level effects, both structural and interactive, on the gendered outcomes. Department-level factors consist of stereotype and diversity attitudes, measures of faculty support, and measures of practices intended to increase diversity. I conclude by summarizing what the data have shown about the significance of department contextual factors for explaining gender inequality in STEM fields. I discuss the implications for furthering a general understanding of how structural and interactive mechanisms operate in organizations to influence women's participation in academic science and other historically male settings.

CHAPTER TWO: A Demand-Side View of Women's Entry into STEM fields: Cognitive Gender Bias and Gendered Admissions Practices.

The Need for a Contextual-Based Approach to Gender and Science Studies

The most common approach for explaining gender differences in entry into STEM fields is at the individual level. For example, studies of differential participation in CSE provide evidence that boys have more exposure to and interest in computers, and more encouragement from parents and teachers to pursue such interest (for a review of research on the gender gap in experience and exposure to computing see Cohoon and Aspray 2006). On the other hand, girls are more likely to have negative perceptions of the field of computer science; by the time they get to the undergraduate level, they are relatively disadvantaged in computer programming. Such findings provide a gender-socialization perspective on women's participation in STEM fields that has been summarized elsewhere (see also McIlwee and Robinson 1992). This perspective contributes to explaining the supply-side imbalance of men and women who are prepared to be leaders in the field.

However, a supply-side gender imbalance at the undergraduate level is likely to account for only a portion of women's underrepresentation at the graduate level in CSE. Careers in CSE do not necessarily follow a straight "pipeline", so undergraduate outcomes cannot fully explain the graduate gender imbalance (Jesse 2006). In a study of differences in faculty gender composition across a range of science fields, Kulis et al. (2002) also conclude that supply-side explanations are limited. They find that women are differentially represented among fields even after controlling for supply/demand factors, especially in the physical sciences and engineering (including CSE), and conclude that

academic “cultures” may be at play. Thus, evidence suggests that CSE is one STEM field among others for which departments could be a source of factors contributing to underrepresentation.

There is much qualitative evidence to support Kulis et al.’s suggestion that the cultures of certain STEM fields contribute to creating and maintaining gender imbalance. A single institution study describes how the physics, chemistry, electrical engineering and computer science departments lost women partly because women rejected a male-centered career model (Etzkowitz et al. 1994). The career model required being aggressive, competitive, and unconditionally devoted to work and achievement, to the exclusion of other commitments and interests. A number of authors echo this work-obsessive career model in engineering and computer science fields and provide thick description of the occupational cultures of these fields (McIlwee and Robinson 1992; Wajcman 1991; Wright 1996). These authors show that in the U.S., engineering and computing occupational cultures consist of behaviors and orientations consistent with the male gender role; namely, they describe an aggressive, competitive, anti-social, technically-oriented person who is obsessed with machinery and gadgets. Wright claims that computing/hacking culture is a quintessential example of the interactional style described for engineers: aggressive displays of technical self-confidence and hands-on ability (Wright 1996). This evidence suggests that academic departments in these fields are sites where such beliefs and behavior are present. Since the aforesaid authors claim that masculine occupational cultures deter women from certain fields, Kulis et al. have ample reason to suggest that academic cultures may be a source of unbalanced participation by men and women.

There is some evidence that the organizational context can vary in whether it reinforces occupational cultures. McIlwee and Robinson (1992) conducted interviews and compared women's experiences in two types of engineering organizations: academic departments and places of work. They found that because departments emphasize academic performance as the measure of achievement, women could rely on their ability to perform well in class as a means to success in their undergraduate programs. However, when women entered the work environment, their ability to demonstrate their competency was challenged by a greater organizational emphasis on the occupational culture of engineering. Thus, the organizational context can differ in the degree to which it reinforces a culture that deters women. The aforesaid evidence suggests that academic departments and their formal academic determinants of who succeeds are less likely than work environments to deter women, but departments themselves could also vary in whether they reinforce a particular occupational culture, and could correspondingly vary in any related gendered outcomes.

Although there are notable examples in the literature of an occupational culture contributing to women's low rates of participation in historically-male fields, many of the theoretical links between social context, culture, and gendered participation are fairly undefined. The need is apparent for what Reskin (2003) describes as a move towards answering the "how" questions in understanding ascriptive inequality, i.e., searching for answers that will point to specific conditions and the changes necessary to bring about better representation. She points to the need for evidence of *mechanisms* regarding how discrimination works systematically in organizations to result in gendered outcomes. The culture theories above suggest that women are perceived to be less likely to succeed

within “male” models of career success. But what are the specific mechanisms involved, for example in the hiring or admissions process, and how might they be measured?

How Interactional Mechanisms Influence the Assessment of Applicant Quality

In recent gender and work literature, researchers attempt to identify specific mechanisms in the organizational context that contribute to gendered outcomes. One focus has been on interactional bias - discrimination that occurs from individuals' direct or indirect contact with each other. Researchers have taken advantage of the rich social-psychological evidence for how cognitive processes contribute to gendered social interactions and applied it to specific interactions in the work place. Summarizing this social-psychological research, Reskin argues that universal cognitive processes are the basis for most interactional bias, rather than purposive actions that dominant group members take to preserve their interests (Reskin 2000). Cognitive processes include social categorization, in-group preferences, stereotyping, and evaluation bias. Evidence shows that these processes influence people's perceptions and memories of others. For example, social categorization such as stereotyping influences perceptions of others during social exchanges, sometimes leading to exclusionary actions.

Ridgeway and Correll (2004) draw on this literature and show that the context is important to whether cognitive processes lead to biased perceptions. For example, they discuss automatic sex categorization, the tendency for people to sort self and other into male and female categories, and how such categorization triggers gender beliefs. They argue that the impact of gender beliefs on social interaction is highly responsive to the

structure of the context. Gender becomes salient in contexts that are gender-typed, that is, environments where stereotypic traits and abilities of one gender are culturally linked to the activities that are central to the context. Given the literature on the occupational cultures of some STEM fields, one can induce that contexts where these fields are practiced are gender-typed and are likely to promote the salience of gender during social interactions. For example, in a computer science department, gender beliefs would be more likely to have an impact on social interaction and outcomes of interactions than they would in a more gender-ambiguous context.

Points of entry into organizations involve social interactions during the hiring and admissions process that could be influenced by gender-typed social contexts. Accordingly, Ridgeway (1997) discusses the direct (e.g. interviews) and indirect (e.g., reviewing resumes) interactions involved in hiring and their importance for gendered outcomes. When gender beliefs are activated they are likely to influence employers' judgments of workers' potential productivity. Recent sociological evidence supports this theoretical argument that gender beliefs such as stereotypes operate during hiring and evaluation practices in real workplaces. Gorman (2005) examines hiring in a large sample of law firms using proportion of new hires as the outcome measure. She identifies stereotypically-male and stereotypically-female characteristics of hiring criteria in law firms, and finds they predict gendered hiring. When firms list more of the "male" traits among their criteria, women are less well-represented among their new hires; the trend is reversed when firms use more "female" traits among their hiring criteria. This evidence indicates that gendered criteria for judging applicants activate gender stereotypes held by

decision makers, stereotypes which in turn influence whether a woman is seen as being a desirable candidate for hire.

Gorman's finding comes from the work setting in the field of law, but the same mechanism could operate in academic admissions processes in STEM fields. In similar fashion to decision-makers in organizations, department faculty apply criteria to unique individuals and determine which applicants show potential for success. In CSE departments, stereotypes about men's greater propensity toward computing could be activated and could distort faculty members' impression of applicants. Gender stereotypes could be activated by stereotypically-male criteria as in law firms, or they could be directly activated by a cultural context that reinforces the use of gender stereotypes. In the case of certain STEM fields, the occupational cultures discussed above would provide a context of gender salience within departments. Just as workplaces are shaped by occupational cultures and associated gendered beliefs, academic departments are sites of social interactions that are subject to disciplinary cultural norms (Fox 1991; Margolis and Fisher 2001). Thus, the activation of gender stereotypes during the admissions process is likely to be one of the specific mechanisms through which social context and occupational culture are linked to gendered outcomes in academic CSE.

Structural Mechanisms: How Formalizing Criteria Can Prevent Interactional Bias

So far, I have discussed evidence for specific interactional mechanisms located within organizations that contribute to gendered outcomes. However, interactional mechanisms operate at the level of individuals and occur both within and outside of organizational contexts. In contrast, structural mechanisms are most likely to be situated in

organizations, and thus are said to be the most proximate source of (or hindrance to) bias in organizations (Reskin 2000). Organizational mechanisms are most proximate because they can mediate the effects of cognitive or interpersonal mechanisms, as discussed below. Social structure in organizations refers to the organization and operation of tasks through formal and informal arrangements and practices. Bias occurring from social structure is different from interactive bias because it results from practices having gendered effects, rather than from interactions between individuals.

One of the structural mechanisms most discussed in the literature on gendered outcomes in organizations are formalized practices. There is well-documented evidence that when organizations institute formalizing practices during hiring and promotion, these practices work to stem the effects of interactional bias (Bielby 2000; Long and Fox 1995; Reskin 2003). Long and Fox (1995) refer particularly to the context of academic science, and their recommendations are very similar to those coming from studies of the workplace. Accordingly, researchers argue that functionally-relevant, objective, and specific information on applicants prevents bias, while unstandardized, vague, and subjective criteria encourage the use of stereotypes and same-gender preferences. These conclusions are explained by evidence on cognitive processes, some of which is discussed above: when evaluations are conducted with ambiguous standards, the discretion of the evaluator is high and as a result, social categories such as sex are more heavily relied on as a source of “information” (i.e., gender beliefs) for making judgments. In contrast, formal and specific criteria promote reliance on specific information from applicants’ backgrounds. The tendency of formalizing practices to moderate stereotyping

effects is one of the few ways in which structural mechanisms have been shown to mediate interactive mechanisms.

Studies that identify the mediating effects of formalizing practices in workplaces generally do not directly measure cognitive processes such as stereotyping or in-group preferences, but rather measure them indirectly through inferring their effects through the association of formalizing practices with gendered outcomes. Still, the documented connection between formalizing practices and gendered outcomes establishes formalization as one of the “proximate mechanisms” that Reskin (2003) refers to as explaining levels of ascriptive inequality in the social context of organizations. However, some empirical evidence about the effectiveness of formalization show it to be more inconsistent than some suggest (Kmec 2005; Konrad and Linnehan 1995). Furthermore, despite the attention given to formalization, this mechanism does not address fundamental structural sources of bias. Other, more dispersed literature suggests the existence of proximate mechanisms affecting gendered outcomes that can only be recognized through a deeper examination of how structures result in bias.

Hidden Structural Factors in Gendered Outcomes: The Admissions Process

According to Acker (1990), structures that are gendered are one of the most fundamental organizational sources of persistent gender inequality. She points to the underlying assumptions embodied in material forms of structures, such as written work rules and systems of job evaluation, that result in different outcomes for men and women. Although structures have historically been openly gendered, for example by prohibiting women from working in an organization (Epstein 1991), most present-day structures are

ostensibly gender-neutral. Nevertheless, ostensible gender-neutrality may hide the ways that structures contribute to gendered participation in unintended ways. Studies of contemporary structural barriers are relatively rare. Those that exist use gross measures of organizational characteristics (e.g., size), and so more research has been called for in this area (Bielby 1991:177).

Reskin provides an example of how gendered structures can operate; she states that unintended disparate effects occur “when a neutral mechanism translates group differences on position, experience or a credential into differential outcomes for ascriptive groups” (2003:14). Because of experiential or cultural differences among groups, generalizations can be made about which group’s members will be more likely to meet particular standards or criteria of evaluation. Reward systems tend to value the qualities that the majority group brings, neglecting the qualities brought by other groups (Acker 1990). Resulting systems of evaluation place minority individuals at a distinct disadvantage.

In undergraduate admissions, such disadvantage has indeed been documented; admissions practices consist of systems of evaluation that have unintended (and sometimes intended) group effects. For example, relative emphasis on grades versus test scores interacts with average background differences among applicants of different racial and ethnic backgrounds to advantage certain groups (Alon and Tienda 2007). The use of particular admissions criteria has historically been an important determinant of which ethnic or racial groups are more likely to enter a university (Karabel 2005). Karabel shows how choice of criteria is not purely based on objective definitions of academic “merit,” but that such definitions are socially constructed and change over time. Variation

in which criteria are emphasized in graduate CSE admissions practices could thus be a structural factor contributing to gendered representation in a program.

The question of whether and how gendered background differences interact with structural practices at entry sites, in academia or in the workplace, remains largely unexplored. Reskin et. al state that almost nothing is known about organizations' use of criteria that are likely to affect men and women differently (Reskin, McBrier and Kmec 1999). However, relevant literature exists from the work place that contributes theoretically to the definition of a specific mechanism through which hidden structural bias might operate.

Structural Mechanisms Continued: Occupational Schemas and Admissions Criteria

Literature from the workplace provides a useful concept for theorizing about academic departments' choice of criteria: the jobholder schema. The concept of a jobholder schema refers to a set of traits possessed by a quintessential jobholder of a position. Such schemas are not shared at the societal level like stereotypes; they are shared at the occupational or organizational level. They are based on the typical traits of those who have performed the job well in the past. Jobholder schemas serve to prescribe who will be successful in the future, and can be used to make judgments about which applicants for a position will be successful. A jobholder schema is a "cognitive representation of a jobholder available to a decision maker" (Perry et al. 1994). Although schemas are cognitive artifacts, when jobholder schemas (also called role-incumbent schemas) are embodied in admissions practices like criteria, they have a structural manifestation.

In a field such as CSE, an organization's jobholder schema is likely to reflect the majority-male history of the field. For example, if managerial jobs have historically been held by males, an organization's role-incumbent schema for managers is likely to define managerial merit with stereotypically-male traits. A role-incumbent schema could thus contribute to evaluation criteria that disadvantage women. One way that such schemas, once manifested in criteria, can bias evaluations is through triggering gender stereotypes (Perry, et al. 1994; Gorman 2005). The Gorman (2005) study discussed above showed that traits from certain role-incumbent schemas can activate gender stereotypes and result in gendered hiring decisions. Another way that schemas could result in gendered outcomes is if gender-neutral characteristics comprising role-incumbent schemas reflect a particular style or model of success that men are more likely to match. That is, a jobholder schema could operate similarly to the way position imprints have been shown to operate in organizations: first incumbents of a position create imprints that constrain subsequent position holders in that organization (Burton and Beckman 2007). Thus, since previous position holders in historically-male fields have generally been men, jobholder schemas could constrain subsequent incumbents to meeting a definition of merit more easily matched by men. In this way, role-incumbent occupational schemas, embodied in seemingly neutral criteria, could theoretically result in gender effects whether or not decision-maker's gender stereotypes are activated.

What might a role-incumbent schema be for computer science departments? Referring back to the literature on the culture of STEM fields, especially the technologically-oriented fields, an occupation-wide schema should involve total work commitment at the expense of other interests. Evidence from a case study of an

undergraduate CSE department describes a role-incumbent schema for CSE students that corroborates the discipline-wide occupational culture of computing (with similarities to other technical fields such as engineering). Margolis and Fisher (2001) summarize descriptions of the iconic solitary male computer geek with little social life or outside interests. The image of an individual devoting all his free time to “hacking” is similar to the engineering icon of an individual whose extra-curricular passion is “tinkering,” both male-stereotyped in the sense of working with and mastering machines. However, a solitary computer geek in some ways contradicts norms of masculinity in its invocation of social passivity and physical weakness. Overall, the schema is sex-labeled with its image of a technically-oriented individual, but when broken down into specific traits it contains neutral or ambiguous traits in addition to gender-stereotypical characteristics that Gorman (2005) and others have used. The image is antithetical to stereotypically-female traits such as “friendly” and “verbally oriented,” but the stereotypically-male traits “assertive,” “energetic,” and “leadership” defy ready application to the CSE student schema. Some aspects of the schema may activate stereotypes, but other traits appear neutral or ambiguous.

This CSE student schema may contribute to the choice and use of criteria for judging applicants. Even if some traits within the CSE student schema are not stereotypically-male, they might still result in gender bias if they emphasize one model or style of success. If there are group differences in men’s and women’s backgrounds, criteria could have gendered outcomes. The documented differences men and women bring with them into their formal educational encounters with CSE show cause for suspecting a gendered filtering affect of certain criteria. In general, women report more

desire to have a balanced life with multiple roles and goals, and college women appear to perceive a career in computing as not well-rounded or conducive to family life (AAUW; Eccles 1994; Eccles et al 1999). Women are less likely than men to have informal experience in computer science, and enter college and introductory CSE courses with less computer programming experience (Margolis and Fisher 2001; Sacrowitz & Parelius 1996). Among those who enter CSE, computing is more often a singular focus for men, comprising much of their extra-curricular interests, while women are more likely to view computing as one among a number of diverse interests (Margolis and Fisher 2001). Thus, if faculty emphasize informal or non-academic computing experience in admissions decisions, women as a group are likely to be at a disadvantage compared to men. Because a particular model of success has been established as the norm, alternative models with fewer gendered outcomes might be ignored.

A gendered filtering effect of admissions criteria was found at Carnegie Mellon University, the site of the Margolis and Fisher study. When admissions officers decreased the use of previous computing experience as criteria, and placed greater emphasis on applicants' "demonstrated independence, energy, creativity, and community involvement," an increase in women's representation was reported (Margolis and Fisher 2001:136). Their finding suggests that departments can differ in the degree to which they utilize criteria embodying a discipline-wide occupational schema for assessing merit in students. Taken together, this case study, the findings on differential impacts of undergraduate admissions practices and the literature on jobholder schemas suggest a structural mechanism that may link social context and occupational culture to gendered participation rates in CSE graduate programs.

It must be noted that gendered outcomes resulting from choice of criteria are not necessarily considered to be a result of unjustified bias or particularism. Long and Fox (1995) define particularism in the sciences as differential outcomes by ascriptive status that are not explained by the application of universalism. In other words, if merit is used to determine who is rewarded (i.e., a universalistic system), then resulting differences by group are not a result of unwarranted bias. Although merit is often socially-defined, criteria can be determined to be more or less functionally relevant in determining merit in a given setting. If criteria that disadvantage women are essential to determining whether a student will succeed, these criteria are not likely to be considered particularistic or a source of unnecessary bias. Similarly, if non-academic computer experience is an important predictor of later success, it may not be considered unnecessary bias. However, evidence suggests the contrary; the informal computing experience that men are more likely to have does not necessarily predict success in academic programs (Beyer and DeKeuster 2006; Ogan et al. 2006; Margolis and Fisher 2001). McIlwee and Robinson (1992) similarly find that the “hands-on” experience that women in engineering undergraduate programs are less likely to have does not directly affect their academic success. Thus criteria related to such experience could be seen as a structural mechanism contributing to particularism rather than to universalism.

Diversity Attitudes and Diversity Practices

As discussed above, structural gender bias is often hidden by practices that appear gender neutral. Formalization of practices may work to stem bias in some settings, but does not address fundamental structural sources of gendered outcomes, such as biased

criteria. Konrad and Linnehan (1995) refer to formalizing practices as “identity-blind” practices in the work place. After examining the effectiveness of such practices in a study of work organizations, they concluded that identity-blind practices are not enough to address inequality at work. Konrad and Linnehan find that “identity-conscious” structures, which take into consideration demographic group identity in human resource practices, are comparatively more effective. Identity-conscious structures include the close monitoring of personnel decisions, keeping and comparing numbers on outcomes by groups, and making special efforts to employ and promote underrepresented groups (Konrad and Linnehan 1995:790).

Kalev, Dobbin, and Kelly (2006) corroborate the relative effectiveness of identity-conscious structures, particularly the presence or absence of leadership on diversity issues. They find that in work settings, the factor that most predicts increased diversity is organizational responsibility for diversity issues, such as the appointing of staff members and/or committees to oversee diversity efforts (see also Bielby 2000). Fox (2000) provides qualitative data showing that such leadership on diversity issues is also an important factor in women’s participation among academic departments in the sciences. At the undergraduate level, department commitment to considering “economic, ethnic and gender diversity” in admissions was one of the factors attributed to the increase of undergraduate women in Carnegie Mellon’s CSE department (Margolis and Fisher 2001:136). Thus, leadership on diversity issues in a department and associated identity-conscious practices are important structural mechanisms affecting gendered outcomes.

Attitudes surrounding the implementation of identity-conscious practices could have implications for whether such practices are effective, and for how faculty interact

with students. Evidence on attitudes towards such practices is most commonly discussed in terms of attitudes towards affirmative action. Many individuals have negative attitudes toward what they perceive to be special treatment of protected groups in employment situations (summarized in Konrad and Linnehan 1995). Diversity practices are viewed as violating principles of fairness and meritocracy when it is believed that preferences are given on the basis of minority status. Such views have been resistant to or even enhanced by practices intended to modify them, namely diversity training (Kalev, Dobbin, and Kelly 2006). However, negative attitudes about diversity may depend on the contextual reasons given to legitimize diversity practices.

Originally, affirmative action (consisting of the same practices as “identity-conscious practices”) was framed by the need to redress past injustices and achieve fair representation in leadership positions. Recently, however, a new legitimizing argument, referred to in both academic and work settings, discusses diversity practices in terms of bringing benefits to all groups. In academia, the advantage that diversity can have on the entire student body is emphasized; for example, diversity is said to nurture students who are more creative, have leadership abilities, and are better prepared to interact with diverse individuals (Bowen and Bok 1998). In the literature on organizations, a “diversity is good for business” argument claims that diversity in teams will lead to an increase in the variety of perspectives brought to a problem, and greater creativity and quality of team performance (summarized in Mannix and Neale 2005). The case for diversity in STEM fields is represented by statements by Bill Wulf, president of the National Academy of Engineering: “diversity is about difference, particularly cultural difference, and how it is valued. Diversity for its own sake may speak to morality and fairness, but

that is a condition. Better that we think of diversity as an asset, an enabler that makes teams more creative, solutions more feasible, products more usable, and citizens diversifying the engineering workforce more knowledgeable” (Wulf 1998). This rationale for diversity has been referred to as the new lingua franca defining the modern diversity movement (Siegel 2005).

This set of beliefs about diversity could operate in social settings the way gendered beliefs operate, through unscripted interactions between individuals. However, both similarities and differences from gender beliefs are important to note. Diversity attitudes and gender beliefs are similar in that both have to do with views of diverse others, and as a result they might be expected to correlate; for example, those who believe that sex is associated with technological ability might be less enthusiastic about increasing gender diversity in a technologically-oriented professional environment. Research supports that stereotypes about minorities predict views on affirmative action (Steinbugler, *et al.* 2006). However, the two types of attitudes are different in that gender is a fundamental social category that is continually reinforced by the larger society, whereas attitudes towards diversity appear to be more easily influenced by knowledge and the local framing of diversity practices (Knight and Hebl 2005).

Some findings support that a positive valuing of diversity works through interactions to result in positive outcomes for minority members. Based on interviews of employees from three firms, Thomas and Ely (2007) examine different workplace orientations towards diversity. In one type of organizational environment, they describe a “value of cultural identity” where managers believe that “cultural differences give rise to different life experiences, knowledge, and insights which can inform alternative views

about work and how best to accomplish it” (Thomas and Ely 2007:313). Where this attitude towards diversity was common, the participation of minority members was enhanced. They conclude that valuing of diversity can result in an environment in which people’s underlying identities and outlooks are valued and used to reconfigure primary tasks in the workplace, and to contribute to the organization’s vision.

In a review of the literature on diverse teams in organizations, Mannix and Neale (2005) corroborate Thomas and Ely’s described work environment as open to change and conducive to creating a diverse organization. They add that essential to such an environment is leadership that values diversity, i.e., “values a variety of opinions and insights”(Mannix and Neale 2005:49). Given these claims, one would expect positive effects of diversity attitudes on outcomes of interactions with minority members. The qualitative evidence suggests that the diversity-value emphasis on appreciating difference would encourage the salience of individuating characteristics during social interactions. In the social-psychological research, individuating information has been contrasted with categorical information like gender as an alternative basis for judgments during social interaction (Nelson 1996). For example, faculty in CSE departments who express a value of diversity may perceive and evaluate minority members such as women by focusing on individuating information rather than gender status. In this way, positive diversity attitudes could counter some of the negative effects of stereotypes. Conversely, negative attitudes towards diversity could reinforce the salience of gender during interaction.

Structural and Interactional Mechanisms Operating Together

Above I have reviewed the literature relating to certain interactional mechanisms and showed why they might apply to women's participation in graduate CSE departments. I have also identified structural mechanisms that could have mediating or independent effects on those outcomes. In general, studies tend to focus on either interactional or structural mechanisms. Yet ideally, both are used for determining how the social context contributes to gendered outcomes. It has been shown that interactional mechanisms operate with gendered consequences in organizations, but less is known about which organizational practices interact with gender beliefs or are immune to them. For example, to what extent do criteria that represent specific traits representing occupational schemas operate independently of gender stereotypes to bias admissions? Are positive affects from criteria or diversity practices explained by diversity attitudes? Given that faculty enact the practices in a department, stereotypes and attitudes by faculty appear likely to enhance or reduce the effectiveness of certain practices or criteria. Theory on interactive mechanisms suggests such a causal role for cognitive processes such as sex categorization (Ridgeway 1997). Empirical tests of these questions that include contextual factors are necessary. Such models have been part of the agenda proposed to better explain gender segregation. For example, Perry et al. state, "Any attempt to study selection bias and gender segregation must consider both contextual and cognitive process variables" (1994:814). In the next chapter, measures for both types of factors are identified for the development of an inclusive model.

CHAPTER THREE: Questions and Methods for the Admissions Process

Research Questions

The literature reviewed suggests several hypotheses about certain interactional and structural mechanisms that are involved in gendered outcomes of the admissions process in graduate CSE departments. Research on stereotypes and on the culture of computing suggest that commonly-held stereotypes about men's superior proficiency at computing operate during admissions processes to restrict women's entrance into a CSE department. If faculty within a department have a higher rate of agreement with gender stereotypes about computing, those gender beliefs are likely to be activated in CSE departments, and should have direct detrimental effects on the evaluations of female applicants, resulting in fewer admissions of women. However, formalization of evaluation processes has been shown to moderate the effects of gender stereotyping on evaluations of women and other minorities.

Hypothesis 1a: When more faculty members in a department agree with the stereotype that men are naturally more inclined than women towards CSE, women's representation will be lower.

Hypothesis 1b: The negative effects of stereotyping on women's representation will be weaker when relatively objective and specific admissions criteria are emphasized, and stronger when ambiguous criteria are emphasized.

Literature on undergraduate education suggests that the choice of criteria emphasized has differing affects on the admission of different demographic groups. Literature on the culture of computing suggest a CSE role-incumbent schema based on previous CSE practitioners, of whom men made up a large proportion. When traits from this schema are put into practice through the emphasis placed on specific admissions criteria, women's admission will be restricted. This is likely to be true even if the criteria are not easily identified as representing stereotypically male traits, because of generalizable differences

between the backgrounds of men and women who consider entering CSE programs in higher education. Criteria embodying this schema would represent non-academic experience with computing, while criteria contradicting this schema would represent non-academic experiences and skills not directly related to computing.

Hypothesis 2: In CSE departments that emphasize admissions criteria relating to the CSE role-incumbent schema, women will represent a smaller proportion of students, while those emphasizing criteria that contradict the schema will have more women.

Research shows that organizations and educational institutions and departments that engage in “identity-conscious” practices increase diversity. There is little research on the effects of decision-makers’ attitudes towards diversity on gendered effects in the admissions process. However, recent research on the valuing of diversity suggests that such attitudes could contribute to a cultural context that accepts and encourages difference. It appears likely that such attitudes will have direct interactive effects on gendered outcomes, similar to the way that other interactive mechanisms operate. Literature also suggests that such attitudes will contribute to the adoption of practices that increase diversity.

Hypothesis 3a: Identity-conscious practices in a department will result in a higher proportion of women in that department.

Hypothesis 3b: Departments where more faculty hold attitudes supportive of diversity will have a higher proportion of women in their department. The effect of these attitudes will partly work through the implementation of diversity practices that benefit women’s admission.

Data and Methods

Data

The data for this study come from the project “Factors Concerning Recruitment and Retention of Women Graduate Students in Computer Science and Engineering,” supported by a 2002 NSF grant, number EIA- 0203127, administered through the Computer Research Association’s Committee on the Status of Women in Computing. Joanne Cohoon was principal investigator and contact on the project. The purpose of the project was to obtain data on the recruitment and retention of women at the graduate level of computer science, to better understand women’s under-representation in graduate computing. The project consisted of both quantitative and qualitative components.

