RECRUITING AND RETAINING WOMEN GRADUATE STUDENTS IN COMPUTER SCIENCE AND ENGINEERING

Report on Research Findings and Workshop Recommendations, October 8, 2006

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1. INTRODUCTION

There is a small but growing body of literature on graduate education (see Lovitts 2001, Golde and Dore 2001, or Nettles and Millett 2006, for example), but very little is known about gender issues and computing education at the graduate level.

To advance women's participation in computing graduate programs, the Computing Research Association (CRA) published a best practices report, *Recruitment and Retention of Women Graduate Students in Computer Science and Engineering* (Cuny and Aspray 2001). To test the validity of the expert recommendations made in that report, the National Science Foundation then funded a study of faculty and students in Computer Science and Engineering (CSE) graduate programs: the CRA Graduate Recruitment and Retention (Grad R&R) project.

Toward the end of the Grad R&R project, a workshop was held in October 2006 to discuss the findings and implications for increasing women's participation in graduate CSE. The workshop goals were to:

1. Draw on research from education, gender studies, and sociology to discuss findings related to recruitment, admission, and retention practices that affect the gender balance in graduate computing programs; and

2. Test the research results against the observations of leading computer science faculty members who are involved in graduate admission and education.

Workshop participants (see inside front cover) included CSE educators, social science researchers who contributed knowledge of other empirical findings about gender diversity or graduate education, as well as leaders of organizations for change in the computing profession.

This report summarizes and expands on the results of the 2006 workshop and outlines research-based practices likely to promote gender balance in graduate computing programs. The practices are divided into three sections—recruiting,

admitting, and retaining—with recommendations for each. Each recommendation includes a summary of supporting evidence, some of which is drawn from contexts other than computing graduate education and some that is not yet published from the Grad R&R project. We speculate that findings from other settings will transfer to academic CSE, but more research is needed to test this hypothesis.

2. RESEARCH-BASED PRACTICES FOR RECRUITING

Recommendation 1: Make timetables and programs flexible, and convey the degree of flexibility available through communications with prospective students.

Women's participation is greater in graduate CS/CE programs with flexible timetables for degree progress (Lord and Cohoon 2007). Surveys show that when considering CSE graduate programs, women more than men placed importance on flexibility in program content (Cohoon and Lord 2007). Flexibility may be important to accommodate actual or anticipated responsibilities outside of work. For example, marriage and parenting often constrain women's job options and deter the progression of their academic careers (Gatta and Roos 2004; Kulis and Sicotte 2002; Wolfinger, Mason, and Goulden 2004). Despite the importance women place on flexibility, on average they do not take longer than men to earn their CSE doctoral degree (Lord and Cohoon 2007).

Recommendation 2: Arrange contact between prospective women students and faculty who are knowledgeable about diversity issues.

The gender balance is particularly unfavorable to women in computing graduate programs where faculty members meet with prospective graduate students (Cohoon and Baylor 2003; Cohoon and Lord 2007). This finding contradicts expectations that personalizing contacts with prospective women is beneficial (Cuny and Aspray 2001). Cohoon and Lord suggest that meeting prospective students has the potential to be an effective tool for recruiting women, but it may be insufficiently applied. Sufficient application would entail steering prospective women students to faculty members who value diversity and are knowledgeable about diversity issues (such as issues discussed in this report and in diversity training resources [e.g., Valian]).

Recommendation 3: Arrange for women graduate students to meet with prospective women students, and reward their efforts for doing so.

Women student recruiters had a greater impact than men recruiters on women's choice of program (Cohoon and Lord 2007). It is also the case that women recruiters are favored by male applicants; therefore this tactic cannot result in improvement of the gender balance unless departments target their women graduate students specifically to prospective women. Targeting such efforts can also reduce the chances of overburdening female graduate students with service.

Recommendation 4: Cultivate and publicize the inclusive aspects of department culture.

In focus groups, women students reported being influenced by their impressions that women had a presence in departments and could fit in. Supporting these reports