Departments were recruited for the project from a stratified random sample of all U.S. post-secondary institutions with active doctoral programs in computer science or computer engineering. The sampling frame consisted of 147 CSE departments that awarded at least three doctorates in academic years ending in 1998, 1999, or 2000. The frame was divided into three tiers according to the departments’ NRC (1993) rating of faculty quality, plus an unrated group. Rated departments were divided into thirds to create tiers. A sample was randomly selected from each group, including the unrated group. Of the 60 departments selected to participate in this study, 49 departments accepted the invitation. The doctoral program in one institution was inactive, so this program was dropped from the study. Unranked programs were later classified into a tier category after consultation with CSE faculty. Forty-eight departments provided data for analysis: 18 top-rank programs, 14 second-rank programs, 16 third-rank programs.

Survey instruments were developed by the principal investigators of the study in consultation with CSE practitioners. Four study departments were visited for pretests of

survey instruments. Three survey instruments were fielded from fall 2003 through winter 2004: chairperson, faculty, and graduate student questionnaires. All full-time graduate faculty and in most cases all students in a department were invited to participate. In especially large departments, up to 85 students were randomly sampled, and women were oversampled up to 50%. The surveys were implemented via the web. Multiple email reminders were sent, and non-respondents received a paper questionnaire follow-up. The resulting response rates were 94% for chairpersons (43 chairs), 63% for faculty (775 faculty), and 56% for students (1976 students). Response rates for particular questions varied.

The faculty survey asked about type and frequency of recruitment activities, admissions criteria, characteristics of the program, the nature of faculty-student interaction, activities to promote diversity, and faculty attitudes towards and expectations of students. The chairperson survey asked about types of programs offered, enrollment numbers, numbers of female and male teaching and research assistants, numbers of male and female faculty supervising graduate students, and some of the same questions asked of faculty. The student survey asked about institutional and interpersonal factors in choosing current program, programmatic and faculty services and support received, faculty-student interaction, satisfaction with various aspects of the program and the social environment, thoughts of leaving, and career goals.

The qualitative component consisted of follow-up site visits in spring 2005 to five departments (a subset of the 48 departments surveyed). An attempt was made to achieve as broad a representation of departments as possible by selecting a variety in geographic location, institutional type, population served, female representation, and responses to

various questions identified as significant from the surveys. Participants in focus groups and interviews were recruited through requesting volunteers, and did not constitute a random sample. Participants were assured confidentiality. Up to 7 faculty members, chairpersons, and administrators were interviewed one-on-one for 20 to 60 minutes. Two sex-segregated focus groups with students were conducted at each department and lasted approximately 90 minutes each. Between 2 and 10 students attended the focus groups. Interviews and focus groups were semi-structured, with facilitators asking open-ended questions that were chosen based on survey questions identified as significant. The purpose was to gain a deeper understanding of survey results. Focus groups and interviews were audio-taped and some have been transcribed. The qualitative data are not analyzed in the present study.

Explanatory Variables

The explanatory variables come from the faculty responses, which were aggregated by department to result in department-level predictors. Since this study focuses on the PhD program, those faculty members who indicated that they are involved with a master's program only were not included in the analysis (2% of faculty).

Typically, cognitive bias is inferred indirectly from the association of gendered outcomes with mediating practices; stereotypes are not measured directly. Here, faculty attitudes are used as a direct measure of gender-stereotyped beliefs. Gender stereotyping regarding competency in CSE is measured by faculty agreement with the statement, "CS/CE as a discipline is inherently unattractive to women." Responses are based on a scale of one (strongly disagree) to five (strongly agree). This question does not ask

specifically about competency, but it does tap into whether there is a fundamental (i.e., “intrinsic”) gender difference in orientation to computing, with strong implications for who is likely to succeed in this field. Agreement with this statement reflects the view that there are fixed gender differences, suggesting gender as a strong marker for evaluating applicants among faculty who hold this view. A dichotomous variable for high/low stereotyping departments was constructed from the stereotype variable, so that non-linear effects of stereotyping could be explored. To construct this variable, departments were coded according to whether the average male faculty response fell above or below the median value for the stereotype question. Four departments whose value fell on the median were placed into the low-stereotyping group.

The explanatory variables relating to admissions practices are faculty responses to admissions-related questions. Faculty members who had served as a member of their department’s admission committee in the previous four years were asked to rate the importance they personally placed on each of a series of criteria for evaluating applicants. In addition, all faculty members were asked to indicate their level of agreement with certain admissions-related attitudes. The latter variables measure general attitudes about what is important to consider in admissions decisions rather than the use of particular criteria for evaluation. These attitudinal questions do not ask whether specific criteria are used by an individual for evaluation, nevertheless they are relevant and are used here as indicators of admissions practices. Even though the department averages of the attitudinal questions include faculty who were not on an admissions committee in the previous four years, their responses are included because interviewed faculty stated that faculty members have an impact on admissions decisions even if they are not on the admissions

committee. Questions from the Faculty Survey are presented in Appendix Tables A3-1 to A3-4.

Formal versus informal criteria and practices are measured by the admissions-related questions which could be clearly classified as either formal or ambiguous according to their specificity, objectivity, explicitness and functional relevance. Criteria that are considered formal include student undergraduate degree in a computing major, undergraduate grades in computing courses, and GRE score. Indicators of informal practices or criteria used include faculty agreement that incoming students can succeed without a CS degree, and faculty agreement that incoming students should have opportunities to bridge gaps in CSE training or skills.

Admissions criteria that are considered embodiments of the CSE student role-incumbent schema are those pertaining to non-academic CSE experience: CSE volunteer/work experience, and computing experience. Indicators of admissions criteria considered as contradictions to the schema are those pertaining to non-academic interests outside of CSE and to social skills: student interest in the social application of computing, communications skills, and life experiences. Departments where faculty placed more importance on these latter criteria or agreed that life experience should be considered in admissions decisions indicate that they contradict the schema.

Variables available to measure diversity practices are somewhat vague. The data set does not include an adequate measure for leadership on diversity issues. However, two variables serve as indicators for “identity-conscious” practices in admissions decisions. Faculty were asked how much effort their department devotes to enrolling women graduate students, and faculty were asked how much importance they placed on

the criterion of membership in an underrepresented group. Both measures suggest practices where faculty are going beyond gender-blind practices, such as formalizing criteria, to more actively increasing diversity.

Faculty diversity attitudes are measured by two variables. These consist of responses to whether they believe their department should actively recruit students from underrepresented groups, and responses about whether they agree that activities meant to diversify the student body will lower the academic quality of incoming students. The first question about recruitment is used as an indicator of overall support for diversity. The question does not specify whether this support is motivated by the valuing of diversity associated with perceived benefits for everyone of a diverse environment, or whether it is motivated by an older ideology of fairness and justice. However, considering evidence that the former motive has to a large extent replaced the latter as the “lingua franca” of the modern diversity movement (Harper and Reskin 2005; Siegel 2005), this recruit-for-diversity variable is used to reflect a valuing of diversity. The diversity-lowers-quality variable is used as an indicator for the degree to which a faculty member believes that diversifying the student body necessarily entails lowering academic standards of quality. If the recruit-for-diversity variable is shown to negatively correlate with the diversity-lowers-quality measure of diversity attitudes, which indicates the degree to which faculty believe diversity practices conflict with meritocracy, this negative correlation will support the interpretation of the recruit-for-diversity variable as representing the recent valuing of diversity movement (given previous evidence that the more recent diversity movement involves fewer trade-offs with diversity, and that generally there is negative correlation between these two types of attitudes; Knight and Hebl 2005). However, these

two measures are conceptually distinct and are not combined in an index here. It is possible that a faculty member could value diversity for the perceived benefits it offers to a department, but believes that diversifying necessarily entails lowering standards in academic quality.

Dependent Variable

The proportion of women granted admission into a PhD program is the outcome of interest in this analysis on gendered admissions. The chairperson survey results provide data on total numbers of PhD students and total number of women PhD students. If departments had missing data for these questions, they were contacted by phone for the information, resulting in values for all 48 departments. A variable for the proportion of female PhD students in each department was then constructed.

The resulting proportion of women for each department result from four processes: recruitment, admission offers, student choice of program, and attrition. This poses a problem as the practices of interest in this study are admissions practices. Although data are not available to determine exactly how much each process contributes to the proportion of women in a department, examination of faculty data related to recruitment and student data related to program choice can help identify possible gendered factors in these processes, and to discern the likelihood of their conflation with the practices that are of interest in this study.

Table A3-5 in the Appendix shows items from the faculty survey regarding recruitment. None of these items was significantly correlated with the dependent variable, suggesting there will be no hidden effects of gendered recruitment when estimating the

effects of admissions practices. Table A3-6 in the Appendix shows items from the student survey asking which factors were important to program selection. Men and women are fairly similar in their ratings of factors, suggesting that gendered program selection might not have a strong impact on the dependent variable. Two significant gender differences support previous literature (see below) that flexibility is a feature that facilitates women's participation: women give more importance than men to "geographic preferences and constraints" and "program flexibility" in their choice of program. Flexibility of a program will be controlled for in the analysis, as discussed below. None of the reasons on which men and women differ are the most important reasons selected by either group, except for institution reputation, which will be controlled for in the analysis. The most important reasons for program choice for both men and women are research opportunities, availability of financial aid, reputation of institution, and reputation of program or professors. These were rated by both men and women on average as very important. For all the other reasons on which there is a significant gender difference, both men and women rated them on average somewhere between slightly and moderately important, except for geographic preferences and department culture, which were rated on average slightly higher than moderately important. The implications for these differences will be discussed.

The analysis will also attempt to control for possible effects of gendered attrition on the dependent variable. By gendered attrition I mean that women may leave some departments at higher rates than men, contributing to lower proportions of women enrolled in those departments. The data do not contain actual figures on attrition of students from departments; however, students were asked whether they had had thoughts

of leaving their department (response options were yes/no). The variable representing gender gaps in thoughts of leaving was constructed from the student survey data (average women's thoughts of leaving minus average men's thoughts of leaving, by department). Since seven departments do not have any female PhD student respondents, missing data was imputed. Since all of the departments with missing data on this variable fell within the smallest quartile of departments, missing data was imputed with the mean gender gap in thoughts of leaving among the smallest quartile of department sizes (this value was approximately 0). Department gender gaps in thoughts of leaving will be used to estimate the effects of gendered attrition on the proportion of women in the following analysis.

Controls

Institutional and other environmental conditions that might affect women's representation are considered for their effect on women's proportion PhD students. Tier, rank, or research orientation of institutions and departments is an important organizational demographic variable that is often included in studies of gender segregation in education (for example, Jacobs 1996). As discussed above, it is possible that gender differences in factors of program choice contribute to different proportions of men and women applying to top rank or high research programs. A variable was constructed for rank using 1993 National Research Council rankings (as discussed in the Data section); this variable was converted to a dichotomous variable representing whether a program had top rank or not. A variable for institutional research focus was also constructed based on whether the

department's institution had a Carnegie Foundation classification as a research university with high research activity or very high research activity.

It is possible that there could be gender differences in preference for large or small program sizes, or for public or private institutions. To account for possible effects on departments' proportion of women, size and public/private status are considered in the analysis. For PhD program size, the sum of all PhD students in a program was computed using chairperson survey data. The proportion of female faculty in a department could also effect gendered enrollment if women are disproportionately attracted to programs with more female faculty. A variable representing the proportion of female faculty was constructed from chair survey data; missing values were computed using the proportion of female faculty respondents for a department, and adjusted for the higher response rate among female faculty. The degree to which the subfield of Computer Engineering is represented in a department could affect gendered enrollment, since women are less represented in this subfield.² To account for possible gender differences in interest in Computer Engineering, the proportion of faculty who specialize in Computer Engineering is taken into account.

Organizational features that accommodate a work-family balance may have a positive affect on women's participation, since women on average have a greater need for such balance (Hochschild 1989). Evidence from academia suggests that women may be more constrained in their choice of academic jobs because of family ties (Kulis and Sicotte 2002). Women interested in pursuing graduate education in CSE appear to be more attracted to flexible programs than men (see above). Thus, indicators of flexibility

² Calculated based on data collected from the CRA Taulbee Survey from 2002-2006: <http://www.cra.org/statistics/>.

are included in the present analysis. All faculty members were asked to rate three aspects of their program's flexibility; these aspects were highly correlated and the question on flexibility in timetables to complete degree was chosen for the analysis since it has the highest correlation with the dependent variable (Appendix, Table A3-2).

Analysis

Correlations between the stereotype variable and diversity attitudes will be presented to assess the relationships between these variables. Because the dependent variable is a proportion, I follow Gorman (2005) and Reskin and McBrier (2000) in converting the proportions to logits (the natural logarithm of the ratio of the proportion to 1 minus the proportion). The resulting analysis is a logistic regression of the variables of interest on the dependent variable. I use weighted least squares with PhD program size as the weight variable because the error variance associated with larger departments will presumably be smaller.

CHAPTER 4: Predicting Women's Proportion PhD Students

Univariate Statistics

The univariate statistics for all variables are presented in Table 4-1. In the average department, approximately 20 percent of the PhD students are female, and the proportion ranges from 7 percent to 36 percent. The variable indicating a gender gap in thoughts of leaving shows an average of 8 percentage points difference between males and females in likelihood of such thoughts. Since a positive value for this variable indicates that women have higher thoughts of leaving, the mean indicates that in the average department, the proportion of women with such thoughts is higher than men's proportion, and that gendered attrition may be a factor contributing to women's proportion of PhD students in a program. The range suggests that gendered attrition varies between departments. Departments range from a gender gap of $-.60$, where men have more thoughts of leaving than do women, to $.80$, where women disproportionately have such thoughts.

The means for department and institutional characteristics show that there are fewer top rank programs than other-ranked programs in the sample with 37.5 percent top-ranked programs. Most programs in the sample, about 71 percent, are located in very high research institutions (Carnegie), while the remaining are located in institutions with high research activity or less. Most departments in the sample, 69 percent, are located in public institutions. The size of programs varies substantially, from 12 to 564 PhD students, with an average of approximately 94 students.

Focusing on conditions within departments, the statistics show that faculty on average report that their programs are fairly flexible. When faculty were asked whether

their timetables for degree progress are flexible, the average response at the department level was 3.62. There are few women faculty in the average department, about 13%. This figure includes faculty that may work exclusively with masters students, so the proportion of female faculty who are in contact with PhD students may be even smaller. The average proportion of faculty who specify Computer Engineering as their discipline is approximately 10 percent; this proportion reaches up to 67 percent in one department, indicating that departments vary in whether this topical area is a substantive part of the program.

On average, faculty tend to disagree with the gender stereotype; the 2.40 mean is between “somewhat disagree” (2) and “neutral” (3) in the survey response options. Regarding support for increasing diversity, faculty in the average department generally believe their department should recruit students from underrepresented groups, with an average among departments of 4.12 on a scale of 1 to 5. Consistent with this indicator of support for initiatives to increase diversity, faculty in the average department generally disagree that diversity lowers the quality of incoming students. Faculty level of disagreement with this statement is about the same as their level of disagreement with the gender stereotype. Although department means for these variables indicate disagreement, the level of disagreement is relatively small and the means are fairly close to the numerical representation for “neutral” in the survey. Thus, the agreement level with these variables may be enough to impact the nature of faculty interactions with minority students.

Examining the various criteria that faculty use to evaluate applicants reveals that grades in CS courses are one of the most important criteria for judging potential for

success, but that faculty are also quite tolerant of applicants that have gaps in their CS skills or that do not have an undergraduate degree in CS; all of these variables have averages around 4.2. To about the same degree that faculty emphasize GRE scores and holding a CS degree, they agree that life experiences should be considered (approximately averaging 3.5 for these variable). Communications skills are considered even slightly more important than GRE scores and holding CS degree (3.82). Computer work or volunteer experience is considered substantially less important on average (2.66).

Statistics for diversity practices show a moderate level of engagement with these practices. Faculty only place slight to moderate amount of importance on whether an applicant is a member of an underrepresented group. The relative lack of importance given to this criteria contrasts with the generally supportive attitude towards recruiting for diversity. This is not surprising given that consideration of ascriptive status during the process of evaluating applicant quality conflicts more with meritocratic ideals than does the recruitment of minority individuals to file an application. Regarding the effort departments devote to enrolling women applicants, departments average between a little to a moderate amount of effort (2.83). Since these efforts are generally less than moderate, while agreement with recruiting for diversity is comparatively high, it appears that actual practices to increase enrollment may not be very common, even though support for at least some types of practices (i.e, recruitment) is present. An average 21 percent of faculty within a department have received diversity training.

Table 4-1: Univariate Statistics

	Mean	S.D.	Range
Female Proportion PhD Students	.199	.061	.07-.36
Beliefs			
Agreement with stereotype	2.4049	.33900	1.71-3.50
Dept should recruit diversity	4.1091	.34892	2.89-4.55
Diversity lowers quality	2.3514	.41424	1.54-3.86
Formality of admissions practice:			
Undergrad CS degree	3.4906	.39163	2.50-4.40
Grades in CS courses	4.2169	.26714	3.50-4.80
GRE score	3.5582	.42088	2.58-4.67
w/o CS degree can succeed (<i>informal</i>)	4.2099	.25764	3.71-4.75
Students can fill CS gaps (<i>informal</i>)	4.2992	.26314	3.55-5.00
CSE occupational schema:			
CS work/volunteer exp	2.6569	.42973	1.60-3.50
CS experience	3.5908	.40173	2.50-4.33
Communications skills (<i>divergence</i>)	3.8240	.33913	3.20-4.60
use skills for social good (<i>divergence</i>)	2.3626	.39208	1.50-3.29
Consider life experiences (<i>divergence</i>)	3.4387	.35816	2.33-4.20
Diversity Practices			
Criteria: underrepresented group	2.5930	.55093	1.25-3.60
Department effort to enroll women	2.8271	.35401	2.00-3.41
Diversity Training	21.2547	18.43806	.00-60.00
Controls:			
Gender gap in thoughts of leaving	.0822	.30970	-.60-.80
Flexible Timetables for progress	3.6229	.29841	3.04-4.25
Rank of department (top rank=1)	.375	.489	0-1
Carnegie (very high research =1)	.708	.459	0-1
Public/Private (private=1)	.3125	.46842	.00-1.00
Female proportion of faculty	.1274	.09515	.00-.42
CE proportion faculty	.0962	.14421	.00-.67
Size (# PhD students)	93.7083	99.31295	12.00-564
N=48			

What Faculty Consider When Making Admissions Decisions

When faculty make admissions decisions they must make complex judgments about which applicants demonstrate the most potential for success in their program.

Qualitative evidence from interviews with faculty suggest that admissions decisions do

not rely on a limited number of criteria, but involve many factors, resulting in holistic assessments of students' varying qualifications and skills. Faculty report that a holistic assessment is called for because of the ineffectiveness of any one or set of criteria in serving as a "formula" for identifying prospective students who will be the most successful. Although test scores and grades are a common tool used to judge applicants, the qualities of independent and creative thinking needed for research are not necessarily measurable from these scores. In addition, choices frequently must be made between students with comparable academic backgrounds, so that many aspects of student background are reportedly important considerations.

The faculty survey data supports faculty reports that many aspects of a student's background are important for making admissions decisions. Table 4-2 shows the ten admissions criteria with highest importance ratings after they have been averaged by department. Every item on the list is considered important by at least half the faculty in the average CSE admissions committee to be a very or extremely important criterion. The list reveals that both formal and ambiguous criteria are commonly seen as important. Although grades in computing courses, a formal and specific measure of competence, is the third most important criteria, the two criteria above it – general quality of academic record and motivation – are vague measures of competence. Communication skills, a criterion not directly connected with academic CS proficiency, ranks fifth among the criteria seen as most important by faculty on average. The presence of many ambiguous and/or non-academic criteria on the list indicates that there is much room for faculty and department discrepancy in judgment about which students show the most potential for success. The process of decision-making in CSE departments thus appears to be one in

which cognitive processes such as stereotypes may influence the evaluation of applicants. In addition, the admissions process appears open to the use of non-academic or ambiguous criteria that are linked to a particular model of success, a model that may constrain decisions about what type of person is likely to succeed.

Table 4-2: Top 10 Admissions Criteria Among Department Faculty

Criteria used in Evaluation of Applicants	Percentage of Faculty in the Average Department that indicated Criteria is Very or Extremely Important	Mean
General quality of academic record	95%	4.4
Motivation	88%	4.2
Grades in computing courses	88%	4.2
Academic letters of recommendation	82%	4.3
Communication skills	71%	3.8
Reputation of undergrad institution or program	70%	3.9
Math background	66%	3.8
Research experience	62%	3.8
GRE score	58%	3.6
Computing experience	56%	3.6

(1= not at all important, 2= slightly important, 3= moderately important, 4= very important, 5= extremely important, DK/NA)

Correlations among Gender and Diversity Attitudes

Before proceeding to determine the effects of the explanatory variables, I examine the measures of gender stereotyping and diversity attitudes to test the assumption that they are indeed distinct measures. Table 4-3 shows the correlations between the stereotype variable and diversity attitudes. The correlations are estimated at the individual faculty level, since I am interested here in whether they represent distinct outlooks among individuals. As expected, the two diversity attitudes are negatively correlated ($r = -.376$, $p < .01$), yet their covariance is enough to warrant retaining them as separate measures. The stereotype variable is significantly associated with attitudes that increasing diversity will lower the quality of incoming students ($r = .205$, $p < .01$). This correlation follows expectations since the belief that there are fundamental differences between genders in

orientation towards computing holds implications for the competence of the diverse others, e.g., women, who are brought into the department. However the stereotype belief is not related to whether a faculty member thinks the department should recruit for diversity. Since recruiting is an outreach activity, rather than actual diversification of the student body, it does not imply the trade-off between diversity and quality that might be inferred from the reference to actual diversification in the previous diversity-lowers-quality variable. Even if one believes that there are fundamental differences among groups regarding competence, one could still logically agree that departments should make an effort to reach out to those members of diverse groups who are competent.

Since attitudes about increasing diversity are not highly correlated with stereotyping, and the diversity attitudes are not highly correlated with each other, they will remain distinct attitudinal measures in the model. Since there is not a battery of related attitudinal questions available from the survey, the correlations among these variables provide some reassurance of their validity. The variables behave in relation to each other as would be reasonably expected.

Table 4-3: Faculty-level Correlations among attitude/beliefs variables

	Diversity Lowers Quality	Gender Stereotype	Recruit for Diversity
Diversity Lowers Quality: Diversifying entails lowering academic quality of student body	1	.205*** N=609	-.376*** N=635
Gender Stereotype: CS/CE inherently unattractive to women		1	-0.031 N=617
Recruit for Diversity: Department should recruit underrepresented groups			1

* $p < .10$; ** $p < .05$; *** $p < .01$ (two tailed test).

Predicting Gendered Admissions

Because of the small sample size of 48 departments, the model predicting female proportion of PhD students is built gradually to monitor the stability of variable effects. Bivariate correlations between all explanatory variables and the dependent variable are provided in Table 4-4 to provide a baseline for monitoring the consistency of the predictive relationships. Using weighted least squares with PhD program size, the model is developed by adding variables individually, starting with gender gap in thoughts of leaving, which is controlled so as to compensate for effects of gendered attrition on the dependent variable.

The results for multivariate regression analysis of women's proportion of PhD students are presented in Table 4-5. The gender gap in thoughts of leaving has a weak but significant negative effect on the female proportion, suggesting that some of the variation in the dependent variable has been accounted for by actual gendered attrition. As would be expected, in departments where more women than men have thoughts of leaving, women's odds of entering a department are decreased. The effect of this indicator of attrition is stable as variables are added; its effect size is weak to moderate as more variables are added.

Other control variables were added next to the model. Of these variables, including rank, Carnegie (institution research activity), proportion of CE faculty, proportion of female faculty, and public/private, only Flexibility has a significant effect. As would be expected, departments that are more flexible in their timetables to degree completion have higher proportions of women. Flexibility significantly predicts female proportion as variables are added with a consistent medium effect. The other control

variables do not show an effect in the correlation table or at any point in the development of the model.

Table 4-4: Bivariate Correlations of Explanatory Variables with Female Proportion Phd Students

	Pearson Correlation	Sig.
Beliefs		
Agreement with stereotype	.023	.878
Dept should recruit diversity	-.002	.991
Diversity lowers quality	.078	.600
Formality of admissions practice:		
Undergrad CS degree	.227	.120
Grades in CS courses	-.003	.984
GRE score	-.007	.961
w/o CS degree can succeed (<i>informal</i>)	-.174	.238
Students can fill CS gaps (<i>informal</i>)	-.169	.252
CSE occupational schema:		
CS work/volunteer exp	-.193	.188
CS experience	.045	.763
Communications skills (<i>divergence</i>)	.046	.756
use skills for social good (<i>divergence</i>)	-.015	.917
Consider life experiences (<i>divergence</i>)	.487***	.000
Diversity Practices		
Criteria: underrepresented group	.221	.131
Department effort to enroll women	.265*	.069
Diversity Training	-.214	.144
Controls:		
Gender gap in thoughts of leaving	-.138	.350
Flexible Timetables for progress	.366**	.011
Rank of department	-.019	.898
Institution rank (Carnegie)	-.058	.697
Public / private	-.062	.675
Female proportion of faculty	.013	.928
CE proportion faculty	-.073	.623
Size (# PhD students)	-.080	.589
N=48		

* $p < .10$; ** $p < .05$; *** $p < .01$ (two tailed test).

Table 4-5: Logistic Regression of Women's Proportion PhD Students on Selected Characteristics.

	Unstand. Coeff.	Odds Ratio
Formality of admissions practice:		
Students can fill CS gaps (<i>informal</i>)	-.450***	.6376
CSE occupational schema:		
CS work/volunteer exp	-.401***	.6697
Consider life experiences (<i>divergence</i>)	.512***	1.6686
Diversity Practices		
Criteria: underrepresented group	.332***	1.3938
Diversity Training	-.006***	.9940
Controls:		
Gender gap in thoughts of leaving	-.184*	.8319
Flexible Timetables for progress	.480***	1.6161
Constant	-2.671***	.0693
N=48		

* p<.10; **p<.05; ***p<.01 (two tailed test).

Next, agreement with the stereotype statement and the diversity attitudes were entered into the model individually as well as together, but they do not show direct effects on female proportion. When indicators of formality of admissions criteria were added to the model, they also did not significantly predict female proportion. However, when indicators of whether students are expected to fit with the CSE occupational schema are added, two variables significantly predict women's representation. As expected, when a department's faculty agree more that life experiences should be considered in admissions decisions (which shows a divergence from the occupational schema), women are better represented in a department. The life experiences variable consistently has a medium to strong positive effect on the dependent variable regardless of other variables in the model. The final model shows that as a department's average emphasis on life experience increases by one unit (on the Likert scale) women's odds of entering that department will be 67% higher. The criterion of CS work and volunteer

experience has a negative effect on women's representation, but only reaches significance when the life experiences variable is in the model. Since emphasis on this criteria indicates use of the CSE occupational schema, its negative effect on women's representation is in the expected direction. As a department's average emphasis on CS work/volunteer experience increases by one unit women's odds of entering that department will decrease by 33%. The other variables representing the extent to which the CSE occupational schemas is emphasized—CS experience, Communication Skills, and Use Skill for Social Good—do not have significant effects.

Effects of diversity practices are examined next. The criteria Underrepresented group has a significant positive effect on women's representation. When a department's average emphasis on an applicant's membership in an underrepresented group increases by one unit, the odds that a woman will enter their program will be 40% higher. Somewhat surprisingly, an opposite effect is found for Diversity Training. When the proportion of faculty in a department who have received diversity training increases by 1%, the odds that a woman will enter the program are decreased by 1%. Finally, variables that had not previously been a significant predictor were entered into the model again to check for effects revealed by the presence of other predictors. One measure of informality, faculty agreement that incoming graduate students should have the opportunity to fill gaps in their computer science background, shows a significant effect in the expected direction. When a departments' average agreement with this statement increases by one unit on the Likert scale, women's odds of entering the program are reduced by 36%. When these last three significant variables are added to the model, the

effect size and significance level of the previous variables in the model do not change substantially.

As mentioned earlier, because of the small number of cases per variable in the model, close attention must be paid to the stability of the variables' effects. Correlations from Table 4-4 show zero-order relationships for each model variable that are in the same direction as their effects shown in the full model, although many of the relationships are not significant. The Life Experience correlation with women's representation stands out as especially strong. The effects of the other variables depend somewhat on the presence of other predictors in the model, but these effects are fairly consistent whether there are 4 or seven variables included in the model. The model is also run with all variables entered, and similar effects are observed (Appendix A, Table A-4).

Because collinearity can cause distortion in small sample sizes, correlations between predictors were examined for strong associations. Only two significant relationships were found. The variable Students Can Fill Gaps is weakly correlated with Life Experiences ($r=.252$, $p<.10$), and Computing Work/Volunteer Experience has a medium correlation with Underrepresented Group ($r=.394$, $p<.01$). Since the latter relationship is fairly substantial, I examined the effect of each variable when the other is removed from the model, to examine whether they each continued to display a significant effect. When Computing Work/Volunteer Experience is pulled from the model, the Underrepresented Group effect and significance is still present, but reduced (odds ratio=1.244, $p=.10$). Similarly, when Underrepresented Group is pulled from the model, the effect and significance of Computing Work/Volunteer Experience is still present but reduced (odds ratio=.772, $p<.05$). Additionally, when placed in the model together with

only control variables, these variables' effects and significance levels are similar to what is shown in the full model. In conclusion, this examination of the overall relationships among variables from correlations and from various forms of the model show the model variable effects to be stable and not artificial.

Interaction Effects Between Attitudes and Practices

The hypothesized effects of gender-stereotyped beliefs and of valuing diversity were not apparent in the model discussed above. However, these beliefs and attitudes may interact with certain practices to influence women's representation. There is some evidence in the above model that informal practices (as shown by the variable representing leniency towards incoming students with gaps in their CS background) decrease women's representation. Previous studies have explained similar effects as the result of interactions between ambiguous standards of evaluation and cognitive bias such as stereotypes. To pursue the possibility further of interaction between beliefs/attitudes and practices, the stereotype and diversity attitude variables were recoded into high/low categories. The effects of various practices on the dependent variable were examined among departments with high and low values on the attitude variables.

First, the effects of formal and informal admissions practices were examined by high- and low-stereotyping departments. Table 4-6 shows only variables with a significant correlation under one of the department types. Placing importance on applicants having an undergraduate degree in computer science (formal) has a strong and significant positive effect among high-stereotyping departments, but no effect among low-stereotyping departments. A permissive attitude towards incoming students with

gaps in CS skills (informal) is detrimental to women's representation among high-stereotyping departments, but ineffectual among low-stereotyping departments. These interactions support previous claims that formal evaluation practices prevent stereotypes from resulting in gender bias. However, an exception to the pattern shown is the effect of Life Experiences, which is a strong positive effect in both types of departments, and is only slightly weaker in high stereotyping departments. Although this variable indicates the use of informal (vague, non-academic) criteria, it appears to increase women's representation even when cognitive bias is present.

Table 4-6: Pearson Correlations of Formal/Informal Criteria by High/Low Stereotyping Depts

	Low		High	
	r	Sig	r	Sig
Undergrad CS degree	-.002	.993	.512**	.013
Students can fill CS gaps (<i>informal</i>)	.067	.752	-.536***	.008
Consider life experiences (<i>informal</i>)	.542***	.005	.416**	.048
N	25		23	

* p<.10; **p<.05; ***p<.01 (two tailed test).

Secondly, the effects of diversity practices were examined by departments with high and low support for recruiting diversity. Table 4-6 shows the effects of diversity practices in departments categorized according to their faculty average on the recruit-diversity variable. The criteria Underrepresented Group and the variable representing department effort to enroll women both have significant positive effects on women's representation only among departments with high support for diversity. Diversity Training has a negative effect on women's representation only among departments with a low support for diversity.

Table 4-7: Pearson Correlations of Diversity Practices by High/Low Recruit-Diversity Depts

	Low		High	
	r	Sig	r	Sig
Criteria: Underrep. Group	-.126	.558	.604***	.002
Dept Effort Enroll Women	.166	.439	.393*	.058
Diversity Training	-.452**	.027	.108	.617
	N	24		24

* $p < .10$; ** $p < .05$; *** $p < .01$ (two tailed test).

These interactions were tested further by creating interaction variables and entering them into the model. The interaction effects were in the expected directions, but did not maintain significance. Given the small sample size, the interaction effects found in the correlations tables are suggestive, but not conclusive. They suggest that diversity attitudes interact with specific types of practices similarly to the way that gendered beliefs have been shown to do.

Discussion

The limitations of the dependent variable must again be considered, demanding caution as the present findings are interpreted. Since the female proportion of PhD students is a snapshot of women's representation in a department, this statistic includes effects from gendered attrition, recruitment, and program choice as well as from admissions decisions. As discussed in Chapter Two, the only significant gender difference among the factors considered most important to program choice is the higher importance men place on reputation of institution. It seems likely that this gender difference does not significantly contribute to the dependent variable, since controlling for Carnegie as well as rank did not change the effects of the explanatory variables of

interest. Another gender difference in reasons for program choice discussed previously is women's higher importance placed on flexibility of program content. The variable Flexibility was used to control for possible effects of this gender difference. The significant effect of flexibility in the model may be related to this gender difference; flexible programs may have higher proportions of women from attracting female applicants who desire to balance career with outside commitments and interests. The use of Flexibility and Carnegie as controls, and the relatively few gender differences in program choice, suggest that effects from gendered program choice on the dependent variable are minimal. Regarding confounding effects from department recruitment practices, faculty-reported recruitment practices did not show significant effects. This fact and reports from faculty that they generally do not actively recruit indicate that recruiting effects on the dependent variable are minimal.

I attempt to control for gendered attrition with the control variable representing gender gaps in thoughts of leaving; although this variable is likely to capture some attrition effects, it is not the ideal control because it does not represent actual attrition. Again, the controls may also help to parcel out attrition effects from the effects of admissions practices. Rank is a factor that is identified in the next section as a predictor of gendered attrition, and is included as a control. The control variable flexibility also serves to parcel out possible attrition effects, besides controlling for program choice effects: women may be more likely to stay in a program that accommodates work-life balance. One further consideration contributes to confidence in the observed effects of admissions practices. If the indicator of gendered admissions is still confounded with gendered attrition when controls are included, logic suggests the confounding effects

would reduce detection of significant effects from admissions practices, rather than artificially inflate such effects. The same is true regarding possible confounding effects of program choice and recruitment practices. The fact that indicators for several admissions practices show significant medium effects can therefore be interpreted with some confidence even though the outcome measure is not ideal.

Another limitation of the analyses is the lack of reliability checks for the explanatory measures, since most are represented by only one survey question. This deficiency is especially true for the measurement of gendered beliefs and diversity attitudes, which may have multiple dimensions. Given these limitations, it is all the more intriguing that one indicator of informality had the expected effect, suggesting indirectly the effects of cognitive bias. In addition, gender stereotypes and diversity attitudes appear to interact with specific practices in expected ways. Relatively few studies have shown the interaction of attitudes and practices in actual professional settings.

Another explanation for the lack of stronger effects of stereotypes and diversity attitudes is the setting of the study in academia. As discussed previously, in these settings success is determined by academic standards. It is possible that the measures of the formality of admissions practices as well as direct effects of stereotypes did not show stronger effects because there is generally a high reliance on formal measures among departments. There is likely to be a relatively high emphasis placed on previous academic markers of quality, as compared to a work setting.

More notable from these findings is the evidence to support the argument that an occupational schema constrains the expectations of what a successful student will be like to a model that men are disproportionately more likely to fit. When practices emphasize a

trait from this schema, CSE work/volunteer experience, women's participation rates are lower. When practices diverge from this schema by taking into consideration a broader range of non-academic background experiences, women's representation is higher. These criteria are not easily associated with a gender-stereotypical trait. Furthermore, these criteria appear to work independently of the indicator for gender stereotypes. That these practices operate with strong effects regardless of gender stereotyping within departments suggests that it is a different type of mechanism, less dependent on cognitive processes. Although occupational schemas exist in part in the mind, their gendered effects may be more alterable through specific practices than are gendered perceptions of others.

The literature documenting gender differences in informal experience with computing contributes to understanding why these criteria disproportionately constrain women. Women in computer science are more likely than men to have diverse interests outside of the field. These differences exist, but they do not predict different likelihoods of success. It is important to note that effectiveness of these criteria does not involve de-emphasizing academic technical background or other criteria of academic functional relevance, a practice sometimes used to promote the goals of affirmative action in undergraduate education. For example, some programs have placed greater emphasis on non-academic skills in lieu of emphasis on academic skills (Harper and Reskin 2005). In the Carnegie Mellon experiment, more women were admitted when CS experience of all types was downplayed (Margolis and Fisher 2001). However, in the graduate situation there is no evidence that women are disadvantaged by high standards of CSE academic proficiency. If anything, they are disadvantaged when such standards are relaxed. Without data on the backgrounds of the full applicant pool, it is impossible to conclude

definitively about the degree to which CSE experience requirements serve as a barrier to women. Nevertheless, the present data strongly indicate that the criteria that affect gendered participation at the graduate level have to do with non-academic qualifications, those which are the hardest to judge objectively.

Since there is no indication that the effects of these non-academic criteria reflect any gender differences in academic proficiency, their effects indicate that the CSE occupational schema could be restraining individuals who show potential for success in the field. Perhaps due to an imprint effect from the previous majority-male position holders of what the ideal type of CSE practitioner is like, alternative models of success in the field are not acknowledged. Life experiences and CS volunteer/work experience appear to represent a particular model of success that men are more likely to match. However, it is important to note that this model of success is likely to constrain men as well as women. Blum and Frieze (2005) discuss how different types of men (e.g., those with broader interests) entered the Carnegie Mellon department when this model of success was de-emphasized.

These findings contribute to the literature on gender and science by identifying a specific mechanism through which the culture of computing may hinder women's participation. This occupational schema may be specific to CSE; however, this level of specificity, that goes beyond identifying the occupational culture as stereotypically masculine, is critical to the task of revealing the gendered definitions of jobs and roles as culturally constructed. This is because general theories about how occupational cultures reinforce norms of masculinity, while providing a general explanation for women's lower participation in many fields, do not account for variation among fields in participation by

women. Explaining this variation is important to showing the inaccuracy of a dichotomy between “male-female” domains of work. In addition, gendered effects from occupation-*specific* practices may indicate a *general* type of structural mechanism leading to gendered outcomes. This mechanism, i.e., the use of evaluation practices reinforcing a constraining model of career success, may work similarly elsewhere, reinforcing a different type of constraining model of career success. In this way these findings have implications for other fields and for the workplace.

Although there is some evidence here that formalizing evaluation practices reduces the negative effects of stereotyping, the fact that the informal criteria of life experiences has a consistent positive effect on women’s representation contradicts implications that across-the-board formalization has beneficial effects on gendered outcomes. Consideration of life experiences is an ambiguous practice for evaluating applicants since there is no objective or consistent way of evaluating such experiences. Yet, this practice appears to allow more women to enter CSE departments, *whether or not* departments have a high level of stereotyping. This finding provides an explanation for why some studies have not found formalization to be effective: because it might involve eliminating criteria beneficial to women. This point demonstrates the relatively superficial level at which formalizing works as a structural mechanism effecting gendered outcomes. Formalizing evaluation criteria to prevent the use of stereotypes will not effect fundamental change in the gender balance if the evaluation criteria themselves result in gender bias. The recognition of how criteria effect women and men differently is needed, and might be instigated through organizational leadership on diversity issues, as argued in the literature.

The positive effect of identity-conscious practices is also shown by the significant results of consideration of membership in an underrepresented group during admissions decisions. This effect is in the expected direction and fits with previous literature on the beneficial effects of practices that target underrepresented groups and promote their participation. There is limited previous research suggesting how diversity attitudes might relate to the effectiveness of specific practices, but preliminary evidence here indicates that positive diversity attitudes are necessary for identity-conscious criteria to be effective. The application of the Underrepresented Group criterion is simply ineffective in departments without a high support for diversity. It is notable that diversity attitudes are more important to effectiveness of diversity practices than stereotypes.

The negative effect of diversity training is in the opposite from expected direction, but fits with findings from a large organizational study (Kalev *et al.* 2006). Like Underrepresented Group, this diversity practice interacts with diversity attitudes: diversity training only has a negative effect on women's representation among departments with low support for recruiting for diversity. This interaction suggests a possible backlash effect from diversity training as has been found elsewhere; for example, Burack and Franks (2004) discuss the frequent resistance to diversity efforts that prevails in academic engineering. It is also possible, however, that diversity training is initiated in departments with low diversity and low support for diversity, as a remedial effort. Ascertaining the causal direction between women's enrollment and diversity training requires further investigation.

CHAPTER 5: Women's Career Aspirations in Context: Findings on Gendered Stereotypes, Diversity Practices, and Social Support

Introduction to Program Participation Section

In this chapter and the next 2 chapters, the focus shifts from gendered admission into CSE graduate programs to gendered retention within these programs. The relevance of retention to women's participation in the field is straightforward: if women leave at higher rates than men, there is an obvious effect on gendered rates of participation. Social connections serve as an indirect measure of participation: social connections represent a mechanism through which participation can be increased. The present chapter reviews literature. Chapter Six identifies and constructs the appropriate variables for social capital and retention, and formulates the research questions. Chapter Seven examines gender differences among the outcomes, and tests the argument that gendered social capital contributes to gendered retention. Showing that gendered social capital contributes to gendered retention will corroborate evidence from the literature that suggests the relevance of gendered social capital in the present setting. In Chapter Eight, the effects of departmental factors on gendered retention and gendered social capital will be examined in a multi-level analysis of the data.

Gendered Career Aspirations and Attrition

Women commonly change their career aspirations away from the sciences and other historically-male fields. For example, at the undergraduate level women have been shown to leave pre-medical programs, and computer science programs at higher rates than men (Cohoon 2006; Fiorentene 1987). This trend has been tied to findings that women have less confidence and lower expectations of success in tasks defined as masculine;

believing that one can succeed at an occupation is critical to one's decision to enter that field (Eccles 1994). Correll shows higher self-assessments in math for men, holding math ability constant, and shows that higher self-assessments in math increase the odds that students choose a college major in science, math or engineering (Correll 2004).

Conversely, women's higher attrition from CSE may be explained by their lower confidence in their ability to succeed. Beyer and DeKeuster (2006) find that undergraduate students in CSE courses show a notable gender difference in confidence, controlling for Mathematics ACT scores. Gender differences in confidence persist in graduate school: women in male-dominated programs express lower academic self-concept and low career commitment compared with male peers (Ulku-Steiner et al. 2000). Prior analysis of the present data similarly shows less confidence among women that they can achieve their educational goals in CSE graduate programs (Cohoon 2007).

Jerry Jacobs (1989) examines the evidence that at every stage of the career path, there are gendered differences in aspirations towards and attrition from historically-male fields. He also notes that, in contrast to theories of sex-role socialization, women also switch into these fields at all different points in the career path. He notes that trends in gendered career aspirations better reflect societal cultural changes in gender beliefs than early socialization. He describes the pattern of occupational gender segregation as one of revolving doors, rather than career decisions that are relatively fixed from early in life. What is in need of explanation, he concludes, is not gendered career aspirations, which change, but gendered attrition from male-dominated occupations. His conclusion that the career experience is in need of elucidation, not patterns of individual choice, allots a much more important role to the social context than is often acknowledged.

Fox (2001) echoes Jacobs view when she argues that the problem of women's low participation in science is not simply one of numbers; factors involved in creating gendered inequality continue once women reach the level of higher education. Fox implicates a gendered culture of science that views women's style of doing science as outside the norm. Thus, even if more women enter science, women may not experience increased success as a group. McIlwee and Robinson's (1992) study is again relevant. The women they interviewed described experiences as engineering undergraduate during which they were aware of being different and observed. They felt pressure to prove themselves, and to outperform their male classmates to show their competence. Even though interactions with faculty and classmates were often positive, their minority status created social dynamics that tended to isolate them and contribute to their lack of self-confidence. This qualitative evidence describes the kinds of career experiences that Jacobs and Fox claim is often missing in the attempt to understand why women leave the sciences.

Evidence from Chapter Two is relevant for explaining how specific interactional mechanisms in the career experience contributes to who participates in certain fields. Studies have demonstrated a link between women's perception of a task as stereotypically masculine and their self-assessment of their competence (Beyer, 1990). Correll (2001, 2004) demonstrates empirical links between career-related gender stereotypes, individuals' self-assessments, and individuals' career aspirations. In one study, she finds that gender beliefs about abilities expressed during an experiment affect the standard undergraduates use to evaluate their performance on a task, with gendered consequences for self-assessments of their own career-related abilities (Correll 2001).

Correll thus shows that gender stereotypes can affect individuals' belief in their abilities to be successful in historically-male fields. She concludes that the impact of society-wide stereotypes depends on the degree to which stereotypes are expressed in the local setting. This is relevant to the literature discussed previously describing masculine occupational cultures for many science fields. Surrounding the practice of such fields are gender beliefs, which appear likely to have a gendered impact on students' confidence and persistence.

There is evidence that the male-stereotypicality of a field also decreases women's ability to self-identify with the field. Among undergraduates in engineering, the gender disparity in persistence has been attributed to women's greater difficulty cultivating an identity as a successful engineer (McIlwee & Robinson 1992; Seymour & Hewitt 1997). For example, Margolis and Fisher's study of an undergraduate CSE department identifies the stereotype of "the solitary male computer geek" as an important factor in women's inability to identify with the major (Margolis and Fisher 2001). Taken together, all these findings provide evidence that gender beliefs surrounding the practice of a historically-male field lead to women's departure from that field due to lowered self-assessments, lowered expectations for success, and lack of professional identity with the field.

As discussed previously, gender beliefs can be understood as interactional mechanisms; as the Correll (2001) experiment shows, when individuals interact with others and encounter gender beliefs, those beliefs contribute to how the individuals evaluate their competence and their own fit with the field. Another interactive mechanism, homophily, has also been implicated in women's attrition from fields where they are a minority. Homophily is the tendency for individuals to associate with socially

similar others (McPherson, Smith-Lovin, and Cook 2001). Thus, men tend to associate with other men and women with other women. In the presence of masculine occupational cultures, this tendency can be accentuated because perceived gender differences are accentuated by the gendered cultures, and women can become socially isolated (Fox 1991; Kanter 1977, McIlwee & Robinson 1992). Social isolation is in turn purported to have negative effects on occupational outcomes. I turn my attention now to the literature on social capital which focuses on social connections and how they are purported to lead to gendered occupational outcomes.

Gendered Social Capital in Organizational Settings

The literature on social capital provides a theoretical understanding of how social connections are related to outcomes. Social Capital refers to the ability of actors to obtain benefits through social networks (Portes 1998:6). As such it describes one of the mechanisms that contributes to how people function within organizations. Social capital is measured in many different ways, from number of different types of connections, to responses about trusting others. For the purposes of this study, specific measures of social capital previously used and their replication is not as relevant as the theoretical concept that individuals receive diffuse occupational benefits from connections with others. There is significant empirical support for the benefits resulting from social connections. The full spectrum of benefits are not easily measured. They are diffuse because they are located in the networks, and they may be withdrawn when needed. But over time they may contribute to important outcomes such as career success.

Social capital can refer to both individual-level or group-level connections. In the literature on social capital and work and education, individual-level connections are predominantly the focus. The quantity of ties individuals have in their networks is frequently used to measure how much social capital individuals have, but Coleman and others also see a qualitative component as crucial to the concept and, for example, attempt to measure trust as an important component of social ties (Coleman 1988; Paxton 1999; Putnam 2000). In educational and occupational settings, those with fewer and lower quality social connections are purported to be at a disadvantage. For example, Coleman uses such measures to explain differential achievement in secondary education by demographic groups.

Along these lines, many studies provide evidence that women in historically male fields have less social capital in professional settings and that their participation in these fields suffers from their restricted access to the resources that come from social capital. It is argued that women have smaller networks at work, get fewer returns to their networks, and/or are excluded from male networks. For example, Roth found that among Wall Street financial professionals, women's mobility had been blocked in part because "they could not penetrate informal networks with male managers, coworkers, or clients, while no men described similar difficulties" (Roth 2004:215). Studies of law settings and other fields report similar findings (Epstein 1983). Without the social connections that men have, women are disadvantaged in access to knowledge and information, sponsorship, emotional support, and instrumental support. Resulting gendered outcomes include differences in likelihood of promotion, ability to bring resources into the organization, or

likelihood of retention in an organization (Palgi and Moore 2004; Blair-Loy 2001; Kay and Hagan 1998).

Mary Frank Fox makes a similar argument regarding women's participation in the academic sciences. In science, Fox claims, men share traditions, styles, and understandings about rules of competing and succeeding; they accept and promote one another, while "women are shut out of ways and means to participate and perform" (Fox 1991:194). She emphasizes that scientists' productivity is carried out through social processes of interaction and exchange rather than in isolation. Collaboration and networking are thus important to the practice of science and are necessary for success through increasing one's information, opportunities, and other support. Women's relative social exclusion reduces their access to these resources and thus puts them at a disadvantage.

Although Fox focuses on women at the faculty level of the academic sciences, her discussion of the importance of collaboration and networking to research is relevant at the graduate level, where students are engaged in the same research and same organizational context as faculty. In a later study, Fox provides quantitative evidence of gender differences in social support. In a national study of doctoral programs in science, including computer science, she finds that women are less likely than men in these disciplines to report positive student-faculty interactions (Fox 2001). For example, women are less likely than men to consider their relationship with an advisor to be a collegial or a mentoring relationship. In addition, Fox finds that women graduate students report fewer collaborations with male graduate students. Her study provides evidence of gender differences in social capital among graduate students in the sciences.

There is also evidence that gendered social capital in the form of peer support, faculty support, and advising can affect women's performance and persistence in the academic sciences. Cohoon finds that among women in undergraduate CSE programs, peer support as measured by the proportion of women in a program is inversely related to women's attrition (Cohoon 2006). Regarding faculty support, Fox's study (2001) showed that programs where women reported being helped by their advisors in research-mentoring activities had higher proportions of women graduating from the programs. Although both Cohoon's and Fox's data do not allow for an explanation of how more social support led to more women graduating from the programs, another study of undergraduate students provides such a link. Seymour and Hewitt examined women's attrition from STEM programs, and find that support from faculty can influence students to persist despite a crisis of confidence (Seymour & Hewitt 1997). This finding corroborates McIlwee and Robinson's (1992) description of engineering undergraduates who frequently worried about their ability to make it through the program. Given the added pressure of having to prove their competence in a stereotypically-male environment, these women's persistence depended particularly on time, support, and encouragement from faculty. These studies show gender differences in social connections in the academic sciences, and that such differences can result in gendered occupational outcomes.

In summary, research has shown that women in historically-male fields often have less access to social connections and less trusting ties than do men, with consequences for their occupational success and persistence. What has been shown much less frequently in

the literature is how gender differences in social capital differ depending on contextual factors in the organization or department. Next I address this gap in the literature.

Organizational Environment and Gendered Outcomes

At the beginning of this chapter I discussed Jacobs' examination of the literature on women's career aspirations and persistence, and his conclusion that gendered career aspirations are likely to be more dependent on the social context than is frequently acknowledged. Above I have described two mechanisms that are likely to operate in the cultural context of CSE departments: gender beliefs, and gendered homophily and social capital. However, these explanations often incur the same limitations as explanations based on individual characteristics: the structures and practices within organizations that mediate these mechanisms are not revealed. Social capital is generally treated as a characteristic of individuals that explains differential outcomes, while the organizational mechanisms that contribute to gendered social capital are not elucidated. The organizational context appears especially important for understanding gender differences in social capital because connections between individuals are not random but organized within larger entities. Reskin's (2000) call for more research on the proximate causes of discrimination – the contextual factors that permit or counter the effects of individual-level cognitive processes such as stereotyping and in-group favoritism- is again relevant.

These limitations to the above explanations raise questions about what types of department practices are relevant to gendered participation in CSE PhD programs.

Two questions in particular emerge about how organizational or department practices contribute to gender inequality. First, what are the department-level structures that predict

gendered retention? Secondly, what are the department-level structures that relate to the gendered distribution of social relationships? A third question naturally arises from the literature about the effect of gendered social capital on gendered outcomes: Can departmental factors decrease gendered attrition by closing the gender gap in social capital? There is relatively little research on how organizations contribute to or reduce these gendered outcomes, but literature on diversity practices and recent discussions of organizational social capital provide some useful evidence for developing more specific questions. These practices can be categorized as identity-conscious (e.g., diversity practices) and identity-blind (e.g., generalized faculty-student support). Although there are many such practices that could be identified, my discussion is limited to practices that can be measured by the present data.

Diversity Practices

A practice intended to limit the effects of interactional bias is diversity training. Social psychological research provides evidence that providing information about out-group members and stereotyping may reduce bias (Nelson, Acker, and Melvin 1996). Such information is delivered in diversity training with the intention of reducing bias against minorities. A review of the literature on diversity practices found that diversity training resulted in more positive attitudes towards diversity (Lobel 1999). But other studies of diversity training suggest that it may activate bias instead of reducing it (Kalev et al. 2006). Reskin uses social-psychological research to argue that focusing observers' attention on a stereotyped category, even through efforts to increase diversity, activates

stereotyping; as a result, diversity efforts could taint evaluations of minorities (Reskin 2000).

One study found different reactions to diversity programs based on how the program is justified by an organization (Kidder et. al. 2004). A justification based on past discrimination and need for fairness (associated with affirmative action) encourages less favorable support of diversity initiatives than a competitive advantage justification (associated with the business case for diversity discussed previously). Similarly, a survey of human resource professionals found that both diversity training adoption and perceived diversity training success were strongly associated with top management support for diversity and positive top management beliefs about diversity (Rynes and Rosen 1995). Thus, the effectiveness of diversity training and other diversity efforts appear to depend on the justification for the practices, as well as beliefs about diversity held by organizational leaders.

None of the above studies focus on how framing of diversity practices and diversity attitudes relate to minority experiences in the organization. Most studies of such attitudes have to do with majority-group acceptance of related practices, and focus on practices targeting racial diversity (Konrad and Linnehan 1999). The small, qualitative Ely and Thomas (2007) study discussed earlier is one exception. In work environments where diverse cultural identities are seen as a resource that should be integrated into work, workers feel that their minority status is a source of value; they express the feeling that their competence and contributions to the organization are valued. Another exceptional study regarding diversity attitudes examined the motivations behind mentoring undergraduates in CSE departments. In a nation-wide survey, Cohoon found

that where mentoring was motivated by the desire for diversity, women undergraduates were retained at rates comparable to men (Cohoon et al. 2004). This is one of the few organizational-level studies that looks at diversity attitudes as a contextual factor, and examines its affect on gendered participation.

Another diversity practice particularly advocated for women in male-majority settings is facilitation of women's groups. It is theorized that women can learn strategies and coping mechanisms from each other, share information, and gain awareness of each others' successes (Kanter 1977). Evidence for the argument that organizational support of networking among women improves women's support structures comes from a case study of the effectiveness of a women's group in an undergraduate CSE department (Blum and Frieze 2005). The group was established to provide networking and professional experiences informally available to men, but difficult for women to access. The group helped improve women's networking and retention. Blum and Frieze conclude that an action-oriented student organization with faculty support is key to building a successful community of women. Once again, it appears that the endorsement of such practices by leaders (i.e., faculty) is critical to their success. Evidence from a large study of organizations and their diversity practices is similar; Kalev et al. (2006) find that efforts to decrease social isolation through targeted networking show modest effects, but effects are increased when organizational responsibility for diversity issues is present.

Increasing Organization-Level Connections

The above practices are identity-conscious because they are targeted to specific demographic groups. However, practices that are not so targeted, and which can be

labeled as identity-blind, have also been theorized to increase participation of minority members. These practices have to do with facilitating social connections overall so as to make a more inclusive environment. Although these arguments are almost exclusively based on the workplace, Fox makes a similar argument that academic departments should facilitate women's incorporation into networks in order to expand their access to research opportunities (Fox 2006). Although Fox does not specify how organizations might shape social exchange to include women, she recommends that organizations take on a more active role in overcoming the informal and unofficial processes of social networking that isolate minority members.

Several researchers have theorized similarly about how organizations might integrate minorities into informal social networks. In contrast to the practices above of facilitating support groups that target minorities, other practices address the social connections among all individuals in an organization. For example, Reskin uses experimental evidence to argue that heterogeneous work groups should facilitate women's social incorporation, because increased and interdependent contact among diverse workers will suppress in-group preference and stereotyping (Reskin 2000). In Kanter's (1977) classic study of women's participation in a large manufacturing firm, a similar argument is made based on data from a real workplace. Kanter claims that organizations can make changes in their structure to reduce the effects of stereotypes and homophily. She proposes that increasing social connections overall within the organization will draw women into social networks so that they receive social and instrumental support.

Several types of practices have been proposed by Kanter and others as a means to increase opportunities for networking. These include collaboration among workers, availability and mentorship of leaders, and structures for information sharing (Cohen and Prusak 2001; Kanter 1977; Leana 1999). By far the most research on these practices is on mentoring. Ragins (1999) provides a review of the research on mentoring relationships which consistently shows that mentoring results in benefits such as more self-esteem, career satisfaction and commitment, and lower turn-over rates. These resources would appear especially useful to women in traditionally-male occupations. Indeed, findings have shown that mentorship is especially important for women in overcoming barriers to advancement in organizations, buffering them from discrimination, conferral of legitimacy, altering stereotypic perceptions, and providing information. There is some evidence that women are particularly benefited from mentors because they do not get as many benefits from other connections. Burt (1998) finds that although women and men managers are likely to have the same types of networks, they benefit differently from those networks. Women are most likely to be promoted early when they rely on the support of a strategic sponsor or “established insider,” while this type of social connection is less important for men. Burt’s concept of a strategic sponsor might be applicable to women in graduate programs where advisors often play key roles in students’ success.

There is evidence that the practices of mentorship and other support from organizational leaders have effects on gendered outcomes in the academic sciences. Joanne Cohoon’s research at the undergraduate level of CSE examines practices within departments for gendered effects on student retention, including frequency of mentoring

and faculty encouragement. In a statewide study, programs were more likely to retain men and women at equal rates when faculty members were supportive (Cohoon 2001). A subsequent nationwide study showed that support from faculty in the form of encouragement to persist was associated with increased retention of women (Cohoon 2006). These studies by Cohoon are unusual in that the department is the unit of analysis; thus they provide a view of faculty practices as contextual factors, a view not available from studies that focus on students or workers' reports of connections with faculty.

Besides collaboration, information-sharing and mentoring, another dimension to the development of inter-organizational connections is the development of social trust. Cohen and Prusak (2001) discuss trust within organizations in terms of the quality of interaction between seniors and other organizational members; trust is promoted when seniors engage with others through active listening and resolution of problems, and through trusting employees by assuming they care about doing their work well. Similarly, Leana (1999) claims organizations can build quality social connections through reliance on generalized trust in employees, rather than reliance on formal monitoring and economic incentives. There is evidence that trust as defined here could have a gendered impact in an academic setting. Seymour and Hewitt, in their book on student attrition from science, mathematics, and engineering, argue that women more than men are deterred by the weed-out system that challenges students and encourages competition (Seymour & Hewitt 1997). This study suggests that faculty play a role in whether a supportive and trusting environment is fostered.

Revisiting Fox's argument about women in the sciences allows for a reassessment of the practices discussed above in terms of how they might be relevant in the specific context of CSE departments. Fox recognizes the structure of social interaction as a primary mechanism through which women's participation in the sciences is shaped (Fox 1991). She sees the organizational context of scientists as the source of important determinants of success such as collegial interaction, work climate and collaborative opportunities: "in sum, productivity in science is irrevocably tied to the environment of work," (Fox 1991:204). In such an environment, especially in the field of CSE, women's career aspirations and productivity are likely to be challenged by the stereotypically-male culture of the field, challenged by both the presence of gender beliefs and by homophily and social exclusion. But departments might vary in their social context by mediating these interactional mechanisms and reducing gendered outcomes. Faculty's use of diversity practices, encouragement of collaboration, information sharing, and mentoring might engage women in the collegial interaction and collaborative opportunities that Fox mentions. Faculty might make the work climate Fox speaks of less gendered by discouraging competition and helping students to resolve problems. In the next Chapter, I attempt to operationalize these concepts.

CHAPTER 6: Questions and Methods for Program Participation

The literature reviewed in Chapter 5 suggests many hypotheses about how departments could contribute to gendered outcomes. The present data can only address some of these questions, however. This study reflects only one step towards a full exploration of the theoretical arguments discussed. For example, CSE graduate programs would be an appropriate site to further test the evidence for the gendered effects of a masculine occupational culture, but appropriate variables are not present. Similarly, variables are not available for measuring the degree of formality used when faculty evaluate students' work or progress in a program, and as discussed in the admissions section, formality of evaluation criteria has been supported by the literature as especially relevant to gendered outcomes. However, the present data does have a number of variables that can measure some of the other important concepts developed in the literature relevant to occupational gender segregation. The research questions below articulate these presently testable questions that arise from the literature.

Research Questions

Individual Level

The literature reviewed suggests several hypotheses about how gender is related to outcomes pertaining to program participation in CSE PhD programs. Previous findings about women's participation in historically-male fields including CSE show that women are more likely than men to leave these fields. Evidence on how women make the choice to switch out of such fields, and evidence specifically on the role of gender stereotypes in

these decisions, suggest that women are more likely to experience a crisis of confidence about whether they fit or would be successful in stereotypically-male fields.

Hypothesis 1a: Women are more likely than men to consider leaving their CSE PhD program.

Hypothesis 1b: Relative to men, women's reasons for contemplating leaving their CSE PhD program is more likely to reflect a lack of confidence in their ability to be successful in the field.

The literature on social capital in work settings, and the literature on women in the academic sciences show that women in historically-male fields experience social isolation relative to men. Evidence shows that women report fewer or less supportive connections with peers and supervisors or faculty than do their male counterparts.

Hypothesis 2: Women in CSE graduate programs will report less social inclusion with faculty and students, less instrumental support from faculty, and connections with faculty that are less trusting.

The theoretical discussions about social capital argue that social connections provide resources to individuals through access to information, sponsorship, and/or instrumental and emotional support. Evidence shows that individuals with more or higher quality social connections are more likely to have favorable outcomes. Research on women in the sciences provides evidence that women leave certain fields at higher rates than men partly because, relative to men, they have fewer or less trusting social connections with peers, supervisors or others in their professional social context.

Hypothesis 3a: Students reporting more social inclusion, more instrumental support and more trusting ties will be less likely to consider leaving their program.

Hypothesis 3b: The gendered distribution of social connections (listed in Hypotheses 2 and 3a) will partly explain the gendered rates of contemplating leaving a program.

Department Level

The literature reviewed suggests several hypotheses about certain interactional and structural mechanisms that are involved at the department level in gendered outcomes of program participation in graduate CSE departments. First, the literature suggests that beliefs and attitudes in an organization play a role. Evidence on the culture of certain STEM fields and on interactional bias in organizations suggests that when there is more gender stereotyping in a local context, such as in the practice of male-stereotypical fields, women will have more social isolation and reduced career aspirations compared to men. Conversely, research from the workplace and from undergraduate CSE departments suggest that a positive valuing of diversity will promote more social inclusion for women and minorities, and reduce thoughts of leaving the organization or department.

Hypothesis 4a: In departments where there is more gender stereotyping, there will be a higher effect of gender on student social capital and on student thoughts of leaving the program.

Hypothesis 4b: In departments where faculty attitudes are more supportive of diversifying the student body, there will be a reduced effect of gender on student social capital and on student thoughts of leaving the program.

Research on the workplace and on academic departments also show that identity-conscious practices such as leadership on diversity issues and social support specifically targeted at minorities within an organization generally promote the inclusive participation and retention of minorities in that organization or department.

Hypothesis 5: In departments where there are more practices intended to increase diversity, there will be a reduced effect of gender on student social capital and on student thoughts of leaving the program.

According to the literature on organizations, practices that promote more social connections and social trust overall will have an especially beneficial effect on women and minorities. Practices such as more accessibility of supervisors/faculty, more

mentoring, and more collaboration and information-sharing are hypothesized to provide women with increased access to support, such as advice and encouragement from department leaders. In addition, the literature suggests that organizations can promote trust among workers and managers, thereby promoting minority retention, by promoting an ethic of cooperation. Literature on women's participation in science also suggests this proposition in reverse, that occupational cultures that promote competition are detrimental to women's participation.

Hypothesis 6a: In departments where there are more practices facilitating availability and mentoring of faculty, collaboration, and information sharing, there will be a reduced effect of gender on student social capital and on student thoughts of leaving the program.

Hypothesis 6b: In departments where faculty discourage competition and provide an ethic of helpfulness towards students, there will be a reduced effect of gender on student social capital and on student thoughts of leaving the program.

Finally, the literature on organizations suggests that practices that promote more social connections and social trust overall will have an especially beneficial effect on women and minorities. Increasing organizational social capital is hypothesized to draw women into networks, reducing their social isolation, and thereby logically (if hypothesis 3b is correct) increasing their likelihood of staying in an organization.

Hypothesis 7: The department-level practices above will decrease the negative effect of gender on students' thoughts of leaving partly through increasing student social capital.

Data

The data for testing the above research questions come from the faculty and student surveys from the project described in Chapter 3. Again, faculty responses are aggregated to the department level to represent general characteristics of departments. Average faculty attitudes represent an ethic or a climate within a department, for example

regarding the goal of increasing diversity; averages based on practices that individual faculty members say they engage in or promote represent overall department practices. Because department variables are represented by averages and all 48 departments had faculty respondents, there are no missing values at the department level.

In the student survey, the number of missing values varies by question. The closer the question is to the end of the survey, the more missing values the question has. This pattern is due to the students dropping out of the web-based survey, since the survey was relatively long. On an open-ended question, a number of students complained about the length of the survey (9 pages). As a result, there were a large number of missing values for the important gender variable, and for other demographic variables such as citizenship. By the third page there were already 149 missing values for PhD students; for the gender question on the ninth page there were 321 missing out of a total of 1296 PhD respondents who answered the first question. The number of missing values for gender is similar to the number of missing for the questions immediately before and after gender. For 105 of the missing cases on gender, a value was assigned based on the name of the respondent. To test the missing data for randomness, a t-test was conducted comparing the substituted cases to cases with non-missing gender responses. No significant differences were detected by gender or outcome variables. The imputed values brought the total number of cases with a gender value to 1076. However, values for other variables such as citizenship could not be substituted, which limits most analysis to approximately 947 cases.

Variables

Individual Level

Retention

In the present study, actual trends of gendered departure from the programs were not available. However a question on the student survey asked whether students had thought of leaving, and for what reason. Students were asked, “Since entering your CS/CE graduate program, have you ever contemplated leaving?” If a student answered “yes” to having contemplated leaving, they were asked to select any of fourteen reasons for their thoughts of leaving (response categories shown in Chapter 7).

Social Capital

Students’ individual social capital is measured by survey questions pertaining to students’ interactions with faculty, with advisors, with other students, and within the department overall. These questions relate to subjective accounts of students’ social inclusion and level of support provided to them. The data set does not include objective measures such as size of networks or number of contacts over a given period. The measures have to do with quality of contacts and how frequently feedback, encouragement and advice are received from those contacts. Although the quality of contacts is only one aspect of social capital, it is likely to be the most relevant to the setting of graduate programs, where students work with a small research group. Their success in the program depends on work with an advisor and others in the group, and does not depend on connections outside the group or department, as in many work settings. As mentioned in the literature review, proponents of the term social capital as a useful explanatory concept often discuss social capital in terms of both the networking and trust aspects, trust being the

qualitative dimension of social ties (Paxton 1999; Putnum 2000) The full list of variables selected for consideration is provided in the Appendix B (Tables B6 1-4).

A factor analysis was performed on the social capital variables listed in the Appendix using Varimax rotation method. The Varimax method was used to maintain orthogonality among the factors. Four factors were identified: Faculty Instrumental, Advising, Social Support and Faculty Undermine (Table 6-1). In order to avoid losing a large number of cases due to list-wise deletion, the means of items were used for missing values. The final factors shown in Table 6-1 do not include all the social capital survey items listed in the Appendix, but rather each factor includes only those items that scored highly on it. After initial factor analysis including all the variables, items that loaded highly onto a factor were entered into separate factor analyses. This variable construction processes is used for the purpose of allowing the study to be more easily reproduced. Appendix B provides the percentage of within-factor variance explained by each factor, and the exact wording of the items (Table B6-5). As can be seen in Table 6-1, Faculty Instrumental, Advisor Support, and Social Support have to do with positive forms of social capital, while Faculty Undermine represents a deficit of social capital.

Table 6-1: Student Social Capital Factors

Faculty Instrumental	Advisor Support	Social Support	Faculty-Undermine
Faculty available for one-on-one advising	Advising quality	My social network includes faculty	Faculty favor certain groups of students
Faculty help with degree progress	Satisfaction with relationship with faculty advisor	My department provides enough social options that I can find a way to participate	Faculty undermine confidence
Faculty give career advice	My advisor gives me adequate feedback for degree progress	My department has a supportive environment	Faculty expectations are too high
Faculty encourage research collaboration	I am comfortable talking with my advisor about plans for the future	The student community is supportive	Must compete with others for faculty attention
Faculty care about me as a person	My advisor understands my needs	I feel part of a graduate peer community	
Faculty are interested in my degree progress Faculty encourage research publication Faculty encourage conference attendance Faculty help with professional contacts Faculty give research advice	I have adequate time with my advisor	I sometimes feel isolated within my department	

Control Variables

Variables that indicate individual characteristics that could theoretically have an impact on thoughts of leaving or social capital were considered for control variables. Certain variables having to do with student reasons for selecting their current graduate degree or program were considered, as follows. A higher average interest in computing and a higher average desire to do research could contribute to a higher desire to stay in the program, while higher interest in applying computational techniques to other areas could decrease desire to stay in the program. Geographic preferences/constraints seem likely to increase desire to stay in one's program. Part-time status could indicate a non-traditional

student, who might have different types of experiences in a graduate program due to outside responsibilities and less time spent in the department. Type of funding could similarly influence student's experiences by causing varying types of responsibilities for students, and could differentially integrate them into the research activity of the department. Previous academic and work experience in CS/CE, and having an undergraduate degree in CSE, could have an influence on students' confidence that they can succeed in the program. Citizenship status could cause differing cultural expectations and experiences, as well as differing practical pressures, and is especially important to take into consideration given the high number of non-citizens in the sample.

Department-Level

Department Gender Beliefs and Diversity Attitudes

The same variables used in the admission section for gender beliefs and diversity attitudes are used presently. To indicate gender stereotyping, faculty agreement with a statement that CSE is inherently unattractive to women is used. For diversity attitudes, responses to two questions are used: agreement that the department should actively recruit to diversify the student body, and agreement that diversifying lowers the quality of incoming students.

Department Practices

On the faculty survey, most of the questions pertaining to faculty or department practices were organized in one of three categories: questions about the graduate program or department, questions about how often faculty personally engage in certain actions, and questions about faculty agreement with statements about students and about how the

graduate program should be run. To reduce the number of variables, factor analysis using Varimax rotation was run on individual-level faculty responses for each survey question category (faculty responses about the program, faculty actions, and faculty views), excepting questions that were conceptually irrelevant to the practices of interest. Most questions were conceptually and empirically related to other questions in the same survey question category. However, several questions were more conceptually related to questions from other categories, and loaded highly with those questions to create a factor. In addition, some questions that were conceptually distinct from other questions and did not load highly onto any factor are included as single-item measures. As in Chapter 3, once factors were determined, most of them were rerun individually with only the items that loaded highly in order to create variables that are more easily reproducible. However the orthogonality allowed for by Varimax rotation was especially important for the factors Faculty-Student Research (used to represent Research Orientation), Support Grad Involvement, and Career Mentoring, which were highly correlated at the department level when they were constructed separately from each other. These three factors were thus created by inclusion in one factor analysis.

Appendix B, Table B6-6 shows the factors with percentage of within-factor variance explained for each one. Two control variables, the Flexibility factor and the Faculty-Student Research factor are included in the table. The exact wording and the descriptive data at the faculty level for each question constituting the factors is also provided there. The number of origin of each question is provided to show which category the question originally belonged with. Cronbach's Alpha is provided to show

the reliability of items within a factor. A summary of each factor variable is given below in Table 6-2.

The variables used to measure diversity practices include the factor Support Women which includes departments' facilitation of women's groups, including women speakers, and showcasing women's successes. The variable Dept Effort refers to efforts to enroll women in the program; this is used as a general measure of department efforts to increase women's participation. The Diversity Training variable is the proportion of faculty in a department that has participated in diversity training.

Table 6-2: Department Variable Factors

Support Women	Explanatory Variables			
	Competition	Support Grad Involvement	Career Mentoring	Advisor Help
Showcase women's success	Grad competition is desirable	Help grads get involved with professional associations	Encourage research careers	Advisors responsible for helping grads succeed
Support groups for women	Grad courses should weed out weak	Encourage grads to teach courses	Discuss career options	Failing students may succeed with extra help
Women guest speakers	Competitive behavior rewarded	Provide opportunities for grads to interact outside courses	Assist grads with professional position	Advisor should offer assistance with non-acad. problems
		Inform faculty of grad success	Advocate for grads	Advising should not be restricted to acad. matters
		Language instruction for intern. grads	Encourage grads personal growth	
		Compliment woman grad	Discuss your satisfaction with career	
		Engage grads in research proposals		

Table 6-2: Department Variable Factors Continued

Explanatory Variables			Control Variables	
Faculty Availability	Information Flow	Student Collaboration	Faculty-Student Research (Research Orientation)	Flexibility
Faculty respect each other	Dept. provides career info. well	Faculty promote study groups	Fund grads attendance at prof meetings	Flexible time tables for progress
Grads seek advice from >1 fac member	Info. disseminated effectively	Encourage grads' collaborative research	Publish research with grads	Flexible time tables for completion
Grads switch advisors w/o negative consequences	Encourage grads' participation in prof. orgs.	Facilitate formation of study groups	Grads present at conferences	Personal leave available
			opportunities for grads to practice presenting	
			Inform grads of research opportunities	
			Meet with grads	
			Describe how to get involved with research	
			Introduce grads to computing professionals	

The variables relating to faculty support of students are used to measure faculty facilitation of collaboration, information sharing, and availability of and mentoring by faculty. The factors Support Grad Involvement, Career Mentoring, Student Collaboration, Information Flow and Career Informal all come from questions asking faculty about their own actions towards students, and thus relate to previous claims that general sponsorship by organizational leaders is particularly beneficial to minorities. Support Grad Involvement pertains to supporting students' needs in other areas besides research (e.g., through professional associations, teaching courses). Career Mentoring involves such interactions as discussing career options, while Student Collaboration involves faculty facilitation of student study groups and student collaboration.

Information Flow and Career Informal have to do with how well information is disseminated to students, and whether it is done so informally. Faculty Availability relates to how available faculty feel they are to students and each other. All of these variables attempt to measure practices that are argued to promote more social connections within an organization.

The variables used to measure trust in departments are Students Own Fault, Advisor Help, and Competition. These variables are intended to represent the degree to which faculty listen to and engage with student concerns, and trust that students will do a good job. These types of interactions are discussed in the literature as promoting generalized trust in the work setting. Students Own Fault, referring to the statement that it is a students' own fault for failing, is a negative measure of trust; Advisor Help is a positive measure of trust since it refers to how much faculty feel advisors should help their students. Competition also suggests less trust, since a competitive structure puts the burden on students to prove their competency, and requires students to compete against each other, suggesting less cooperation and trust among students.

Control Variables

Tier, rank, or research orientation of institutions and departments is an important organizational demographic variable that is often included in studies of gender segregation in education (for example, Jacobs 1996). Several variables are used to measure research orientation. As discussed in Chapter Three, Rank and Carnegie reflect external rankings of programs and institutions, respectively, based to a large extent on research activity. Two faculty survey questions relate to the level of research in a department. Faculty-Student Research concerns the level of faculty-student research

collaboration, and Grads Research refers to whether incoming graduate students are involved in research. All four of these variables are highly correlated with each other; although they measure somewhat different things on face value, they all measure research orientation. The variables derived from the faculty survey are likely to be the most accurate measure of research activity in departments because they are continuous variables and thus contain more information on the variation among departments. All four variables will be examined for effects on the outcome variables.

As discussed in Chapter Three, various types of flexibility in an organization relate to gendered preferences for work-life balance. The Flexibility variable includes flexibility in progress towards degree and availability of personal leave. Studies First, a question asking faculty whether students must put studies ahead of all other commitments to be successful, is also used to measure department conduciveness to work-life balance.

More women faculty in a department could provide a source of support to women students through role models and same-gender networking. The proportion of female faculty comes from the chair survey; missing values were computed using the proportion of female faculty respondents for a department, adjusted for the higher response rate among female faculty. The proportion of female students has been shown previously to be an important factor for women's retention in CSE; this association has been attributed to the same-sex peer support available to women when departments have higher numbers of women students (Cohoon 2001). The variable for proportion of female PhD students used in the admissions section will also be used here.

The proportion of faculty who selected Computer Engineering as their discipline represents a sub-discipline within the field of CSE which could relate to the occupational

culture of the department. Whether a program is public or private could affect how diversity practices are mandated. The size of the PhD program could allow for more networking among minorities. All these factors will be considered so that their potential effects can be discerned from those of the department variables of interest. A list of single-item department control variables and their descriptive statistics are listed in Appendix Table B6-7.

Analytic Model

The multi-level nature of the research questions and nested data structure require use of a hierarchical linear model (HLM). At level one, students' contemplation of leaving and social capital are predicted by gender and individual-level characteristics; at level two, the variations in regression slopes among departments are explained as a result of department-level practices. The final outcome remains individual students' thoughts of leaving and social capital, rather than department-level averages of students' contemplation of leaving and social capital.

HLM is more than a simple slopes-as-outcomes model and allows for various deficiencies in the latter type of analysis. In sum, HLM accounts for: 1) the often large sampling variability in first-stage model, 2) variation in sampling precision of the estimated slopes across groups (i.e., departments), 3) the need to estimate separate sampling and parameter variances so that the substantive significance of results from the second stage can be interpreted, and 4) the covariance structures that exist among the multiple-regression coefficients estimated within each group (Osborne 2000). Since it accounts for the above deficiencies, HLM makes it possible to discern effects of group-

level variables that would otherwise seem weak. In addition, HLM makes it possible to apply controls at both stages of the analysis. In summary, HLM allows the separation of within-department phenomena from between-department phenomena. The effects of the department as a sociological unit can be taken into account. This powerful analytic tool is used to examine whether the effect of gender on individual outcomes differs because of departmental practices.

CHAPTER 7: Predicting Thoughts of Leaving and Social Capital with Individual-Level Factors

This Chapter tests the present data for the presence of gendered outcomes in CSE PhD programs, outcomes suggested by the literature. These outcomes include retention and social capital in departments. I have previously discussed how these outcomes are measured through students' accounts of their thoughts of leaving and their social connections. I begin by examining thoughts of leaving by gender.

Gender Differences in Thoughts of Leaving

Across all departments, 30% of student survey respondents were women. This proportion is higher than the actual average proportion of women PhDs in a department due to the over-sampling of women (20%) as part of the survey sampling design. Overall, 46% of students had contemplated leaving their department since having entered their department. Table 7-1 shows proportions of students by gender who thought of leaving for any reason, and the proportions who selected each reason for contemplating leaving. Women are significantly more likely to think of leaving for any reason; 53% of women have such thoughts compared to 43% of men. The most commonly selected reason for women's thoughts of leaving overall is lack of confidence in one's abilities. For men the most commonly selected reason is to take a job. The gender differences in percentages selecting the confidence and job reasons are significant at ($p < .01$). Other significant gender differences include women's higher likelihood of selecting "constantly having to 'prove yourself' in your graduate work," and "the work is too demanding." This gendered pattern in selection of reasons supports the literature that women feel the need to prove

their competency in stereotypically-male fields, while men do not. In contrast, men are more likely to select reasons that appear less associated to the social context. Thus, not only do women think of leaving more than men do, but they do so for different reasons.

Table 7-1: Reasons for thoughts of leaving, by gender (Proportion of students out of those who contemplated leaving only. Students could select more than one reason).

	Men	Women
Have contemplated leaving for any reason***	0.43	0.53
To take a job***	0.62	0.37
Your academic performance to date	0.33	0.36
Program limitations	0.36	0.31
Constantly having to "prove yourself" in your graduate work**	0.39	0.49
Personal reasons not related to the department or program	0.50	0.46
Economic reasons	0.41	0.35
To enter another field	0.21	0.24
Because you were not confident in your abilities***	0.36	0.50
Because your advisor was not confident in your abilities	0.25	0.22
Did not pass Preliminary exam	0.11	0.08
The work is too demanding*	0.27	0.35
Poor relations with other students	0.13	0.13
Unpleasant living environment in the geographic area	0.16	0.19
Other reason	0.11	0.13
Poor relationship with advisor	0.02	0.02
N for contemplated leaving	685	294
N for specific reasons (only those who thought of leaving)	293	156

*Difference between men and women is significant at $p \leq .10$

** Difference between men and women is significant at $p \leq .05$

*** Difference between men and women is significant at $p \leq .01$

Next, the Control variables are examined by gender. Table 7-2 shows that men and women differ significantly on several variables. Men are more likely to have chosen their field because of interest/enjoyment of computing and desire to do research, while women are more likely to have been influenced by a desire to apply computational techniques to other areas, and by geographic preferences and constraints. As undergraduates, men are more likely to have majored in computer engineering while women are more likely to have majored in a non-computing discipline. Men are more likely to have had CS/CE work experience while women are more likely to have had other kinds of CS/CE experiences, not listed in the survey. Women are more likely to have a fellowship as their current source of funding, and less likely to have a research assistantship. It is noteworthy that slightly more than half of both men and women are non-citizens. This must be examined further since non-citizenship is likely to include students with a variety of cultural backgrounds involving different gender beliefs from U.S. citizens. Non-citizens may also have different practical constraints influencing whether they think of leaving the program. Next, thoughts of leaving are explored by citizenship.

Table 7-2: Gender differences in Control Variable Means For All Ph.D. Students

	Male			Female		
	N	Mean	S.D.	N	Mean	S. D.
Factors in selection of current graduate degree/program:						
Interest/enjoyment of computing***	746	4.23	0.86	319	4.01	1.04
Desire to apply computational techniques to other area*	715	2.88	1.30	300	3.04	1.36
Desire to do research***	753	4.27	0.94	320	4.05	0.99
Geographic preferences or constraints***	730	2.99	1.27	312	3.26	1.35
Paid employment in computing-related field immediately prior to gradschool	650	0.58	0.49	280	0.57	0.50
Full-time (1) vs. Part-time (2) student	673	1.05	0.23	287	1.06	0.23
Teaching Assistantship	679	0.28	0.45	293	0.28	0.45
Research Assistantship*	679	0.63	0.48	293	0.56	0.50
Fellowship***	679	0.15	0.35	293	0.24	0.43
Current job outside department	687	2.82	0.51	297	2.81	0.51
Undergrad major in Computer Science	686	0.65	0.48	294	0.65	0.48
Undergrad major in Computer Engineering***	686	0.20	0.40	294	0.13	0.33
Other Computing Major	686	0.03	0.16	294	0.04	0.21
Majored in non-computing discipline**	686	0.27	0.45	294	0.34	0.48
CS/CE work experience***	644	0.54	0.50	278	0.45	0.50
CS/CE internship experience	644	0.32	0.46	278	0.36	0.48
CS/CE undergrad research experience	644	0.45	0.50	278	0.45	0.50
Other CS/CE experience*	644	0.05	0.23	278	0.08	0.28
Years since completion of bachelor's degree	677	5.30	4.76	287	5.42	4.93
Years since beginning current program	674	2.48	2.28	289	2.33	2.02
age	669	27.99	5.35	287	28.03	5.30
Primary caregiver to any children	676	0.12	0.32	292	0.13	0.34
Native-born U.S. citizen	660	0.49	0.50	287	0.48	0.50

*Difference between men and women is significant at $p \leq .10$

** Difference between men and women is significant at $p \leq .05$

*** Difference between men and women is significant at $p \leq .01$

When contemplation of leaving and associated reasons are examined by citizenship, a larger gender gap is apparent among citizens. The top row of Table 7-3 shows the proportion of those who contemplated leaving for any reason by gender and citizenship. Non-citizen women responded to the question more similarly to citizen men

(47% and 48%, respectively) than to citizen women (62%). In addition, non-citizen women show a different pattern of reasons for contemplating leaving than citizen women, especially regarding the reasons discussed above that were more common for women as a group: “having to ‘prove yourself,’” “not confident in your abilities,” and “work too demanding.” Citizen women were much more likely to choose these reasons, while non-citizen women were more likely to choose “to take a job,” “program limitations,” and “economic reasons.” When gender differences are compared among citizens, significance tests show differences in the same reasons noted above, but non-citizens do not differ on these variables. There is also a gender difference among citizens in another confidence-related reason, “Advisor not confident in your abilities,” although not significant. Interestingly, non-citizen women are significantly *less* likely than non-citizen men to think of leaving because their advisor is not confident in their abilities. The gender gap observed among citizens is not present among non-citizens. It is again apparent that citizen women are more likely to think of leaving than other groups, and also do so for different reasons.

Table 7-3: Reasons for thoughts of leaving for PhD students, by gender and citizenship (Proportion of students out of those who contemplated leaving only. Students could select more than one reason.)

	Citizens		Non-Citizens	
	Men	Women	Men	Women
Contemplated leaving***	0.48	0.62	0.39	0.47
To take a job***##	0.59	0.32	0.64	0.45
Academic performance	0.32	0.39	0.34	0.31
Program limitations	0.29	0.26	0.42	0.39
Having to prove yourself***	0.41	0.59	0.35	0.36
Personal reasons	0.47	0.45	0.54	0.49
Economic reasons	0.33	0.29	0.47	0.40
To enter another field	0.20	0.25	0.21	0.22
Not confident in your abilities***	0.45	0.65	0.28	0.34
Advisor not confident in your abilities#	0.22	0.27	0.29	0.16
Did not pass Preliminary exam	0.12	0.08	0.11	0.09
The work is too demanding**	0.32	0.45	0.22	0.21
Poor relations with other students	0.14	0.15	0.11	0.09
Unpleasant living environment	0.15	0.20	0.17	0.18
Other reason	0.14	0.19	0.08	0.07
Poor relationship with advisor	0.03	0.04	0.02	0.00
N for contemplated leaving	320	138	335	144
N for specific reasons	152	85	132	67

*Difference between citizen men and citizen women is significant at $p \leq .10$

** Difference between citizen men and citizen women is significant at $p \leq .05$

*** Difference between citizen men and citizen women is significant at $p \leq .01$

#Difference between non-citizen men and non-citizen women is significant at $p \leq .10$

Difference between non-citizen men and non-citizen women is significant at $p \leq .05$

In order to explore further the causes of contemplating leaving for reasons particular to citizen women, a second dependent variable for contemplation of leaving was constructed. To construct this variable, only certain cases were retained. The cases of those who thought of leaving for at least one of the five reasons related to confidence/prove-self (discussed above) and the cases of those who did not think of leaving were retained. Other cases were selected out (i.e., those who had not selected at least one of the reasons: confidence, prove self, demanding work, advisor not confident, and relationship with advisor). The new variable, Thoughts of Leaving for Confidence Reasons (TOL-Conf), contrasts students who have thought of leaving for at least one of the five confidence-related reasons, with those who have not thought of leaving. This variable can be compared to the first dependent variable above which will be called TOL-

ALL (thoughts of leaving for all reasons). Some cases are lost with use of the new dependent variable. This variable is useful because it allows for identification of the causes of contemplating leaving for the reasons that are especially common for citizen women, who contribute most to the gender gap. When department-level conditions are examined, departmental conditions that are particularly likely to lead to these reasons for contemplating leaving can be identified. The proportions of those who have had TOL-Conf is reported by gender and citizenship below in Table 7-4. The gender difference among citizens is substantial at 19%, and small among non-citizens at 4%.

Table 7-4: Proportions of Men and Women Who Contemplate Leaving for Confidence Reasons by Citizenship

	Citizens***		Non-Citizens	
	Men	Women	Men	Women
Contemplating Leaving-Confidence	.38	.57	.28	.32
Total N=787	N=269	N=124	N=281	N=113

***gender difference among citizens significant at $p \leq .01$

Correlations between additional control variables and TOL-Conf were examined for significance. Appendix Table B7-1 shows the control variables that are correlated with thoughts of leaving for confidence reasons. A multivariate model was developed to determine the effect of gender once the citizenship-gender interaction and control variables are taken into account. The control variables relating to desire to do research, interest/enjoyment of computing, and majoring in a computing discipline are significant predictors of TOL-Conf. Table 7-5 shows a one-level logistic regression model using HLM software and modeling random effects for Female. As would be expected, having more desire to do research and more interest in computing decreases a student's odds of

having TOL-Conf. Having a non-computing major increases the odds. A significant gender difference among citizens remains after the effects of controls are taken into account; among citizens, being a woman increases the odds of having TOL-Conf by 98% once other factors are controlled.

Table 7-5: Logistic Regression of Individual-Level Predictors on TOL-Conf

<i>Fixed Effects</i>	<i>Odds Ratio</i>	
Intercept	0.450	***
Female	1.977	**
Non-Citizen	0.890	
Non-Citizen Female	0.416	**
Desire to do Research#	0.608	***
Interest in Computing#	0.828	**
No CS Undergrad Major	1.490	**
<i>Random Effects</i>		
Female	Variance .729	p .003
d.f.	41	
Reliability	.405	
Level 1 N	760	

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$

denotes centered at grand mean.

Gender Differences in Social Capital

To test the hypothesis that men have more social capital than women in CSE departments, comparisons of means by gender were conducted on social capital factors. Women, citizens and non-citizens included, have significantly less Faculty Instrumental support ($p < .10$), and significantly more Faculty Undermine ($p < .05$) indicators. The differences are in the expected direction. Women are less likely to agree that faculty do such things as give career advice and help with degree progress. Women are more likely to say that faculty do such things as undermine their confidence and favor certain groups of students. When comparisons between men and women are conducted by citizenship, only the gender difference in Faculty Undermine is significant.

Next, controls were regressed with gender on the social capital variables in HLM, with random effects for gender. No significant effects are found for gender without the gender-citizenship interaction term. However, when the interaction term is added, gender becomes significant for Faculty Undermine and Social Support. After controlling for individual factors, citizen women have significantly more Faculty Undermine and less Social Support than do citizen men. Interaction effects for non-citizen women go in the opposite direction. Thus, the gender differences for social capital are located in the same place as the gender difference in TOL-Conf; that is, the differences are located among citizens. Table 7-6 shows the Regression models with the significant predictors of these two forms of social capital.

Table 7-6: Linear Regression Predicting Social Capital with Individual Characteristics

	Social Support			Faculty Undermine			
	<i>Coeff.</i>	<i>Std. Error</i>	<i>p</i>	<i>Coeff.</i>	<i>Std. Error</i>	<i>p</i>	
<i>Fixed Effects</i>							
Intercept	0.034	0.072		0.031	0.084		
Female	-0.274	0.131	**	0.256	0.126	**	
Non-Citizen	-0.168	0.082	**	0.228	0.085	***	
Non-Citizen Female	0.355	0.152	**	-0.377	0.157	**	
Desire to do Research#	0.145	0.037	***	-0.105	0.039	***	
Interest in Computing#	0.100	0.037	***				
Fellowship	0.272	0.095	***				
Job	-0.325	0.107	***				
Undergrad CS Research Experience	0.183	0.069	***	-0.145	0.071	**	
Other CS Experience	0.296	0.136	**	-0.358	0.143	**	
Desire to Apply CS to Other Area#				0.104	0.027	***	
CS Work Experience				-0.156	0.071	**	
<i>Random Effects</i>							
Female		<i>Variance</i>	<i>p</i>	<i>df</i>	<i>Variance</i>	<i>p</i>	<i>df</i>
Level 1		0.192	.000	41	0.112	.005	42
ICC		0.932			1.000		
Reliability		.171			.101		
Level 1 N		.523			.369		
		858			838		

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$

denotes centered at grand mean.

A number of individual characteristics predict Social Support: having more desire to do research, interesting in computing, CS research experience, and other CS experience, and holding a fellowship increase one's Social Support capital, while holding an outside job decreases one's Social Support (as expected). The effects of the control variables suggest that having more experience in CS enables a student to feel more included by other students and faculty. The fact that there are gender differences in several of these characteristics explains why controlling for them revealed a gender difference. Regarding Faculty Undermine, having more desire to do research, having CS research experience, other CS experience, and CS work experience decrease feelings of exclusion by faculty, while wanting to apply CS skills to other areas increases feelings of exclusion by faculty. Again, CS experience has important effects on social capital.

Social Capital Predictors of Retention – Gendered Patterns

To test whether positive forms of social capital increase retention, the social capital indicators were entered into the model developed above predicting thoughts of leaving for confidence reasons. Faculty Instrumental is not significant in the presence of the other social capital measures; however, the other three forms of social capital significantly predict TOL-Conf in the expected direction. More Social Support and more Advisor Support decrease the likelihood of TOL-Conf, while higher scores on the Faculty Undermine factor increase the likelihood of TOL-Conf. The effects of social capital are somewhat higher than the effects of other individual-level characteristics. Unexpectedly, the effect of being a citizen female only changes minimally when social capital is accounted for. The increase in odds of TOL-Conf if one is a women is 85%, compared to

97% before social capital variables are added to the model. Table 7-7 shows the model before social capital is added (repeated from Table 7-5) and after social capital is added for more convenient comparison between models.

Table 7-7: Logistic Regression of Individual-Level Predictors on TOL-Conf with Social Capital Added

	Model 1:		Model 2: Model 1 with Social Capital	
<i>Fixed Effects</i>	<i>Odds Ratio</i>		<i>Odds Ratio</i>	
Intercept	0.4504	***	0.459	***
Female	1.9766	**	1.852	*
Non-Citizen	0.8898		0.743	
Non-Citizen Female	0.4163	**	0.458	*
Desire to do Research#	0.6083	***	0.680	***
Interest in Computing#	0.828	**	0.841	*
No CS Undergrad Major	1.4901	**	1.460	*
Advisor Support#			0.601	***
Social Support#			0.747	***
Faculty Undermine#			1.669	***
<i>Random Effects</i>	<i>Variance</i>	<i>p</i>	<i>Variance</i>	<i>p</i>
Female	.729	.003	.824	.005
d.f.	41		41	
Reliability	.405		.383	
Level 1 N	760		760	

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$

denotes centered at grand mean.

Table 7-8 shows Pearson correlations between the social capital factors and two different categories of reasons for contemplating leaving: “confidence” and “other” reasons.³ The reason for this comparison is to examine whether confidence-related reasons are more likely to be associated with students’ social ties in their departments compared to other reasons. Results suggest that Contemplation Leaving-Confidence is better predicted by social relations within departments than is contemplation of leaving

³ A “contemplation leaving-other” was constructed for comparison purposes. Those who contemplated leaving for reasons other than those included in the TOL-Conf variable were given a value of 1 (such as leaving to take a job, for economic reasons, or personal reasons). Those who did not think of leaving were given a value of 0, and all others were put in the missing category. Since the “other” reasons for contemplating leaving are less explicitly related to departmental conditions, they should be less easily predicted by departmental conditions.

for other reasons (such as personal or economic reasons), as expected. The most noticeable difference is that Contemplation leaving-confidence is especially predicted by the higher Faculty-Undermine scores, and lower Advisor Support scores, suggesting that perceptions of relationships with faculty (Faculty Undermine) are particularly important to the reasons for leaving that citizen women are most likely to select, and that advisor support is particularly important to reducing these types of thoughts of leaving.

Table 7-8: Bivariate Correlations of Social Capital with Two Types of TOL

	Contemplation Leaving- Other	Contemplation Leaving- Confidence
Advisor Support	-.215***	-.388***
Faculty-Instrumental	-.188***	-.202***
Social Support	-.242***	-.322***
Faculty-Undermine	.122***	.325***
N	693	825

*** Correlation is significant at $p \leq .01$

Finally, bivariate correlations between social capital and TOL-Conf are examined by gender to determine whether social capital has differential effects for men and women (Table 7-9). Consistent with the data in the previous table, correlations show that Advisor Support and Faculty Undermine are both stronger predictors of TOL-Conf for women than for men. From all indications, then, it appears that social relationships within departments are especially influential on women's thoughts of leaving, and particularly on citizen women's thoughts of leaving. Feelings of exclusion from faculty and of support from advisors are particularly strong predictors. Nevertheless, these social relationships do not go very far towards explaining the gender gap in thoughts of leaving.

Table 7-9: Bivariate Correlations of Social Capital with TOL-Conf, by Gender

	Women	Men
Advisor Support	-.471***	-.346***
Faculty-Instrumental	-.209***	-.192***
Social Support	-.314***	-.322***
Faculty-Undermine	.388***	.282***
N=825		

Discussion

The findings in this chapter support previous findings that women have higher attrition than men in many traditionally-male fields. Examination of the central retention indicator, women's contemplation of leaving due to confidence reasons, reveals significant gender differences among citizens. Evidence that departmental conditions particularly impact citizen women's thoughts of leaving is revealed in the different patterns selected by citizen men and women for thoughts of leaving. Reasons more common among women, those related to confidence in their abilities and the need to prove themselves within their departments, appear more related to departmental conditions than the reason men most commonly select, to take a job. The reasons selected by citizen women are those discussed in the literature as being influenced by masculine occupational cultures, and more specifically by gender stereotypes. The reasons chosen more often by other groups (personal reasons, economic reasons, to take a job, and program limitations) appear to be less context-dependent and more related to individual needs and preferences.

Control variables do not reduce the gender gap in contemplation of leaving. Gendered outcomes are apparently not caused by factors that the department cannot control, such as holding an outside job or other outside responsibilities. Although some background differences between men and women noted in the literature at the

undergraduate level are also a source of gender difference here (e.g. undergrad major outside of CSE, and CS/CE work experience), the differences are substantively small and do not explain the gender differences in contemplation of leaving. A limitation of this study is the unavailability of performance data to control for background differences that might explain the gender gap in contemplation of leaving, i.e., test scores or grades of students. Ultimately, however, the point of this study is to identify whether departmental conditions mediate between gender and thoughts of leaving, rather than to fully explain the gender gap. As long as women are equally as likely as men to desire to stay in their program (i.e. they are not more likely to want to switch fields, or want to leave to get a job), departmental conditions may have the potential to reduce their thoughts of leaving regardless of their background characteristics. For example, women's greater lack of confidence could plausibly be changed by the environment even if background deficiencies in CSE experience were eventually shown to contribute to their lower confidence levels.

Regarding the effect of citizenship on contemplation leaving, it is not clear why citizens overall have higher thoughts of leaving. A speculation is that non-citizens' responses to contemplation of leaving reflect that they will have to return to their home country if they choose to leave a program, and there may be fewer opportunities available to them in their home country. Another possibility is that the gender stereotypes that have been shown to influence women's occupational persistence may not be present or may differ in the countries of origin of non-citizens. Whatever the cause, the lack of gender difference among non-citizens is telling; it shows that a gender gap in CSE outcomes is

not inevitable, and that cultural or situational conditions can dramatically alter gendered outcomes.

Findings here also support previous findings about gender differences in social capital within traditionally-male fields, but the differences are not as dramatic as expected. There are no gender differences in advising, which may be due to the use of advisors as strategic sponsors, as discussed in the literature. The gender differences in Faculty Instrumental disappear when controls are taken into account. Gender differences in Social Support and Faculty Undermine persist despite controls. The relatively small differences may be due to the structured nature of research activity in the departments into which students are integrated and find support. This contrasts with more informal networking and collaboration in the work setting, where interactional mechanisms resulting in bias may have more influence. Women's higher reports of the negative form of social capital Faculty Undermine support qualitative studies reporting that women must prove their competence in traditionally male fields.

Finally, it is noteworthy that the data here support the arguments that social capital has important occupational effects in that it predicts indicators of retention. Social capital is the most consequential for women, indicating again that their thoughts of leaving are disproportionately influenced by the social context. Faculty Undermine is particularly important in contributing to Contemplation-Leaving-Confidence, which makes it especially noteworthy that women citizens, who are most likely to contemplate leaving for confidence reasons, have more of this negative form of social capital than their male peers. The fact that advisor support also particularly reduces contemplating leaving for women supports the suggestion above that women use advisors as a

strategic sponsor to attain support (Burt 1998). Overall, the relationships between social capital and retention confirm the importance of examining the causes of gendered social capital, and specifically of identifying departmental practices that mediate the gender difference in social capital. It is important to note also that social capital is likely to have occupational effects that are not measured here, such as effects on productivity, recognition, and long-term career success.

There are several limitations to the outcome variables here. The ideal dependent variable for persistence would consist of actual retention figures, which would demonstrate actual trends of gendered departure from the field. However, the present measure of thoughts of leaving is not atypical from measures used elsewhere to examine gender segregation. The literature on how personal choice is related to occupational gender segregation examines outcome variables that range from gendered career aspirations to gendered attrition rates of programs or organizations. Questions about career aspirations or intention to persist do not measure actual decisions, but the gender differences that are detected among such measures are still informative.

Another limitation to the measure TOL-Conf is that a gendered social desirability bias may influence students' answers. For example, men may hesitate more than women to admit that they are not confident in their abilities. If this were the case, more men would select reasons such as "to take a job" instead of confidence reasons, even though they may have the same doubts about their confidence as women. In order to address this limitation, I will also use a retention indicator that includes all the reasons for thoughts of leaving, called TOL-All. This measure distinguishes between those who thought of leaving for any reason, and those who did not think of leaving. If those who selected non-

confidence reasons really did have confidence reasons for thoughts of leaving, then I would expect department characteristics to have stronger or different effects on TOL-All than on TOL-Conf. If TOL-Conf is a fairly accurate measure of those who thought of leaving for confidence reasons, I would expect the department predictors to have less effect on the TOL-All outcome, since it includes those whose reasons are not as related to department conditions.

The social capital measures here also have some limitations. They do not measure objective networks, and so for example do not allow for a comparison between men and women on number of connections. The present measures are highly subjective, measuring how students feel about their relationships towards others in the department. However, more objective types of measures also have some limitations in that they are not as informative about the nature of the connections. In the present setting of graduate programs, students are not as dependent on broad networks or making new connections as might be true in many work settings. Students work in stable research groups and their success depends on work with a limited group of people. Qualitative studies have consistently shown that gendered student outcomes in many science fields are effected by qualitative aspects of interactions with faculty, i.e., whether interactions are inclusive and supportive. Therefore, I argue that measures of the qualitative nature of social relationships are more relevant to the types of relationships that are important for graduate students. As discussed previously, qualitative measures of social capital are recognized in the literature as an important dimension to understanding how individuals gain benefits from connections with others.

CHAPTER 8 – Predicting Gender Gaps in Contemplation of Leaving and in Social Capital with Department Variables

The previous chapter developed individual-level models to explain the outcomes. In this chapter, the focus is shifted to department-level characteristics and effects on outcomes. I start by examining some of the descriptive statistics of department characteristics in order to show what the typical CSE PhD program is like. Subsequently I develop multi-level models for thoughts of leaving and social capital.

A Profile of the Average Department Based on Univariate Statistics

From the descriptive statistics of the independent variables in Appendix B, Table B6-6, it is apparent that the practices involved in Faculty-Student Research, involvement of incoming graduate students in research, and Career Mentoring are generally practiced frequently. This confirms what would be expected, that in an academic program research is a central activity through which faculty and students interact. Support Grad Involvement, which consists of practices not directly related to research, is less common on average but is not rare. Faculty also generally agree that an advisor's role is to help students succeed, including helping with non-academic matters. From these response summaries it can be seen that the mentoring/advising relationships (often carried out by the same faculty member for any given student) are intense in both quantity and quality of interaction. The central role of advisors fits with Fox's discussion of the decentralized nature of academic research (Fox 2001). Perhaps because of this decentralization, the descriptives for Career Info Informal indicate that the dissemination of information is fairly informal.

On average faculty are “neutral” about whether it is the fault of the student if he/she is failing, indicating an ambivalent stance on the issue of students who are experiencing academic difficulty. Faculty are also generally ambivalent about statements about the desirability of competition and whether courses should “weed out” students, but they tend slightly toward disagreeing with these statements (more so than with most other variables). However, they are inclined to assert that successful students put studies ahead of all other commitments. They indicate that it is between moderately and very accurate that their programs are flexible, in that program timetables are flexible, and that personal leave is readily available to graduate students. Overall, these variables portray an environment better described as demanding of students rather than competitive, and one where there is some understanding given to students struggling with academics or other problems.

In terms of indicators of diversity practices and attitudes, faculty appear neutral about recruiting for diversity. The fact that faculty only “somewhat disagree” on average that activities meant to diversify will lower the quality of incoming students shows that faculty have some reservations about increasing diversity. Faculty generally indicate that their departments put slightly less than moderate effort towards increasing the enrollment of women. In general, women’s support groups and other networking opportunities with women are moderately supported. Finally, as discussed previously, faculty tend to somewhat disagree that women are inherently less likely to be attracted to CS/CE, which leaves room for some ambivalence among faculty about whether men and women are “hard-wired” in their orientations towards computing.

In order to determine which department characteristics vary by department, ANCOVAs were run in HLM for each department variable derived from faculty responses. Because many characteristics were correlated with Research Orientation, Research Orientation was controlled (except for the Research Orientation variable itself, for which an ANOVA was run). The individual level variance was compared to the between-department variance for each variable. The resulting Intraclass Correlation Coefficient (ICC) shows how much “groupness” each variable has (shown in Table 8-1). A very low ICC suggests a purely individualistic practice; that is, a higher department mean on that practice indicates there are more individuals in that department who choose to carry out that practice (or hold that attitude). On the other hand, a higher ICC for a variable suggests a practice initiated or somehow facilitated by the department, i.e., a true department practice. According to Table 8-1, diversity practices as a group appear to be the most department-based practices. On the other hand, gender beliefs appear to purely vary by individual, with no effect from departments. These numbers follow expectations, since gender beliefs result from individuals’ cognitive processes, while diversity practices require department-wide organization. The numbers in the table are also noteworthy in the low ICC’s for most of the faculty-student interaction variables. This is likely due to the decentralized nature of academic organization, such that departments do not manage faculty-student interactions.

Table 8-1: Department Variables: Variance and ICC for variables derived from faculty survey

	Variance		ICC
	Level 1	Level 2	
Independent Variables			
Dept Practices for Women/Diversity:			
Dept Effort Women	0.569	0.067***	11%
% Diversity Training	0.153	0.022***	12%
Support Women	0.843	0.138***	14%
Dept Practices for Student Support:			
Support Grad Involvement	0.960	0.045***	4%
Career Mentoring	0.963	0.041***	4%
Encourage Student Collaboration	0.956	0.043	4%
Faculty Availability	0.830	0.149***	15%
Information Flow	0.925	0.075***	7%
Career Info Informal	0.780	0.001	0%
Competitive vs. Helping (trust):			
Advisor Help	0.944	0.035***	4%
Students' Own Fault	0.925	0.006	1%
Competition Desirable	0.850	0.133***	13%
Beliefs related to women's participation in CSE:			
Recruit Underrepresented Groups	0.749	0.032***	4%
Diversity Lowers Quality	1.112	0.048**	4%
Stereotype	1.349	0.002	0%
Controls			
Research Orientation:			
Faculty-Student Research	0.914	0.098***	10%
Incoming Grads Research	0.543	0.070***	12%
Rank			
Carnegie			
Total # PhD Students			
Public/Private			
Proportion CE faculty			
Work-Life Balance:			
Studies First	0.910	0.013	1%
Flexibility	0.913	0.083***	8%
Proportion Female Faculty			
Proportion Female Students			

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$ (significance of variance between departments).

Note: ICC values can only be computed for variables that have variance at level 1; but the complete list of department characteristics is provided for reference.

Contemplation of Leaving

Introduction to the HLM Model Predicting TOL-Conf.

In Chapter Seven, individual-level predictors of students' thoughts of leaving for confidence related reasons (TOL-conf) were identified and entered into a logistic regression with gender. Even after controlling for desire to do research, interest in and enjoyment of computing, and having a non-computing undergraduate major, a significant gender gap remains among citizens. In this chapter, the same variables are modeled with HLM software in order to incorporate the department-level variables into a multi-level model. A two-level randomly varying slope-as-outcome model is developed in a series of steps. The outcome of interest is the Gender slope: how much do departments vary in the effect of gender on TOL-conf, and which departmental practices are associated with how steep or flat the gender slope is in a department? A steeper slope indicates greater gender difference in the outcome variables.

In a multi-level model, there are two kinds of effects to predict: fixed effects and random effects. Fixed effects are modeled as the average coefficient for all groups (departments). A random effect reflects the degree to which a coefficient varies between groups (as with an ANOVA). In the present case, the coefficient for the gender slope is a fixed effect and the random effect is the amount of variation between departments for that gender slope. Depending on the purpose of the study, either or both effects are considered when interpreting the model. Fixed effects relate to the strength and direction of prediction of level-two independent variables, similar to the way predictors are interpreted in an OLS Regression model. The impact of level-two (departmental) variables can also be assessed in terms of how much variation between departments they

explain for a given coefficient. For the present purposes, the goal is to identify significant department predictors of the gender slope rather than to explain all the variation between departments. The fixed effects are of primary interest, but the variance explained will also be noted.

Table 8-2 shows variables of interest in 5 steps of the model. The variables for gender and citizenship, and the gender-citizenship interaction have been coded such that the reference group is citizen men. Thus the intercept is the odds that citizen men will have TOL-conf, when all other variables in the model equal zero. That is, the intercept represents the odds for citizen men when Female, Non-citizen, and FemaleXNon-Citizen equal 0, when “desire to do research” and “interest in computing” are at their grand means (set to 0), and when those who do not have an undergraduate degree in Computer Science are excluded. The odds ratio for Female represents the grand mean effect of being a citizen woman on TOL-conf, when other variables are similarly set to 0. The odds ratio for Non-Citizen intercept represents the grand mean effect of being a non-citizen holding all else constant, and the odds ratio for Non-CitizenxFemale is the grand mean interaction effect of being a female non-citizen, over and above the effects of Female and Non-Citizen.

The Female effect is of primary interest here since this represents how women citizens differ from the reference group, citizen males, and it is between these two groups where most of the gender gap in TOL-conf is located. I am interested in predicting the Female effect with Department Characteristics. Thus the odds ratios of primary interest are listed under “Department Interactions with Female.” These show the effects of department characteristics on the mean effect of Female. Once department variables are

added here to predict Female, the effect of Female (towards the top of the table under Student Characteristics) will change and depend on the coding of the department variables for interpretation. That is, the Female odds ratio will be the Female effect when department variables in the model equal 0. However the odds ratio for Female is less informative for this part of the study than the department interactions with Female. Department variables are also added to predict the intercept, i.e., the level of thoughts of leaving among citizen men (under Department Characteristics in the Table). It is important to control for the effect of department characteristics on men citizens, and to compare department effects between men and women.

Department Effects on Gender Differences in TOL-Conf among Citizens

Model 1 in Table 8-2 includes no additional variables besides the level-1 predictors of TOL-conf. Model 1 shows that when individual-level controls are set to zero, the odds that a citizen man will think of leaving is .450. If a student is female, the odds of that student having TOL-conf increase by 97.7 percent (odds ratio = 1.977). There is no significant effect of citizenship among men. The Female Non-Citizen term is significant, because non-citizen women's thoughts of leaving are much lower than citizen women's, as discussed previously (for the interaction term, the coefficient must be computed by including the combined effects of the Female, Non-Citizenship, and Female-Non-Citizenship effects). As would be expected, these effects are the same as those found in the individual-level analysis in the previous chapter. With the succeeding models, I will focus on interpretation of the department interactions with Female, and will not dwell on the student characteristics effects. The student effects will largely

remain constant since they are not being predicted by department variables, except for Female.

At the bottom of the table, the random effect for Female - the amount of between-department variance, or tau - is reported. For Model 1, there is a significant level of variance between departments on how much being female increases the odds that a student will think of leaving for confidence reasons ($p < .01$). The tau for Female (.729) is substantially larger than the taus for the effects of the other demographic groups, which for citizen men is .136, ($p = < .05$), for non-citizen men is .090 ($p > .10$), and for non-citizen women interaction effect is .137 ($p > .10$) (not shown in table). These taus indicate that department-level variables are likely to play a role in citizen women's thoughts of leaving, and are much less likely to be important in predicting other groups' thoughts of leaving.

Table 8-2: Multi-level Logistic Regression Models Predicting Thoughts of Leaving for Confidence Reasons with Department Characteristics

Fixed Effects	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	Odds Ratio	p	Odds Ratio	p	Odds Ratio	p	Odds Ratio	p	Odds Ratio	p	Odds Ratio	p
Intercept	.450	***	.419	***	.423	***	.389	***	.388	***	.391	***
Student Characteristics												
Female	1.977	**	1.781	**	1.738	*	1.940	**	1.862	**	1.846	**
Non-Citizen	.890		.902		.905		.955		.954		.954	
Non-Citizen Female	.416	**	.420	**	.399	**	.368	***	.376	**	.359	***
Desire to do Research#	.608	***	.584	***	.581	***	.582	***	.574	***	.572	***
Interest in Computing#	.828	**	.828	**	.838	*	.829	**	.834	**	.834	*
No CS Undergrad Major	1.490	**	1.506	**	1.496	**	1.528	**	1.516	**	1.503	**
Department Characteristics												
Research Orient. (fac-stud) #			1.193		1.189		1.147		1.127		1.113	
Support Grad Involvement #					1.080		1.073		1.090		1.092	
Recruit for Diversity #						*	1.240	*	1.265	**	1.267	**
Diversity Training #									.931		.927	
Career Informal#											.949	
Department Interactions with Female												
Research Orient. (fac-stud) #			1.817	**	1.927	**	2.146	***	2.615	***	3.150	***
Support Grad Involvement #				**	.565	**	.579	**	.477	***	.485	***
Recruit for Diversity #				*	.636	*		*	.526	**	.507	**
Diversity Training #									1.703	**	1.834	***
Career Informal#											1.648	***
Random Effects												
Female	.729	.003	.338	.076	.315	.190	.302	.202	.262	.309	.210	.406
d.f.	41		40		39		38		37		36	
Reliability	.405		.245		.227		.220		.195		.163	

* p≤.10; ** p≤.05; *** p≤.01 Note: Level 1 N=760; Level 2 N=48. # denotes centered at grand mean.

To determine the effect of department-level predictors, variables were first added to the model one at a time. As in Section One, the sample size for departments is small at 48, limiting the number of variables that can be added and adequately estimated at one time. To begin with, the four variables relating to research orientation of the department were added as control variables: department rank, Carnegie institution rating, incoming graduate students' participation in research, and faculty-student research activity. All four variables have a positive effect on the gender slope, but only the Faculty-Student Research factor had a significance level at the $p < .05$ level. Table 8-2, Model 2 shows that one standard deviation increase above the mean in research orientation (as measured by Faculty-Student Research) increases the odds ratio for Female by 1.817, or by about 80%. The same increase in research orientation does not have a significant effect on the odds ratio for citizen men. In departments with higher research orientation, women have significantly higher thoughts of leaving for confidence reasons, but not so for men. The random effects have been reduced to .338 ($p = .076$), indicating that Research Orientation explains 46% of the variance among departments in the gender slope, a sizable proportion. This strong gendered effect of research orientation was not predicted by the hypotheses and will be explored further at the end of this chapter, where the differing environments of high research departments and relatively low research departments will be contrasted.

While keeping Research Orientation in the model, other variables were added one at a time. First, additional control variables were added: total number of students in PhD program, public/private status, proportion of CE faculty, and variables relating to department conduciveness to work-life balance. However, none of these variables had

significant effects on Female. Surprisingly, variables relating to proportion of women (both students and faculty) in a department also showed no significant results.

Next, department variables representing the central variables of interest were added individually to the model with Research Orientation. Department faculty variables are all standardized, so in this discussion, “more” of these practices refers to a one unit increase, or one standard deviation above the mean. First, variables relating to diversity practices were added. Department effort to enroll women, practices to support women students, and diversity training were not found to be significant predictors. Next, variables relating to faculty social support were added. Grad Involvement shows significant negative effects (see Table 8-2, Model 3). When a department’s faculty is more likely to undertake supportive actions beyond faculty-student research activity, actions such as encouraging a graduate student to teach a course or informing faculty of a student’s success, the Female effect on TOL-conf is significantly decreased. Holding research orientation constant at the mean, the odds ratio for Female decreases by 43.5%. The variance between departments is only slightly reduced. Other types of social support have no significant effect on Female.

Next, variables representing whether trust is fostered in a department were entered one at a time into the model with Research Orientation and Grad Involvement. No significant effects on Female were found. Finally, diversity beliefs and the stereotype variable were entered one at a time into the model with Research Orientation and Grad Involvement. Two of these variables had notable effects: Recruit Diversity and Diversity Lowers Quality. Table 8-2, Model 4 shows that in departments where faculty agree more that their department should recruit underrepresented groups, the effect of Female is

reduced. When Research Orientation and Grad Involvement are set to their means, the odds ratio for Female is reduced by 36% ($p < .10$). The variable Diversity Lowers Quality shows an effect in the opposite direction, as would be expected. Among departments where faculty agree more that “activities meant to diversify the graduate student body will lower the academic quality of incoming students,” the odds ratio for the Female is increased by 44 %, with a p value just out of the significance range at $p = .107$ (not shown in table). When the two diversity variables are placed in the model together, both lose significance because of their negative correlation with each other. Although Diversity Lowers Quality explains more of the remaining variance (24% versus 4% with Recruit Diversity), Recruit Diversity is kept in the model because of its higher significance level. With Recruit for Diversity added to the model, the effects of Research Orientation and Grad Involvement remain similar. Shifting focus for a moment to department effects on citizen men’s thoughts of leaving, Models 3 and 4 show that Research Orientation and Grad Involvement have no significant effect on citizen men’s odds of TOL-conf. However, Recruit for Diversity increases their odds of TOL-conf by 24% ($p < .10$).

With Research Orientation, Grad Involvement, and Recruit for Diversity in the model, other variables were again examined for effects. One variable, Diversity Training has a significant positive (i.e., detrimental) effect on Female, holding the other three department predictors constant. When more faculty in a department have had diversity training, the odds ratio for Female increases by 70% (Table 8-2, model 5). The Female tau is reduced to .262, an insignificant level of between-department variance, but still notably higher than the tau for the other demographic groups seen in the unconditional model. Diversity Training does not have an effect on the odds for citizen men.

The detrimental effect of Diversity Training on Female is in the opposite from expected direction, and its effects are only significant in the presence of the other three significant department predictors. Diversity Training was examined for collinearity with the other predictors; it is weakly to moderately positively correlated with Grad Involve ($r=.333$, $p=.021$) and Recruit Diversity ($r=.271$, $p=.063$). The correlations are not high enough to be considered collinear, but they explain why Diversity Training is not significantly predictive without these variables in the model. With Diversity Training in the model there are 43 degrees of freedom at the department level, and four department-level predictors, which still allows for ten cases per department predictor.

Interestingly, other variables representing department diversity practices similarly have positive effects on Female, although they are not significant. When departments exert more effort to enroll women graduate students (controlling for Research Orientation, Grad Involvement, and Recruit Diversity), the odds ratio for Female increases by 56% ($p=.103$); when there is more support for women, such as women's groups, the odds ratio for Female is also increased, by 32% ($p=.303$). These diversity practices, Department Effort and Support Women, are also generally positively correlated with Grad Involvement and Recruit Diversity, and require their presence in the model to have a notable positive effect. Thus, once the beneficial effects of Recruit for Diversity and Grad Involvement are parceled out from the effects of diversity practices, the diversity practices tend to increase the gender gap in TOL-conf.

This consistent unfavorable effect of Diversity Practices is interesting since these practices are not all correlated with each other (Diversity Training is not significantly correlated with the other two diversity practices, but Support Women and Department

Effort are significantly correlated: $r=.552, p<.01$). The diversity practices are correlated with other department practices, which might explain the trend of positive effects on Female. However, when all the department social support variables, trust variables, diversity/stereotype attitudes, and diversity practices are entered into the model together, the effects of the three diversity practices are still positive, but not significant for Department Effort and Women Support. In this larger model, the effect of Diversity Training, along with the effects of Research Orientation, Grad Involvement, and Recruit Diversity, remain similar and often stronger, with significance at least at the $p=.05$ level.

It is difficult to determine with the present sample size whether particular conditions determine whether Diversity Training has positive or negative effects. It is possible that Diversity Training interacts with Grad Involve or Recruit Diversity, but no significant interactions were found with this data. One conclusion that can be made about diversity practices with this data, however, is that the expected beneficial effects are clearly not evident.

Once Diversity Training was added to the model, other variables were again added to detect additional predictors. One additional variable, Career Informal has a significant positive (detrimental) effect (Table 8-2, Model 6). When faculty agree more that career development information is disseminated to graduate students primarily through informal channels, the odds ratio for Female increases by 65% ($p<.05$). This effect is only revealed when the other four variables are in the model (Research Orientation, Grad Involvement, Recruit Diversity, and Diversity Training). Career Informal is not significantly correlated with any of the other predictors in the model; however, weak correlations with other variables apparently hide the effects of Career

Informal when they are not accounted for. Career Informal has stronger effect, still significant at $p < .05$, when all the department social support variables, trust variables, diversity/stereotype attitudes, and diversity practices are entered into the model together (not shown). Career Informal has no effect on men's odds of TOL-Conf.

A final presentation of the data describing department effects on the gendered distribution of TOL-Conf is given in Table 8-3. Actual proportions of citizen women and citizen men with TOL-Conf are presented by different department conditions. To create indicators of different department conditions, the significant predictors from the final model were divided into two equal groups to create low versus high groupings of department types on each variable. The numbers show that more citizen women in high research departments have thoughts of leaving for confidence reasons than in low research departments, and that the increase between department types is greater for women than for men. Citizen women in high Grad Involvement departments and in high Recruit Diversity departments have fewer TOL-conf, while citizen men in these departments have more TOL-Conf. In departments high in Diversity Training, both men and women have fewer TOL-Conf; for women, this trend is most likely explained by the fact that departments high in Diversity Training are also high in Grad Involvement and Recruit Diversity. When no other variables are accounted for, fewer women in Career Informal departments have TOL-Conf.

Table 8-3: Proportions of Those with TOL-Conf Under Various Department Conditions, by Gender among Citizens

		Men	Women
Research Orientation	Low	30.8	45.5
	High	41.0	63.8
Grad Involvement	Low	32.9	59.7
	High	43.6	54.4
Recruit Diversity	Low	31.7	63.5
	High	40.1	52.8
Diversity Training	Low	39.5	60.4
	High	35.7	54.9
Career Informal	Low	37.6	62.5
	High	37.5	50.0

N=393

Testing for a Mediating effect of Individual Social Capital

Above I identified department practices and attitudes that significantly interact with the Female effect on TOL-conf. It is possible that these department variables work through increasing or decreasing women's supportive connections with faculty, advisors or students in the department. For example, Grad Involvement could work by increasing women's connections with and perceptions of support from faculty; these supportive connections would then directly reduce thoughts of leaving. If this were the case, then adding individual-level variables representing students reports of such connections should explain and reduce the effect of Grad Involvement in the model. To test this possibility, the individual-level social capital variables were added at level one to the model with the department predictors.

As discussed in chapter 7, these variables do not explain much of the gender gap in TOL-conf, although they do predict TOL-conf overall. Thus, it is not surprising that the effects of department predictors do not change notably when these variables are added to the model (Table 8-4, Model 1). Instead of being reduced, each department

predictor becomes somewhat stronger and is significant at $p < .01$, except for Career Informal where $p < .10$. According to these results, departmental practices involved in Grad Involvement, Diversity Training, and Career Informal, and the attitude Recruit Diversity, do not work through individual-level social capital to influence the Female effect on TOL-conf. The fact that department effects are stronger when controlling for individual-level social capital is explained by the fact that the gendered distribution of social capital among departments is now accounted for in the model, and this distribution appears to have been co-varying with, and “hiding” a small portion of the variance among departments in the gender slope. With the increase in between-department variance available for explanation, the department predictors could demonstrate greater predictive power.

Table 8-4: Multilevel Logistic Regression Models Predicting Thoughts of Leaving for Confidence Reasons (Model 1) and Thoughts of Leaving for Any Reason (Model 2)

	Model 1: Add Level One Social Support		Model 2: TOL-All as Outcome	
<i>Fixed Effects</i>	<i>Odds</i>		<i>Odds</i>	
	<i>Ratio</i>		<i>Ratio</i>	
Intercept	.366	***	.829	
Student Characteristics				
Female	1.719	**	1.384	
Non-Citizen	.799		.763	
Non-Citizen Female	.359	***	.760	
Desire to do Research#	.633	***	.712	***
Interest in Computing#	.853		.912	
No CS Undergrad Major	1.473	**	1.075	
Advisor Support#	.599	***	.661	***
Social Support#	.706	***	.655	***
Faculty Undermine#	1.898	***	1.492	***
Department Characteristics				
Research Orientation (fac-stud) #	1.039		.937	
Support Grad Involvement #	1.088		1.055	
Recruit for Diversity #	1.693	***	1.395	***
Diversity Training #	.884		.929	
Career Informal#	.903		.898	
Career Mentoring#			1.083	
Department Interactions with Female				
Research Orientation (fac-stud) #	4.079	***	2.858	***
Support Grad Involvement #	.342	***	.536	***
Recruit for Diversity #	.429	***	.559	**
Diversity Training #	2.191	***	1.587	**
Career Informal#	1.709	*	1.444	
Career Mentoring#			.689	*
Random Effects	<i>Variance</i>	<i>p</i>	<i>Variance</i>	<i>p</i>
Female	.028	>.500	.081	.342
d.f.	36		36	
Reliability	.021		.082	
Level 1 N	760		913	

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$. Level 2 N=48. # denotes centered at grand mean.

Predicting TOL-All with the Model

As discussed in a previous chapter, there are two possible outcome variables for measuring gender differences in thoughts of leaving. Above I have used a variable that distinguishes between students who have thought of leaving for confidence reasons and those who have not thought of leaving. The other outcome variable distinguishes between

those who have thought of leaving for *any* reason and those who have not thought of leaving. This second variable includes more students, and proportionately more men than women, since men were relatively more likely to think of leaving for other reasons besides confidence reasons (e.g., to get a job, personal reasons, etc.). To test whether the department variables identified above are significantly predictive of the gender effect on this broader measure of thoughts of leaving, the final model, Model 6, was run with the TOL-All variable as the outcome variable. Because TOL-All includes those whose reasons for leaving appear to be largely external to departmental conditions, it was expected that TOL-All is more difficult to predict with department-level variables.

Table 8-4, Model 2 reports the odds ratios for the final model predicting TOL-All. The number of cases at level one increases to 913. The unconditional model predicting TOL-All confirms that there is less departmental variance for this outcome. With all the individual-level predictors in the model, but no department-level predictors, tau for the gender slope is .486, a 33% reduction compared to the TOL-Conf unconditional model (not shown in table). Once department predictors are added, the odds ratios reveal consistent but reduced effects. The fact that the predictors' effects are reduced is likely due to the ineffectiveness of these variables in predicting thoughts of leaving for citizen women who do not have confidence reasons for such thoughts. With these individuals included in the model, the predictors are less effective at predicting who will think of leaving versus who will not.

In the TOL-All as outcome model, Career Informal is no longer significant; however, another variable has a significant effect. When faculty engage more in career mentoring, the odds ratio for Female decreases by 31% ($p=.054$). Because Career

Mentoring is only significant in the TOL-All model, it appears that Career Mentoring is the only variable that is particularly effective at predicting thoughts of leaving for citizen women who had *other than* confident reasons. Table 8-4, Model 2 results are similar when all the department social support variables, trust variables, diversity/stereotype attitudes, and diversity practices are entered into the model together (not shown), and no additional variables become significant.

Social Capital

Above I have determined department predictors of gendered thoughts of leaving. In this section I examine a different type of gendered outcome, social capital. In Chapter Seven, individual-level predictors of different types of student social capital were identified and entered into a logistic regression with gender. Even after controlling for individual characteristics such as desire to do research, a significant gender gap remains among citizens in Social Support and Faculty Undermine. Here, the same variables are modeled with HLM software to incorporate the department-level variables into additional multi-level models. Just as with the above models, a two-level randomly varying slope-as-outcome model is developed.

Once again, the significant gender gap on these social capital measures is among citizens, and the two groups that are contrasted are citizen men and citizen women. The Female Non-Citizen interaction term is again included in the model, so that the Female effect represents the effect of being a woman citizen on social capital. As with the models above predicting TOL, unconditional models in HLM show substantially more between-department variance for Female (citizen women) than for the variables representing the

other 3 groups. For example, the variance for Female is still notably higher than the variance for Female Non-Citizen, which has the second highest between-department variance on the social capital measures, in a comparison of all four demographic groups. The ICC (Intraclass Correlation Coefficient) for each groups is useful for comparison. The ICC is the proportion of between-group variance relative to the total variance (within-group plus between-group variance); an ICC of at least 10% is considered noteworthy. The ICC for Female compared to Female Non-Citizen is 17% and 8% respectively in the unconditional model for Social Support, and 10% and 5% respectively in the unconditional model for Faculty Undermine. This pattern further supports the evidence that department-level phenomena have the most effect on citizen women.

The figures of primary interest are again listed under “Department Interactions with Female,” in Table 8-5. These show the effects of department characteristics on the mean effect of Female. However, since the outcomes are continuous, linear regression is used to model the effects, and coefficients are given instead of odds ratios. Since having more Social Capital is considered a beneficial outcome, in contrast to TOL, department practices that have positive effects on Female are considered beneficial when Social Capital is the outcome variable. Alternatively, having more Faculty Undermine is an unfavorable outcome, so department practices which have positive effects on Female are considered unfavorable effects for women when Faculty Undermine is the outcome variable. Both social capital measures are standardized and thus a one unit increase represents one standard deviation above the mean.

Department Predictors of Social Support Social Capital

To develop the model for Social Support, department variables were added one at a time as above. No control variables have significant effects, but one department practice relating to student support has a consistent significant effect on Female: Information Flow. When faculty agree more that they disseminate information effectively to graduate students, women are disproportionately more likely to say they feel included in a network that includes faculty and to feel more included in other social aspects as well. When Information Flow increases by one standard deviation, the coefficient for female is increased by .167 of a standard deviation in Social Support. Information Flow compensates for more than half of the negative effect of being a citizen women on Social Support. The significance of Information Flow persists when all other department practices, trust indicators, and attitudes are added to the model, and no other department variables have a consistent significant effect on Female. The ICC for Female is decreased to 13% from 17% with the unconditional model, so there is still a notable amount of between-department variance to be explained. Information Flow does not significantly effect citizen men's Social Support.

Some department variables were found to predict both citizen men's and citizen women's Social Support, without displaying gendered effects. Regarding control variables, faculty agreement that their department allows for flexibility in graduate students' progress through the program has a positive effect on Social Capital. Regarding the main predictors of interest, Faculty encouragement of student collaboration has the expected positive effect on Social Support, while faculty encouragement of competition among students has the expected negative effect (under Department Characteristics

section of Table 8-5). Because there is no significant effect of these variables on Female (i.e., they do not have gendered effects on Social Support), they are not included as predictors of Female. The fact that these effects are not gendered is worthy of note since it was hypothesized that these department characteristics would have gendered effects. The magnitude of these variable's non-gendered effects is notably smaller than the gendered effect of Information Flow.

Table 8-5: Multi-Level Regression Predicting Social Support and Faculty Undermine

	Social Support			Faculty Undermine		
	<i>Coeff.</i>	<i>Std. Error</i>	<i>p</i>	<i>Coeff.</i>	<i>Std. Error</i>	<i>p</i>
<i>Fixed Effects</i>						
Intercept	-.008	.072		.033	.084	
Student Characteristics						
Female	-.250	.125	**	.227	.112	**
Non-Citizen	-.096	.084		.225	.086	***
Non-Citizen Female	.308	.150	**	-.331	.154	**
Desire to do Research#	.136	.037	***	-.104	.039	***
Interest in Computing#	.094	.037	**			
Fellowship	.289	.094	***			
Job	-.302	.106	***			
Undergrad CS Research Experience	.150	.069	**	-.156	.071	**
Other CS Experience	.287	.134	**	-.363	.142	**
Desire to Apply CS to Other Area#				.107	.026	***
CS Work Experience				-.149	.071	**
Department Characteristics						
Information Flow#	.003	.041				
Student Collaboration#	.111	.041	***	-.024	.048	
Competition#	-.084	.039	**			
Flexibility#	.106	.040	***			
Student's Own Fault #				-.003	.048	
Diversity Lowers Quality #				.086	.042	**
Department Interactions with Female						
Information Flow#	.167	.097	*			
Student Collaboration				.161	.089	*
Student's Own Fault #				-.156	.090	*
Diversity Lowers Quality #				.153	.085	*
<i>Random Effects</i>						
Female		<i>Variance</i>	<i>p</i>	<i>df</i>	<i>Variance</i>	<i>p</i>
Level 1		.139	.001	40	.014	.190
ICC		.911			1.004	
Reliability		.132			.01	
Level 1 N		.453			.073	
		855			838	

*p≤.10; ** p≤.05; *** p≤.01. Level 2 N=48. # denotes centered at grand mean.

Department Predictors of Faculty Undermine (negative) Social Capital

Variables were tested for effects on the Female coefficient for Faculty Undermine (Table 8-5). No control variable effects were detected, but three main department variables have effects at the $p < .10$ level. When all three variables are in the model together, Student Collaboration and Student's Own Fault have effects in the opposite direction than expected; Diversity Lowers Quality has a positive (detrimental) effect, as expected. When faculty agree more that they promote study groups, citizen women are disproportionately more likely to say that faculty undermine their confidence. When faculty agree more that it is a students' own fault when the student is failing, the citizen women are disproportionately less likely to say that faculty undermine their confidence. Finally, in departments where faculty agree more that diversifying will lower the quality of incoming students, citizen women are disproportionately more likely to say that faculty undermine their confidence. When all the department social support variables, trust variables, diversity/stereotype attitudes, and diversity practices are entered into the model together, the direction of the effects remain the same, but the effects lose significance. Diversity Lowers Quality still approaches significance however, with $p = .116$, and is significant at $p < .05$ in the large model when robust standard errors are used.

Interestingly, Diversity Lowers Quality also significantly increases Faculty Undermine for citizen men, but to a lesser extent. Since the total effect of Diversity Lowers Quality on citizen women is the Female interaction effect of the variable plus the effect of the variable on the reference group, the total effect of a one standard deviation's increase in Diversity Lowers Quality for citizen women is .239, which is more than the

gender gap in Faculty Undermine. (However if Diversity Lowers Quality were increased in a particular department by one standard deviation, the gender gap would not be fully accounted for because men's Faculty Undermine would also be increased).

Differences By Research Orientation

Because of the important effect of research orientation on TOL, the characteristics of different levels of research orientation were explored. Departments were divided into high and low research departments, and compared on the means of variables.

Significance levels of department differences by research orientation is presented in Appendix B, Table B8-1. These figures show that many practices and attitudes of students and faculty differ by program research orientation.

In high research-orientation programs, students indicate more of a commitment to research in their reports of past experiences and their reasons for going to grad school. For example, students in high-research programs are more likely to report they decided to go to graduate school in order to pursue research, and less likely to report dependable employment as a reason, compared to students in low-research departments. They also are more likely to have full-time status and less likely to have outside family, financial, and work constraints. Students in high-research programs are more likely to have funding from the department and to be satisfied with funding. For example, they are more likely to be research assistants. Students in high-research programs also report more opportunities to do research with faculty and more collaboration with faculty. Their involvement extends to other department activities, such as having a voice in departmental governance, helping to recruit new students, opportunities to attend

conferences, and women's groups. These findings illustrate that the increased research activity found in high-research programs contributes to an environment conducive to networking with faculty, as well as increased departmental involvement in other ways. In high-research programs, faculty and students appear more committed to and invested in a departmental community of research and professional activity.

Low-research programs provide a contrast in that students report less involvement in research with faculty, and less availability of associated research and professional opportunities. In addition to fewer research opportunities, students report less access to faculty; they are more likely than peers in top-rank programs to report that courses are meant to weed out students, and that faculty use graduate students as a source of cheap labor to advance their own research. Faculty in low-research programs indicate more support for competition among students and more agreement that it is a student's own fault for failing. Thus there appears to be less trust and community between students and faculty in low-research programs. Since students here report more exclusion from study groups and less Social Support social capital, the relative deficiency in community appears also extends to student-student interaction.

This descriptive data on differences between low and high research programs provides context for the findings about the relationship between research orientation and gendered TOL. In programs where there is less structure for networking and faculty collaboration with students, there is less of a gender gap in TOL. In contexts where there is more of a networking and collaboration structure in place through research collaboration, there is more of a gender gap in TOL. This shows that networking and

collaboration are not one of the most important predictors in this setting of gendered TOL.

It is also important to note that while students in low research programs have less Social Support social capital, they nevertheless feel more comfortable asking questions in class, and are more confident in their ability to complete their program. In contrast, students in high research programs feel more overwhelmed by the fast pace or heavy workload of their courses. This pattern suggests that while students in high research programs may have better connections with faculty and other students, they experience other kinds of challenges to their success, namely more academic pressure and less confidence in their ability to succeed. Thus, in contexts where women are sufficiently socially connected with faculty and students, but academic pressures are higher, women's quality of interactions with faculty becomes especially challenged.

Discussion

The fact that research orientation is a strong predictor of gendered thoughts of leaving requires an explanation of what it is about high-research departments that contributes to this gender gap. In previous studies on gender segregation in education, research orientation is examined in terms of the relative proportions of women and men in differently ranked locations, and there is little evidence regarding the role of research orientation in women's retention in academic programs. However, the comparison above between high and low research departments offers some insight. On the one hand, high research departments appear to have environments that should be relatively conducive to women's retention: they are more likely to offer practices to support women, and they are

more likely to involve students in a collaborative structure through research. On the other hand, all students in high research programs are significantly higher in the Faculty Undermine form of negative social capital. This is likely related to increased faculty expectations of students in top rank programs, expressed by student agreement with feeling overwhelmed by the fast pace or heavy workload of their courses. In an environment of higher academic pressures, faculty appear to play an especially important role in students' experiences. This observation is especially true for women. Faculty Undermine is an especially important contributor to women's thoughts of leaving, relative to other forms of social capital, and women are more likely to say that faculty undermine their confidence and favor certain students.

Given the findings that the gender gap in thoughts of leaving is due in the first place to women's lowered self-assessments in ability to succeed and increased perception of performance pressure, it can be concluded that high research orientation increases the gender gap through its environment of increased expectations and pressure on students to perform, which disproportionately challenges women. It appears that women are especially challenged by this environment because they are more influenced by perceptions that faculty do not favor them or think they can succeed. Thus the present evidence on the role of research orientation supports previous qualitative studies about the importance of social context to gendered rates of persistence in science. These studies show that in scientific contexts, particularly in technical fields like CSE, women experience greater performance pressure and disproportionately more deterrence due to perceptions that faculty lack confidence in them. Here it is shown that the higher the performance expectations, the more this gendered trend is in effect. The gendered effects

of such increased pressures could be an important part to understanding women's particularly small representation in top tier programs later in the academic career path (Long and Fox 1995).

Considering women's higher feelings of alienation from faculty, it is revealing that two of the most significant determinants of women's disproportionate thoughts of leaving for confidence reasons have to do with faculty attitudes regarding diversity. Considering that faculty diversity attitudes and gendered thoughts of leaving are measured independently of each other within departments, the causal role that can be attributed to these faculty attitudes is more conclusive than is evidence based only on student reports. Identification of such contextual attitudinal determinants of differential participation is unusual even in organizational studies, and is unusual in its generalizability.

The data consistently show that positive beliefs about increasing department diversity have a substantive and significant effect on women's thoughts of leaving. The beneficial effects of valuing diversity, indicated by agreement that the department should actively recruit underrepresented groups, corroborates Ely and Thomas' (2007) qualitative study showing a climate of valuing diversity enhances participation of minority members. Faculty agreement that diversifying lowers the academic quality of incoming students shows an unfavorable trend on women's persistence (as shown by a positive effect on TOL-Conf), and is the most consistent significant predictor of the gender effect on perceptions of faculty undermining confidence. It is telling that these effects are reliable in this study, and that they support Cohoon et al.'s (2004) finding that

mentoring motivated by a desire to increase diversity increases undergraduate women's retention in CSE.

It is not surprising that faculty diversity attitudes are one of the most important contextual factors, given the role that faculty play in students' experiences. The descriptive data show that faculty members' relationships with students are intense; in addition to interacting with students as junior research partners, faculty encourage students to persist in the field, and believe that their role as advisors is to help students succeed. With these types of relationships between faculty and students, the importance of interactional mechanisms to gendered participation is apparent. The fact that stereotyping does not have effects is unexpected, and may be due to the limitations of the measure used. Although diversity attitudes have not been the focus of most studies on interactional mechanisms such as stereotyping, diversity attitudes could work similarly by influencing perceptions of minority groups. In the case of a positive valuing of diversity, perceptions of minority groups during social interaction might be beneficially influenced from increased focus on individuating characteristics that suggest enhancement of group creativity.

Although the ICC for the diversity attitude variables are low (Table 8-1), they show some "groupness," in contrast to the Stereotype variable. This suggests that departments may have a role in perpetuating or hindering an ethic of support for diversity. Previous evidence suggests that the official justification and approaches that are utilized when diversity issues are addressed are likely to influence individual views on whether diversification is desirable. This evidence on the role of contextual framing for the acceptance of diversity initiatives, together with present findings that diversity

attitudes matter for improving gendered outcomes, suggest an important avenue through which departments can be effective. Departments can play a role in encouraging a value of diversity that results in positive interactions for women students. This study contributes to the literature by identifying attitudes towards diversity practices as factors requiring further examination in studies of women's participation in traditionally-male fields.

The trend of diversity practices such as diversity training towards increasing gendered thoughts of leaving is somewhat surprising. Table 8-1 suggests that these variables come closest as a group to being department-facilitated practices as opposed to individually-motivated practices. Previous literature suggests that a department's facilitation of women's groups, women speakers, and information about women's successes, would reduce women's social isolation and increase professional identification with CSE, thereby reducing thoughts of leaving. However, those who make this suggestion also stipulate that same-gender networking not be marginal to the central tasks at hand (Blum and Frieze 2005; Kanter 1977). It is certainly possible that the Support Women practices are marginal to the daily research activities in the departments. That Diversity Training does not appear to improve gendered retention is less surprising as others have shown similar findings (Kalev, Dobbin, and Kelly 2006). What the present analysis contributes in this regard is the distinction of diversity practices effects from diversity attitude effects. Only when the positive effects of valuing of diversity have been parceled out from Diversity Training and Support Women do these practices show negative trends on gendered persistence. These trends could be explained by a backlash effect; Burack and Franks (2004) provide qualitative evidence from engineering

departments demonstrating that resistance to diversity initiatives is a viable explanation.

At minimum the present data show that diversity initiatives are not effective and may even be damaging unless a value of diversity is present. This conclusion supports qualitative findings that the support of leaders through positive diversity attitudes is critical to the effectiveness of diversity practices.

The descriptive data presented here indicate that graduate programs are generally sites of active research between faculty and students, and that through such research students have access to professional support through faculty, research collaboration with faculty, and instrumental support from faculty. These kinds of support are all frequent while other kinds of support and networking not directly related to research are somewhat less common overall. This may be why Grad Involvement is particularly important to gendered persistence, because it indicates multi-faceted faculty support of students. Grad Involve includes such actions as helping students who desire to expand their professional repertoire beyond research to teaching, and complimenting a woman graduate student. These actions suggest a measure of whether faculty go beyond the generic role of research mentoring to recognizing students as unique individuals. Interestingly, these actions do not predict men's thoughts of leaving, while they significantly predict fewer of such thoughts among citizen women. This finding, as well as the fact that department practices in general appear to have a stronger effect on women's thoughts of leaving, support the view that organizations have the potential to differentially impact women's outcomes through certain forms of faculty-student interaction. The fact that Grad Involvement is effective even without apparent department facilitation (i.e., a low ICC) suggests the potential for increased effectiveness if departments encourage such actions.

However, the data show a surprising lack of evidence that faculty practices can reduce the gender gap in the broader networking and feelings of social inclusion through most other faculty-student interaction variables; neither do these variables have direct effects on gendered thoughts of leaving. It is unexpected that variables like Career Mentoring and Advisor Help do not work through Advisor or Faculty Support forms of student social capital to result in benefits for women. Similarly, practices hypothesized to encourage overall networking in departments, for example encouragement of student study groups or faculty availability, do not have beneficial effects particular to women on any of the outcomes (although some of them promote student social capital without gendered effects). Interestingly, encouraging student collaboration actually has unfavorable gendered effects by increasing women's reports that faculty undermine their confidence.

However, the practice of effective dissemination of important information has beneficial effects on the gender gap in social support, and a trend suggests that informal sharing of career information increases gendered thoughts of leaving. This finding, along with the effectiveness of Grad Involve, suggests that while departments will be less effective at addressing gendered outcomes through encouraging generalized networking, they may be more effective through direct provision of the support and information that often comes from networks. Furthermore, the effectiveness of both Grand Involve and Recruit Diversity suggest that recognizing, valuing, and addressing the unique needs of individuals is particularly beneficial to women. Taken together, the findings support previous research showing that identity-blind practices, in this case the facilitation of

generalized social support, is relatively ineffective at improving minority participation, while identity-aware practices are remarkably effective as a group.

Overall the findings bolster theories and evidence supporting the importance of contextual effects and arguments that such effects are under-recognized in the literature. First of all, the fact that the gender gap in thoughts of leaving and social capital is small or non-existent among non-citizens compared to among citizens is a possible indicator that cultural factors are in effect. Secondly, that departments display noteworthy variation on gendered outcomes for citizens after controlling for individual level factors suggest contextual effects. Finally, specific department-level factors measured independently of the students within those departments were found to be significant predictors of gendered outcomes. This evidence corroborates the evidence of Jacobs (1989) and others that career aspirations and occupational choices are not as fixed as they are often portrayed to be based on individual-level evidence, and that contextual factors can influence such aspirations at any point in a career path.

CHAPTER 9: Conclusion

In Section 1 of this study, I developed and tested several hypotheses regarding how departmental factors in the admissions process contribute to the proportion of women PhD students in a department. In Section 2, I developed and tested hypotheses regarding how departmental factors contribute to gender differences in outcomes regarding graduate students' program participation. In this Chapter, I summarize the findings by revisiting each of the hypotheses, discussing the support that was found for the hypotheses (if any), and offering interpretations of the findings. After the summary, I conclude the study with a general overview of the general strengths and limitations of the project and some implications of the findings.

Summary of Findings

Gender Stereotypes and the Mediating Effects of Formalization

Based on the literature on gender beliefs and gendered occupational outcomes, I hypothesized that when more faculty members in a department agree with gender stereotypes regarding the practice of CSE, women's representation will be lower, the gender gap in thoughts of leaving will be higher, and the gender gap in social capital will be higher (Section 1, Hypothesis 1a and Section 2, Hypothesis 4a). I did not find evidence that faculty gender stereotyping has a direct effect on these outcomes. This may be due to the inadequacy of the measure. The faculty survey includes only one statement that relates to whether men and women have different inherent orientations towards computing: "CS/CE as a discipline is inherently unattractive to women." It is possible that this statement does not adequately capture the belief that women have less

computing ability; even if faculty believe that CSE is inherently unattractive to women, they may not believe women are less competent at computing. In addition, responses to this question could reflect social desirability effects. Some faculty may not want to violate social norms by indicating belief in inherent gender orientations. Furthermore, the present search for direct effects of gender beliefs is fairly unusual; previous research has demonstrated the effects of gender stereotypes when they are triggered by a specific contextual factor, such as gender-stereotyped criteria. Here I do not have appropriate data for measuring factors that may trigger these attitudes so that they have an effect. I have said that the cultural context in these departments is already one in which gender is salient; gender beliefs should be activated, and whether a department has more or less gender beliefs should have a corresponding effect. However it is likely that mediating factors still play an important role. As mentioned earlier, McIlwee and Robinson (1992) show that different engineering environments have different levels of gendered occupational culture present. The present dataset is limited in offering the potential of measuring possible mediating factors, such as gender stereotypical evaluation criteria. Therefore, I do not find the lack of effects here to be conclusive. Instead, I would suggest that the effects of gender stereotypes on gendered outcomes depends on the presence of specific contextual factors, and that the role of mediating factors requires further exploration.

In the admissions section, I showed evidence for the mediating effects of formalizing practices, evidence which corroborates findings from elsewhere. In Hypothesis 1b, I hypothesized that the negative effects of stereotyping on women's representation will be weaker when relatively objective and specific admissions criteria

are emphasized, and stronger when ambiguous criteria are emphasized. There was indirect evidence supporting this hypothesis in the multivariate regression model. When more faculty in a department indicate that students should be able to fill gaps in CSE skills after entering the program, a lower representation of women results. I interpret faculty indication that students can fill gaps as representing less stringency in the admissions process, i.e., less emphasis on formal requirements and skills for admission of students. Thus, departments that have more informal admission practices have fewer women, which fits previous findings that informality allows stereotypes to play a larger role in the evaluation of individuals. Further support was evident in the correlations in Table 4-6. This table showed that the negative effect of permitting students to fill gaps is only apparent in departments relatively high in stereotyping. In addition, a department's relative emphasis on whether an applicant holds an undergraduate CSE degree was also used to indicate formality. The correlations showed that among high-stereotyping departments, faculty emphasis on a CSE undergraduate degree has a positive effect on women's representation, suggesting that formalization of evaluation criteria counter-acts the negative effects of stereotyping at high levels of stereotyping. Interaction effects were not revealed in the multivariate model, but this may be due to the small sample size.

However, not all uses of informal admissions criteria appear to enhance the unfavorable effects of stereotyping. When faculty emphasize life experiences in admissions decisions, this practice has a strong beneficial effect on women's representation even among high stereotyping environments. Thus it appears that generic formalization of criteria may not increase women's representation, and that formalizing

must be done in conjunction with the evaluation of the practices for other types of gendered effects.

Admission Criteria and the CSE Occupational Schema

In Chapter 2, I reviewed literature that describes a CSE occupational schema with its icon of a CSE student whose devotion to computers encompasses all spheres of life to the exclusion of other interests. I used the concept of a role-incumbent schema to predict that the practices of CSE departments may reflect a CSE student role-incumbent schema that constrains more women than men. Specifically, I hypothesized that in departments which emphasize admissions criteria embodying the aforesaid schema, women will represent a smaller proportion of students (Section 1, Hypothesis 2). The data supports this hypothesis: two practices used to measure presence or absence of the schema showed significant effects. Emphasis on CSE work or volunteer experience (presence of the schema) predicts a lower representation of women, while emphasis on life experiences (absence of the schema) predicts a higher representation of women. These findings corroborate previous qualitative findings of the gendered effects of a CSE student schema in undergraduate admissions. The use of these criteria suggest certain views, embodied in practices, of what type of non-academic background experiences predict success in the field. The practices that emphasize non-academic computing experience and de-emphasize other types of non-academic experiences appear to constrain women more than men from entering departments.

The two non-academic criteria above were entered into a model to predict their effects on admissions, along with measures of formal academic criteria, a more common way of judging potential success (according to the rankings in the faculty survey results

of most commonly used criteria). The inclusion of formal criteria did not alter the effects of Computing Work/Volunteer and Life Experiences. Since the effects of these criteria are independent of any effects from more direct measure of students' academic potential for success, they may work to restrict students who show potential for success but do not fit the traditional occupational schema. This schema may thus serve as an unnecessarily constraining model of success. It has been shown elsewhere that this schema may also restrict men from entering the field if they do not have the non-academic background that fits the occupational schema (Blum and Frieze 2005).

The effects of these non-academic criteria also appear to be independent from possible effects of gender stereotyping, since they are gender ambiguous rather than gender-stereotypical, and there is no indication that they would trigger the use of gender stereotypes. In addition, the stereotype variable was included in the model and should serve as a control for associated effects of gender stereotyping. The non-academic criteria are also entered into the model with the criteria of membership in an underrepresented group; resulting independent effects of these variables show that emphasis on life experiences is not a purposeful advantaging of minorities in admissions decisions. Thus the effects of Computing Work/Volunteer and Life Experiences suggest a mechanism, distinct from gender beliefs or identity-conscious practices, through which evaluations in historically-male fields result in gendered outcomes that contribute to the maintenance of gender-segregated occupations.

Diversity Practices and Attitudes in the Admissions Process

I hypothesized that identity-conscious practices in a department will result in a higher proportion of women in that department (in hypothesis 3a). Findings support this

hypothesis. Placing emphasis on membership in an underrepresented group when evaluating applicants results in a higher proportion of women. This finding is similar to evidence at the undergraduate level that consideration of race in admissions decisions improves the racial diversity of incoming students, and evidence from the workplace that affirmative action improves minority representation (as discussed in previous chapters). While the underrepresented-group criterion shows effects in the multivariate model, the criterion measuring department effort to enroll women did not. The difference in effects suggests that efforts to increase diversity may not be effective unless they are an integral part of the decision-making process. Regarding the practice of diversity training, significant effects in the opposite direction from expected were detected: departments where more faculty had received diversity training have lower proportions of women doctoral students. These effects must be interpreted with caution because they are revealed only when other significant variables are present in the model, and the proportion of variables to sample size is large. The negative effect of diversity training on women's representation may be caused by a backlash effect, where faculty perceive and resist expectations that they privilege certain demographic groups. Such perceived expectations would be resisted because they conflict with an ideology of meritocracy. An alternative interpretation involves reversing the causal direction of effects: low diversity in departments could be leading to more diversity training. For example, if some faculty in a department (or administrators outside the department) perceive the need to take action to improve the low representation of women, they might implement diversity training as a result.

I also hypothesized that where more faculty members hold attitudes supportive of diversity, there will be a higher proportion of women (Section 1, Hypothesis 3b). This was not shown to be the case, but interactions between diversity attitudes and practices are suggested by correlations. As shown previously in Table 4-7, the beneficial effects of considering minority group membership in admissions decisions is only present among departments with high faculty beliefs that the department should recruit for diversity. In these departments, the bivariate relationship between consideration of group membership and proportion of women is exceptionally strong. Similarly, department effort to enroll women has a significant beneficial effect only in departments with high positive attitudes towards recruiting diversity. On the other hand, the unfavorable effect of diversity training is only present among departments with relatively low support for recruiting diversity. Although these interactions could not be tested more rigorously with the present data, they are intriguing; they support limited previous research showing that attitudes among organizational leaders can improve the effectiveness of diversity practices.

A likely interpretation of the beneficial effects of diversity attitudes is that faculty who express supportive views of diversity hold the view that diversity provides benefits to the department as a whole by contributing to a more creative work environment. With this value-added view of diversity, faculty are more likely to embrace practices intended to increase diversity. Meanwhile, those who do not view increased diversity in this way may have a harder time justifying and accepting diversity practices. This interpretation and the interaction findings upon which it is based contribute to understanding the negative effects of diversity training as a reaction based on disapproving attitudes

regarding diversity efforts. More research is needed on the interaction between diversity attitudes and diversity practices, and on the role of the organization in productively framing diversity goals and practices.

Gender Differences in Program Participation: Thoughts of Leaving the Program and Social Capital

After addressing the admissions process, I examined gender differences in outcomes related to program participation. I hypothesized that women would be more likely than men to consider leaving, and that their reasons for considering leaving would more likely be due to less confidence in their ability to be successful in CSE (Hypothesis 1a and Hypothesis 1b). The data supported this hypothesis, corroborating similar findings in other traditionally male fields. Women in this study are also more likely to contemplate leaving because they feel they have to prove themselves, which again supports previous literature; specifically, evidence shows detrimental gendered outcomes resulting from occupational contexts in which women perceive they need to prove their competence amidst lowered expectations of their success.

Further analysis revealed that the gender gap in contemplation of leaving and in leaving for confidence reasons is almost entirely due to a gap among citizens, and that there is not a significant gender difference among non-citizens. This finding was unexpected. However, since the literature claims that the gender gap in confidence is due to cultural beliefs about gender, it is not surprising that the gender gap is not consistent among students from different cultures, although other factors specific to non-citizenship—in particular, the fact that leaving the program would mean, for many non-citizen students, having to leave the United States—could be involved as well. Among citizens, a significant gender difference remains after predicting thoughts of leaving for

confidence reasons with individual-level characteristics, such as desire to do research and various forms of background experience in CSE.

I also find evidence for gender differences in social capital, although the gender gap is not as large as expected. I hypothesized that Women in CSE graduate programs will report less social inclusion from faculty and students, less instrumental support from faculty, and connections with faculty that are less trusting (Section 2, Hypothesis 2). Once individual-level controls were taken into account, there were no significant gender differences in reports of support from advisors or in instrumental support from faculty, contrary to previous evidence (the discrepancies may be due to the use of individual-level controls in the present study). However, gender gaps persisted, despite controls, in reports of social inclusion (defined as feeling included in networks with students and/or faculty) and in distrust towards faculty (defined by impressions that faculty undermine one's confidence and favor certain students). Again, this gender gap only existed among citizens and showed unfavorable outcomes for citizen women. The gender gaps in social capital suggest that the interactive mechanism of homophily is at work, contributing to women's social isolation relative to men, as claimed elsewhere. The gender gap in distrust of faculty again fits with theories that women encounter gender stereotypes in certain cultural contexts that cause them to not only question their own abilities, but also to perceive lowered expectations of their competence by others.

I hypothesized that students reporting more social capital will be less likely to consider leaving their program (Section 2, Hypothesis 3a). The data show that the forms of social capital examined here predict thoughts of leaving. Correlations between social capital and thoughts of leaving by gender show that advising support and distrust of

faculty are stronger predictors of thoughts of leaving for women than for men. These correlations suggest that faculty acceptance and support is most consequential to women's career progression. The gender differences in correlations also indicate that advising support is especially beneficial for women. A possible interpretation of the gendered advising effect is that women compensate for their relative deficiency in trust of faculty with support from advisors. Gender differences in social capital only marginally account for gendered thoughts of leaving for confidence reasons, contrary to my prediction (Hypothesis 3b). The persistence of the gender gap in thoughts of leaving when social capital is taken into account does not mean that social capital is not consequential, however. Gender differences in social capital may contribute to a number of other gendered outcomes that could not be shown with the present data, such as articles published or professional positions secured.

Next, I move on to summarize the findings about how department characteristics predict the gendered outcomes in program participation just discussed. Even though the hypotheses on program participation mostly have to do with different departmental factors from those tested in the admissions process, the findings from both sections can be integrated in some ways. Some of the findings below echo the finding from the admissions section that leaders in the field are likely to be effective at increasing gender diversity when they recognize and validate more than one model for success in the pursuit of a career in CSE. In the department characteristics discussed below, varying "models for success" are not tested as directly as they were in the admissions section, but certain characteristics are related to this concept, such as support for diversity, and

support of students as individuals with differing needs. This integration of findings will be discussed again at the end of the summary of findings.

Research Orientation and Gendered Thoughts of Leaving

After documenting the above gender differences in program participation outcomes, I proceeded to test hypotheses regarding department conditions that predict these gender differences. The department characteristic with the strongest effects was one of the control variables for research orientation, a measure of faculty-student research activity. The strong effect of research orientation was unexpected, and is interpreted as resulting from the heightened expectations placed on students in these departments. It is likely that contexts demanding high performance especially challenge women's self-assessments of their ability to be successful in a historically male field, given evidence that gendered self-assessments exist overall in such fields. This finding is discussed in more detail in Chapter 8.

Diversity Practices, Diversity Attitudes, and Gendered Outcomes in Program Participation

I hypothesized that practices intended to increase diversity would reduce gendered outcomes during program participation (Section 2, Hypothesis 5). Multivariate regression results again showed significant unfavorable effects from diversity training. Diversity Training is associated with increased thoughts of leaving for citizen women, relative to citizen men. Again, the causal direction is not clear. It could be that departmental conditions leading to women's greater desire to leave have also spurred faculty or administrators to take action to address diversity issues, such as by implementing diversity training. Alternatively, diversity training could result in a backlash effect through promoting alternative ways of perceiving and enacting department practices.

Changes in the status quo of the department, especially changes that threaten the status of the dominant group, could result in practices and attitudes among faculty that are detrimental to women's self-assessments of fit in the department. Such an interpretation has been suggested elsewhere, but more research is needed to clarify why diversity training is associated with detrimental gendered outcomes. As found in the admissions process, the unfavorable effect of diversity training on gendered outcomes appears to be conditional on diversity attitudes; the detrimental effects are only detectable when beneficial effects from diversity attitudes (attitudes supportive of diversity) are taken into account.

Other diversity practices failed to show beneficial effects. Previous literature has focused more on the role of identity-conscious practices at sites of entry into organizations, and there is less evidence to suggest how such practices work on career progression. Some have suggested, however, that increased networking among women or minorities will result in beneficial outcomes for minorities. No such beneficial effects were found here for a variable representing practices intended to support women students, practices such as facilitation of a women's group and showcasing women's successes. A likely explanation is that these practices are not directly tied to the central activities of research in the daily life of departments. If it is the case that women's lack of confidence in their CSE ability relative to men is the primary source of gendered attrition, then these gendered self-assessments would need to be mediated in the context of work where abilities are used and demonstrated, in order to be improved.

Unlike same-sex networking (i.e., women's groups), diversity attitudes have the potential to be in effect in the immediate context of research. The analysis here confirms

my hypothesis that faculty attitudes supportive of diversifying the student body reduce the effect of gender on student thoughts of leaving for confidence reasons (Section 2, Hypothesis 4b). Diversity attitudes also predict the gender gap in trust of faculty. The belief that efforts to increase diversity will lower the quality of incoming students predicts more distrust of faculty for women relative to men. Previous researchers have discussed the link that women subjects themselves make between their feelings of social exclusion and faculty attitudes towards women's participation in historically-male fields. Here, this link is made using women's reports and actual responses of faculty. This finding shows that women's reports of social exclusion are associated with independently-measured faculty attitudes present in the social context.

Literature on diversity attitudes that can contribute to the interpretation of these results is sparse. Attitudes supportive of diversity may work through interactions between faculty and students by counteracting women's gendered self-assessments regarding CSE abilities. The belief that increasing diversity necessarily entails lowering academic standards may also operate through faculty-student interaction, for example, if faculty express doubt that women are competent at computing. More research needs to be done to determine how diversity attitudes affect gendered outcomes of program participation and how departments might encourage attitudes supportive of diversity.

Department Support of Students and Gendered Outcomes in Program Participation

I hypothesized that in departments where there are more practices facilitating mentoring by faculty, and more faculty availability, student collaboration, and information sharing, there will be a reduced effect of gender on student social capital and on student thoughts of leaving the program (Hypothesis 6a). The rationale for this

hypothesis was that such facilitation of networking and social support would reduce women's social isolation through providing more access to social support, thereby reducing the need to access support through informal connections based on same-sex preferences. With increased access to social support, women should have more access to resources, such as instrumental and emotional encouragement, that reduce thoughts of leaving. I thus hypothesized that the above department-level practices would decrease the unfavorable effect of gender on students' thoughts of leaving partly through increasing student social capital (Hypothesis 7).

The findings provide some support that these department practices reduce the gender gap in thoughts of leaving, but these practices do not work through increasing women's social support or faculty trust, as expected. Grad Involvement (a construct developed from factor analysis of the faculty survey responses) has direct beneficial effects on the gender gap in thoughts of leaving, but does not increase feelings of social inclusion or trust in faculty. Close examination of the variables that compose this factor suggest a definition of Grad Involvement as multifaceted support of students as individuals. Grad Involvement consists of supporting students' individual needs such as the need for English language instruction, or the need for help with one's own research proposal (distinct from faculty-student research). Additionally, Grad Involvement consists of multifaceted support in that it involves faculty support of students in other areas besides research, such as in the encouragement of teaching. Grad Involvement also consists of expressions of confidence in students, such as complimenting a student or informing faculty of students' successes.

A likely interpretation of how this Grad Involvement might directly decrease women's thoughts of leaving is that this type of support acknowledges multiple models of occupational success, and validates the competence of students as individuals who have varied interests, goals, and styles. This interpretation fits with the finding from the admissions section that broadening criteria and acknowledging more than one possible definition of success in CSE increases women's representation. Grad Involvement might reduce the gender gap in thoughts of leaving through enabling multiple models of success rather than only one masculine occupational culture of computing, which has been said to disproportionately constrain women (Wright 1996). More specifically, in social contexts with more support for alternative models of success, women's self-assessments of their abilities to succeed in the field might be higher, resulting in fewer thoughts of leaving.

Besides Grad Involvement, most other measures of faculty support, including facilitation of student collaboration, faculty career mentoring and faculty availability, do not have significant *beneficial* effects on the gender gap in thoughts of leaving or on the gender gaps in social capital. It may be that these practices are not structured or formalized enough to provide increased availability of resources to women, and thus do not compensate for the informal social mechanisms that favor men's access to social support and resources. Faculty facilitation of student collaboration does have a significant positive effect on student social support, which indicates that this faculty practices does have a generic effect on this measure of student social capital in the expected direction. However, this practice (faculty facilitation of student collaboration) has *detrimental* effects on the gender gap in trust of faculty, contrary to expectations. It may be that faculty facilitation of student collaboration results in the support of only certain students.

Recall that the factor for trust in faculty (Faculty Undermine) consists of student reports that faculty favor certain groups of students over others, and that one must compete with other students for faculty attention. A possible interpretation of this finding is that faculty attempts to increase student social capital can actually reinforce women's social exclusion. However, since this finding is in the opposite direction from expectations and is only significant at $p < .10$, it must be interpreted with caution.

One additional faculty practice hypothesized to reduce the gender differences in thoughts of leaving and in social capital had the expected effect. Faculty agreement that career information is passed on informally increases the gender gap in thoughts of leaving for confidence reasons (again, this practice does *not* work indirectly through decreasing the gender gap in social capital). A similar practice (measured in the opposite direction), effective dissemination of information, decreases the gender gap in student social support. These findings indicate that formalized information sharing is particularly beneficial to women. When departments promote formal and effective information sharing, women likely have better access to resources to which they do not have access through informal networks, resources such as knowledge about career opportunities, or knowledge about social and academic opportunities within the department. Perhaps it is through increased access to such resources that women's social inclusion is increased. Women's disproportional thoughts of leaving are effected specifically by access to career information, perhaps because when women gain knowledge of career opportunities, this knowledge can lead to higher expectations of their success in the field.

I also hypothesized that in departments where faculty discourage competition and provide an ethic of helpfulness towards students, there will be a reduced effect of gender

on student social capital and on student thoughts of leaving the program (Hypothesis 6a and 6b). The rationale for this argument is based on organizational literature claiming that when leaders model cooperation, helpfulness, and trust, organizational members will have higher quality working relationships. Again I argued that such practices aimed at students overall would particularly benefit women by facilitating their access to resources and social support. However, the evidence does not support this hypothesis. Variables representing faculty support of competition among students, advisor helpfulness, and faculty beliefs that it is a students' own fault for failing had no expected effects on gendered thoughts of leaving and gendered social capital. However, when faculty agree more that it is a student's own fault for failing, the gender gap in trust of faculty (Faculty Undermine) is unexpectedly reduced. One possible explanation for this finding is that the variable Students' Own Fault serves as a measure of formality or stringency in standards of student evaluation. As in the admissions process, and as shown in other settings, more formal and specific standards of evaluation can benefit women by reducing cognitive gender bias. Unfortunately this could not be tested further with the present data. However, this unexpected finding and the lack of effects of other variables in this category suggest that departments that provide extra help and a "softer" environment in terms of competition do not close the gender gaps in important outcomes through these practices.

In summarizing findings from the program participation section, I conclude that many of the faculty support practices hypothesized to close the gender gap in important outcomes do not have the expected beneficial effects. Even though women report more thoughts of leaving because of less confidence in their own abilities, more feelings of

social exclusion, and more alienation from faculty, they do not appear to benefit from “hand-holding” practices such as advisors’ provision of extra help, less faculty endorsement of competition, and support targeted specifically at women (such as women’s groups). Some related practices actually appear to have detrimental effects. Rather, the attitudes and practices that have been shown with the present data to have beneficial gendered effects are those which support the goal of diversity, validate and support students as individuals with varying needs and interests, and provide formal practices of communicating information so that all students have access to career-related knowledge. The findings on program participation reinforce the findings from the admissions process that leaders in the field are effective at increasing gender diversity when they recognize and validate more than one model for success in the pursuit of a career in CSE.

Limitations and Implications

In this study I have attempted to test some of the theories proposed elsewhere about why gender segregation in the academic sciences persists. Since much of this theory is based on case studies and often does not fully elucidate specific mechanisms of gender inequality, I have attempted to improve the state of knowledge in this area by testing specific mechanisms with a representative sample of CSE departments. The strengths and limitations of this study both stem from my attempt at a broader, more clearly specified examination of factors related to gendered outcomes in the sciences.

On the one hand, even though the sample is relatively small compared to some organizational studies, the sample is relatively large compared to many studies that focus

on social processes within organizations, such as gender and diversity beliefs, the qualitative nature of interactions between faculty and students, and differential reports of social inclusion. Data about the social life within organizations is usually limited to case studies. I used the opportunity this data provided to propose hypotheses for testing interactive and structural mechanisms that have been shown to be important in other literatures, such as the gender and work literature, and the diversity and organizations literature. The formulation of these hypotheses has itself been constructive in its translation of abstract arguments about the effects of socio-cultural contexts into testable propositions. The results show that some of the previously identified mechanisms are indeed factors contributing to gendered outcomes in the CSE context of academic science. I also detect the effects of other mechanisms that have been less commonly identified. Since I include different mechanisms in a single model to predict gendered outcomes, the present analysis has the benefit of modeling some of the complexity of concrete social contexts.

On the other hand, the findings fall short of the explanatory power that can result from studies based on only one type of mechanism or on only one or two case studies. This study stems from a larger project designed and partly carried out prior to my involvement, so this work is constrained by design decisions made at earlier stages. Measures for each type of mechanism were limited in number, and some did not fully capture the specific concept of interest. In addition, some practices that have been hypothesized to reduce gender bias (e.g., the formalization of performance evaluation practices) could not be measured and thus were absent from the multivariate analyses. Although I attempted to model some of the complexity of the social context, the sample

of 48 cases limited the number of variables whose effects could be considered simultaneously. It is possible that effect sizes would have been different if all relevant variables could be entered into a model simultaneously without risk of jeopardizing the integrity of the results. As a result, the conclusions here are intriguing and informative, but less straightforward and conclusive than would be ideal.

The findings correspond with theories about a gendered culture of computing and science in several ways, although the evidence is often indirect. First, the gendered effects of certain admissions criteria suggest the influence of an occupational schema that disproportionately constrains women. Secondly, once women enter their departments, their outcomes are more influenced overall by departmental social factors; women appear to be somewhat excluded from social support, and are more likely to think of leaving because they feel pressured to prove themselves. Thirdly, attitudes about diversifying CSE, and to a lesser extent gender stereotyping, influence the presence of women in the field of CSE. Several departmental practices appear likely to mediate unfavorable gendered outcomes resulting from the socio-cultural context. These include formalization of evaluation criteria, formalization of information dissemination, broadening the definition of a model CSE student, fostering an ethic of valuing diversity, and supporting students as individuals with differing goals, styles, and needs.

One of the most significant contributions of this study is to provide more evidence on the role of both interactive and structural factors in the social context of historically-male fields. Previous literature has addressed the interactions between interactive and structural mechanisms by examining how formalizing practices mediate the effects of cognitive bias. This study takes this line of inquiry further by also considering other

gendered effects of evaluation criteria, faculty-student support practices, and diversity practices, and at the same time considering gender beliefs and diversity attitudes in a department. I have identified practices whose effects persist when gender beliefs and diversity attitudes are taken into account, and others whose effects are partly explained by the presence or absence of such attitudes. A comprehensive approach to contextual factors such as the present one is relevant to the development of practices that departments may effectively implement to improve women's participation even in the presence of gender stereotyping or negative views on increasing diversity.

The findings can perhaps be applied—with due caution—to the work setting. Much of the inspiration for the practices tested here came from the literature on gender in work settings, which often parallels the literature on gender and the academic sciences (e.g., in discussions of gender stereotypes, formalization of practices, and gendered social exclusion). The present findings can potentially be transferred back to the work setting, but important differences in the settings must be taken into account. First, measures of success in graduate programs are likely to be relatively formal compared to those in work settings; thus, gender stereotypes may contribute more to gendered outcomes in places of work. Secondly, some of the present findings may be somewhat limited to the context of the privatized and decentralized structure of academia. The student-advisor relationship is particular to academic departments; in work settings, gendered outcomes may depend more on the complexity and quality of various social connections.

The findings here seem especially relevant to work settings in regards to how and when diversity initiatives should be carried out. Evidence points to the need to consider how diversity initiatives are framed and how an organization might foster a value of

diversity at the same time as it implements active *practices* to increase diversity. More generally, the findings suggest the need, in both work and academic settings, to consider interactive and structural factors together and to continue to pinpoint the social context as an important site of factors leading to gendered occupational outcomes.

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APPENDIX A: Admissions Section

Table A3-1: Faculty Survey: “How much importance did you personally place on each of the following criteria when you evaluated applicants?”

Undergraduate degree in a computing major
General quality of academic record
Grades in computing courses
Grades in non-computing courses
EE background
Research experience
Work or volunteer experience in the computing field
Work or volunteer experience in non-computing fields
Leadership experience
Computing experience
Math background
GRE score
GRE CS subject exam score
Academic letters of recommendation
Area of research interest
Motivation
Communication skills
Desire to use technical skills for social good
Having been away from formal education for a time
Membership in an underrepresented group
Reputation of undergraduate institution or program
Maturity

(1= not at all important, 2= slightly important, 3= moderately important, 4= very important, 5= extremely important, DK/NA)

Table A3-2: Faculty Survey: “To what extent does each of the following statements accurately describe your graduate program or department?”

Timetables for degree progress are flexible.
--

(1=not at all accurate, 2=slightly accurate, 3=moderately accurate, 4=very accurate, 5=extremely accurate, DK/NA)

Table A3-3: Faculty Survey: “Please indicate the extent to which *you* personally agree or disagree with the following statements:”

Students without a computer science undergraduate degree can be successful in getting a Ph.D. in computer science.
Life experiences should be considered when evaluating students for admission into the graduate program.
Incoming graduate students should have the opportunity to fill gaps in their computer science background without prejudicing evaluations of their progress.
The department should actively recruit students from underrepresented groups (i.e., women, minorities, students with disabilities).
Activities meant to diversify the graduate student body will lower the academic quality of incoming students.
CS/CE as a discipline is inherently unattractive to women.

(1=Strongly disagree, 2=somewhat disagree, 3=neutral, 4=somewhat agree, 5=strongly agree, DK/NA)

Table A3-4: Faculty Survey

In your opinion how much effort does your department devote to enrolling women graduate students?

(1=Strongly disagree, 2=somewhat disagree, 3=neutral, 4=somewhat agree, 5=strongly agree, DK/NA)

Table A3-5: Faculty Survey: How often do you perform each of the following recruitment activities?

Personally call prospective students.
Send personal letters or email to prospective students.
Meet with prospective students during on-campus visits.
Recruit through personal contacts with undergraduate CS/CE departments at other institutions.
Actively recruit students from women’s colleges.
Actively recruit students from liberal arts colleges.
Teach summer research courses designed to recruit students from under-represented groups.
Actively recruit students at conferences.
Encourage promising undergraduates to go to graduate school.
Encourage promising Master’s students to continue on for their Ph.D.
Involve undergraduates in my research.
Give presentations that encourage graduate study to groups of CS/CE undergraduates.
Assist students with their graduate school applications.

(1=never, 2=rarely, 3=sometimes, 4=Frequently, 5=always, DK/NA)

Table A3-6: Recruitment/Program Choice Questions from the Student Survey

Please assess how important each of the following institutional factors was in selecting your current graduate program:

Expense
 Availability of financial aid
 Geographic preferences or constraints***
 Availability of course offerings during the academic year
 Courses offered at convenient times of day
 Flexibility in program content**
 Reputation of institution+
 Reputation of program or professor(s)
 Ability to pursue a particular computing specialization
 Teaching opportunities*
 Research opportunities
 Departmental recruitment literature or webpage
 Size of institution
 Number of faculty in the program
 Employer tuition reimbursement program
 Earned prior degree from same institution
 Minimal academic or bureaucratic obstacles

Please assess how important each of the following interpersonal factors was in selecting your current graduate program:

Opportunity to work with a particular research advisor
 Your impression of students during a campus visit**
 Your impression of faculty during a campus visit
 Departmental culture*
 Social atmosphere of the campus
 Presence of women students***
 Presence of women faculty***
 Prior enrollment of family or friend(s)***
 Recommendation of faculty or mentor
 Faculty member's visit at your undergraduate department*
 Phone call or mail from graduate faculty member(s)***

(1= not at all important, 2= slightly important, 3= moderately important, 4= very important, 5= extremely important, DK/NA)

* $p < .10$; ** $p < .05$; *** $p < .01$ (significance of gender difference, higher mean for women PhD students)

+ $p < .10$; ++ $p < .05$; +++ $p < .01$ (significance of gender difference, higher mean for men PhD students)

Table A4 : Logistic Regression Model Predicting Women's Proportion PhD Students with all Explanatory Variables Added

	Coeff.	Std. Error	Sig.
Beliefs			
Agreement with stereotype	0.272	0.249	0.285
Dept should recruit diversity	0.219	0.254	0.398
Diversity lowers quality	0.118	0.127	0.363
Formality of admissions practice:			
Undergrad CS degree	0.333	0.152	0.038
Grades in CS courses	-0.199	0.231	0.398
GRE score	-0.192	0.121	0.125
w/o CS degree can succeed (<i>informal</i>)	0.022	0.237	0.927
Students can fill CS gaps (<i>informal</i>)	-0.492	0.225	0.039
CSE occupational schema:			
CS work/volunteer exp	-0.385	0.171	0.034
CS experience	-0.062	0.145	0.673
Communications skills (<i>divergence</i>)	0.080	0.178	0.659
use skills for social good (<i>divergence</i>)	-0.034	0.111	0.761
Consider life experiences (<i>divergence</i>)	0.518	0.165	0.005
Diversity Practices			
Criteria: underrepresented group	0.208	0.115	0.083
Department effort to enroll women	0.065	0.224	0.774
Diversity Training	-0.006	0.002	0.024
Controls:			
Gender gap in thoughts of leaving	-0.100	0.156	0.527
Flexible Timetables for progress	0.628	0.172	0.001
Rank of department (top rank=1)	0.033	0.138	0.814
Carnegie (very high research =1)	-0.115	0.160	0.479
Public/Private (private=1)	0.093	0.108	0.395
Female proportion of faculty	0.000	0.750	1.000
CE proportion faculty	0.160	0.408	0.698
N=48			

APPENDIX B: Program Participation Section

Table B6-1: Please indicate how many people in your graduate program interact with you in the following ways.

Faculty are available for one-on-one advising.
 Faculty encourage me to publish research .
 Faculty expectations of graduate students are too high.
 Faculty encourage me to attend professional conferences.
 Faculty help me make professional contacts.
 Faculty undermine my confidence in my abilities.
 Faculty help me progress toward my degree.
 Faculty give me useful career advice.
 Faculty give me useful advice about my research.
 Faculty encourage me to collaborate on research with my fellow students.
 Faculty care about me as a person.
 Faculty, besides my major advisor, take an interest in my progress toward my degree.
 Faculty favor certain groups of students over others.

(1=None, 2=Few, 3=Some, 4=Most, 5=All, DK/NA)

Table B6-2: How satisfied or dissatisfied are you with your current degree program in each of the following areas?

Quality of advising
 Relationship with your assigned faculty advisor
 Career mentoring
 Supportiveness of faculty
 Working relationships with professors
 Working relationships with other students
 Dissemination of important information

(1=Very dissatisfied, 2=Somewhat dissatisfied, 3=Neutral, 4=Somewhat satisfied, 5=Very satisfied, DK/NA)

Table B6-3: How much do you agree or disagree with each statement about your experience of the work environment in your graduate program?

My faculty advisor gives me adequate feedback on my progress toward my degree.
 I feel comfortable talking to my faculty advisor about my plans for the future.
 My faculty advisor understands my needs as a graduate student.
 I get adequate time with my faculty advisor.
 There is a departmental person or office I can turn to if I have a problem (e.g., a problem with an advisor, coursework, or other students).
 My department encourages me to do collaborative work with faculty.
 Graduate students are involved in research with faculty.
 Faculty use graduate students as a source of cheap labor to advance their own research.
 Faculty routinely publish papers with graduate students.
 My department encourages study groups.
 I was readily accepted into a research group.
 I often feel I have to compete with other students for faculty attention.

(1=Strongly disagree, 2=somewhat disagree, 3=neutral, 4=somewhat agree, 5=strongly agree, DK/NA)

Table B6- 4: How much do you agree or disagree with each statement about your experience of the social environment in your graduate program

I feel included in a social network that includes faculty members.
 My department has a supportive environment.
 The student community is supportive.
 I have sometimes felt excluded from formal or informal study groups.
 I feel part of a peer community among graduate students.
 All the other students in my graduate program treat me respectfully.
 I sometimes feel isolated within my department.
 The department provides enough social options that I could find a way to participate.

(1=Strongly disagree, 2=somewhat disagree, 3=neutral, 4=somewhat agree, 5=strongly agree, DK/NA)

Table B6-5: Student Social Capital Factors

All items for factors have a minimum value of 1 and a maximum value of 5.

Faculty Instrumental Factor	Cronbach's Alpha=.92	57% of Variance	
	N	Mean	Std. Deviation
Faculty are available for one-on-one advising	1,011	3.35	1.02
Faculty help me progress toward my degree.	1,000	3.14	1.01
Faculty give me useful career advice.	938	2.81	1.05
Faculty give me useful advice about my research.	985	3.12	0.97
Faculty encourage me to collaborate on research with my fellow students.	981	2.98	1.12
Faculty care about me as a person.	977	3.08	1.07
Faculty, besides my major advisor, take an interest in my progress toward my degree.	955	2.55	1.10
Faculty encourage me to publish research .	961	3.65	1.11
Faculty encourage me to attend professional conferences.	961	3.17	1.15
Faculty help me make professional contacts.	899	2.61	1.09
Advisor Support Factor	Cronbach's Alpha=.92	70% of Variance	
	N	Mean	Std. Deviation
My faculty advisor gives me adequate feedback on my progress toward my degree.	945	3.92	1.16
I feel comfortable talking to my faculty advisor about my plans for the future.	969	4.09	1.14
My faculty advisor understands my needs as a graduate student.	961	3.96	1.17
I get adequate time with my faculty advisor.	967	3.99	1.22
Quality of advising	1,015	3.82	1.17
Relationship with your assigned faculty advisor	982	4.16	1.14
Social Support Factor	Cronbach's Alpha=.84	55% of Variance	
	N	Mean	Std. Deviation
I feel included in a social network that includes faculty members.	950	3.09	1.21
1. I sometimes feel isolated within my department.	961	2.77	1.31
The department provides enough social options that I could find a way to participate.	937	3.51	1.14
2. My department has a supportive environment.	960	3.72	1.03
3. The student community is supportive.	956	3.81	1.00
I feel part of a peer community among graduate students.	941	3.68	1.07
Faculty Undermine Factor	Cronbach's Alpha=.69	51% of Variance	
	N	Mean	Std. Deviation
Faculty favor certain groups of students over others.	798	2.32	1.09
Faculty expectations of graduate students are too high.	922	2.32	0.99
Faculty undermine my confidence in my abilities.	943	1.76	0.95
I often feel I have to compete with other students for faculty attention.	955	2.78	1.29

Table B6-6 Department Factors and Single-Item Measures**Factors taken from question 11 – faculty responses about program: ***

To what extent does each of the following statements accurately describe your graduate program or department?

*1=not at all accurate, 2=slightly accurate, 3=moderately accurate, 4=very accurate, 5=extremely accurate, DK/NA***Support Women Cronbach's Alpha =.71 59% of variance**

	Mean	Std. Deviation	N	Missing N
q11_a_13 The successes of women in the department are showcased.	3.24	1.069	751	134
q11_a_14 The department facilitates peer communities or support groups for women.	3.39	1.066	751	204
q11_a_10 Women are routinely included as visiting faculty or guest speakers.	3.32	1.001	751	79

Flexibility Cronbach's Alpha = .776 68% of variance

	Mean	Std. Deviation	N	Missing N
q11_a_2 Timetables for degree progress are flexible.	3.62	0.786	751	73
q11_a_3 Timetables for degree completion are flexible.	3.71	0.759	751	76
q11_a_4 Personal leave is readily available to graduate students.	3.64	0.793	751	204

Faculty respect Cronbach's Alpha = .606 54% of variance

	Mean	Std. Deviation	N	Missing N
q11_a_1 Faculty treat each other with respect.	4.03	0.867	751	48
q11_a_5 Graduate students commonly approach more than one faculty member for advice.	3.56	0.837	751	95
q11_a_6 If graduate students switch advisors, there are no negative consequences.	3.81	0.898	751	98

Table B6-6 Department Factors and Single-Item Measures Continued

Factors taken from question 14 – faculty responses about their actions: *
 Using the following five-point scale, please indicate how often you do each of the following actions.
1=never, 2=rarely, 3=sometimes, 4=Frequently, 5=always, DK/NA

Faculty-Student Research		Cronbach's Alpha = .896		57% of variance	
		Mean	Std. Deviation	N	Missing N
q14_a_1	Fund graduate students' attendance at professional meetings	3.74	0.958	751	86
q14_a_15	Give students opportunities to practice presenting their research	4.21	0.764	751	72
q14_a_17	Have students present papers at conferences	4.08	0.870	751	82
q14_a_18	Meet with your graduate students	4.60	0.564	751	71
q14_a_3	Publish research with graduate students as co-authors	4.41	0.745	751	73
q14_a_4	Inform individual graduate students of research opportunities	4.23	0.761	751	69
q14_a_7	Discuss career options with individual graduate students	4.12	0.772	751	69
q14_a_8	Describe to graduate students how they can get involved with a research project	4.09	0.777	751	70
q14_a_9	Introduce graduate students to your colleagues or computing professionals	3.91	0.850	751	78
Grad Involvement		Cronbach's Alpha = .802		49% of variance	
		Mean	Std. Deviation	N	Missing N
q14_a_10	Provide opportunities for graduate students to interact outside the classroom	3.62	0.981	751	85
q14_a_11	Help graduate students get involved in professional associations	3.05	1.027	751	100
q14_a_12	Compliment a woman graduate student on her academic or research accomplishments	3.73	0.852	751	129
q14_a_13	Inform faculty of graduate student successes	3.68	0.860	751	80
q14_a_14	Arrange language instruction for international students if needed	2.79	1.171	751	144
q14_a_5	Encourage individual graduate students to teach courses	2.87	0.974	751	98

Table B6-6 Department Factors and Single-Item Measures Continued

Career Mentoring		Cronbach's Alpha = .809		63% of variance	
		Mean	Std. Deviation	N	Missing N
q14_a_19	Assist students with obtaining a professional position	4.16	0.809	751	110
q14_a_20	Advocate on behalf of your students	4.22	0.765	751	82
q14_a_21	Encourage a student's personal growth	4.13	0.789	751	86
q14_a_22	Discuss with graduate students the personal satisfaction you get from your career	3.75	0.904	751	75

Factors taken from question 16 – faculty views: *

Please indicate the extent to which you personally agree or disagree with the following statements.
 1=Strongly disagree, 2=somewhat disagree, 3=neutral, 4=somewhat agree, 5=strongly agree,
 DK/NA

Advisor Help		Cronbach's Alpha = .623		48% of variance	
		Mean	Std. Deviation	N	Missing N
q16_a_13	It is an advisor's responsibility to help students succeed in graduate school.	4.40	0.754	751	91
q16_a_14	A student who is failing may succeed with extra help.	4.02	0.752	751	97
q16_a_15	If non-academic problems or outside circumstances are affecting a student, a faculty advisor should offer assistance.	3.88	0.796	751	100
q16_a_5rec	Advising should be restricted to academic matters. (reversed)	-1.13	0.92016	751	90

Factors taken from multiple question categories:*

Information Flow		Cronbach's Alpha=.714		61% of variance	
		Mean	Std. Deviation	N	Missing N
q16_a_23	The department does a good job of providing career development information to all graduate students.	3.20	0.886	751	178
q11_a_16	Important information is disseminated effectively to graduate students.	3.65	0.823	751	101
q11_a_15	Graduate student participation in professional organizations is encouraged.	3.57	0.902	751	103

Table B6-6 Department Factors and Single-Item Measures, Continued

Competition		Cronbach's Alpha = .649		57% of variance	
		Mean	Std. Deviation	N	Missing N
q16_a_18	Competition among graduate students is a desirable part of graduate school.	2.91	1.184	751	95
q16_a_9	First-year graduate school courses should "weed out" weaker students.	2.81	1.083	751	109
q11_a_9	Competitive behavior is rewarded.	2.78	0.991	751	153

Student Collaboration		Cronbach's Alpha = .642		59% of Variance	
		Mean	Std. Deviation	N	Missing N
q16_a_16	Faculty should promote the formation of study groups	3.74	0.897	751	93
q16_a_17	Students should be encouraged to do collaborative research.	4.44	0.688	751	91
q14_a_2	Facilitate formation of graduate student study groups	2.97	1.126	751	92

Single-Item Variables:

	Mean	Std. Dev.	N
q11_a_11 Incoming graduate students are given the opportunity to participate in research.	4.07	0.822	698
q11_a_7 Career development information is disseminated to graduate students primarily through informal channels.	3.36	0.886	615
q16_a_3 If a student is failing, it is usually the student's own fault.	3.24	0.962	652
q11_a_8 Successful graduate students put their studies ahead of all other commitments.	3.36	0.969	628
q16_a_27 CS/CE as a discipline is inherently unattractive to women.	2.42	1.157	625
q8 In your opinion, how much effort does your department devote to enrolling women graduate students? <i>1=No effort, 2=A little effort, 3=Moderate effort, 4=Extensive effort, 5=Very extensive effort</i>	2.87	.794	716
q18_a_1 Have you ever participated in any of the following training activities at your current university? (Diversity Training) <i>1=Yes, 2=No</i>	.22	.417	636

*For each variable, missing values are replaced with the variable mean.

Table B6-7 Single-Item Control Variables

	Mean	Std. Deviation	Min	Max
Proportion Female Faculty	0.127	0.095	0.000	0.417
Proportion Female Students	0.199	0.061	0.071	0.365
Rank	0.375	0.489	0.000	1.000
Public/Private	0.313	0.468	0.000	1.000
Carnegie (Very High Research Activity or not)	0.708	0.459	0.000	1.000
Total # PhD Students	93.708	99.313	12.000	564.000
Proportion CE faculty	0.096	0.144	0.000	0.667

N=48

Table B7-1: Correlations Between Control Variables and Dependent Variables, and intercorrelations between dependent variables

	TOL- Conf.	Advisor Support	Faculty Instrum.	Social Support	Faculty Underm
Dependent Variables:					
Advisor Support	-.39***				
Faculty Instrumental	-.20***	.49***			
Social Support	-.32***	.47***	.49***		
Faculty Undermine	.33***	-.37***	-.12***	-.35***	
Control Variables:					
Factors in selection of current graduate degree/program:					
Desire to do research	-.27***	.18***	.15***	.15***	-.07**
Interest/enjoyment of computing	-.11***	.08***	.07**	.08**	-0.05
Desire to apply computational techniques to other area	-0.05	-0.01	0.06	0.00	.13***
Geographic preferences or constraints	0.05	0.02	0.02	0.00	-0.01
Paid employment in computing-related field immediately prior to entering current program	-0.01	0.00	0.01	-0.01	-0.03
Full-time (1) vs. Part-time (2) student	0.03	-0.04	-0.06*	-0.06*	-0.05
Teaching Assistantship	0.00	-0.02	0.01	0.00	.07**
Research Assistantship	-0.02	.08***	.07**	.06**	-0.05*
Fellowship	0.00	-0.01	0.04	.13***	0.00
Current job outside department	0.07*	-.09***	-.08**	-.13***	-0.02
Undergrad major in Computer Science	0.00	0.02	.08**	.08**	-0.05
Undergrad major in Computer Engineering	-0.04	-0.02	-0.06*	-0.01	0.01
Other Computing Major	0.00	0.04	0.00	0.02	-0.05
Majored in non-computing discipline	.12***	0.00	0.01	-0.04	0.03
CS/CE work experience	-0.03	0.00	0.02	0.01	-.081**
CS/CE internship experience	0.01	0.01	0.01	0.04	-0.04
CS/CE undergrad research experience	0.00	0.05	.11***	.13***	-.08**
Other CS/CE experience	0.00	0.03	0.02	0.06*	-0.06**
Years since completion of bachelor's degree	0.06	0.00	-.07**	-.11***	-0.06*
Years since beginning current program	.16***	-0.037	-.08**	-.09***	0.000
age	0.04	0.00	-.08**	-.10***	-0.02
Primary caregiver to any children	-0.06*	0.03	0.00	-0.03	0.00
Native-born U.S. citizen	.15***	-.07**	0.04	0.05	-.07**
Rank (top rank=1, other = 0)	.11***	-0.01	-0.03	.09***	0.00

* Correlation is significant at $p \leq .10$

** Correlation is significant at $p \leq .05$

*** Correlation is significant at $p \leq .01$

Table B8-1: Significant Differences by Research Orientation for Student and Faculty Variables

	Higher Among High Research Programs	Higher Among Low Research Programs	No difference High and Low Research Programs
Student variables N=1079	N=608	N=471	
Student Demographics:			
Full time status	***		
Current source of funding = Research Assistantship	***		
Current source of funding = fellowship	***		
Undergrad major CS	***		
Undergrad CS/CE internship	***		
Undergrad CS/CE research experience	***		
Corporate sponsorship		**	
Current job outside dept		***	
Current source of funding = loan		*	
Years since bachelors		***	
age		***	
Primary caregiver to any children		**	
Do not expect to relocate upon completing degree		***	
Current source of funding = Teaching Assistantship			--
Student Reports of Important Factors in students' decisions to pursue current graduate degree in CS/CE:			
Desire to do research	**		
Positive undergrad experience	***		
Undergrad instructor	**		
Undergrad advisor	***		
Gain credibility		***	
Fulfill familial expectations		***	
Desire an advanced degree for its ownsake		***	
Apply computational techniques in another interest area		***	
Advance non-academic career		*	
Salary potential		***	
Dependable employment		***	
Avoid job market		*	
Spouse/Significant other		*	
Student Reports of Important Factors in selecting current program:			
Research opportunities	**		
Institution reputation*	***		
Program or professor reputation*	***		
expense*		***	
Employer tuition reimbursement*		***	
Degree from same institution*		***	
Few academic/bureaucratic obstacles*		***	
Course offerings*		***	
Convenient course times*		***	

Student Reports of Department Environment			
Department offers orientation programs	**		
Department offers grad student mentoring	*		
Department offers women's support groups	***		
Satisfaction with funding	***		
Satisfied with exposure to cutting-edge technology	***		
Satisfaction with equipment and facilities	***		
Satisfied with opportunities to attend conferences	***		
Satisfied with opportunities to do research	**		
Satisfied with dissemination of important information	*		
Satisfied with curriculum	**		
I frequently feel overwhelmed by the fast pace or heavy workload of my courses.	**		
Graduate students have a voice in departmental governance.	***		
Have helped out in the recruitment of new graduate students	***		
Social Support factor (students feel a part of faculty and peer networks)	**		
I am comfortable asking questions in class.		***	
Some courses are meant to weed out students from the program.		*	
I am confident in my ability to complete this graduate program.		***	
There are too many bureaucratic hurdles.		**	
Faculty use graduate students as a source of cheap labor to advance their own research.		***	
Excluded from study groups		**	
Faculty favor certain groups of students over others.		**	
Academic advisor is mentor		***	
Faculty-Support factor			--
Advisor-Support factor			--
Faculty-Undermine factor			--
Faculty Variables N=751			
Women-support factor (include women speakers, women support groups, etc.)	***		
Research-mentoring factor (publish research w/grads, etc., describe how to do research)	***		
Advisor-helper factor (believe advisor is responsible for helping students succeed)	***		
11_11 incoming grads participate in research	***		
16_11 all grads should participate in dept research activities	***		
16_23 dept provides career info well	*		
16_21 believe dept should recruit underrepresented groups	**		
Competition factor (courses should weed out weak; competition desirable)		**	
16_03 If a student is failing, it is usually the student's fault		*	
11_02 Flexible timetables for degree progress		*	
Career-Mentoring factor			--

Grad Involvement factor			--
Flexibility factor			--
Faculty-Respect factor			--

Significance level of differences between High and Low Research programs: * $p < .10$; ** $p < .05$; *** $p < .01$ (two tailed test).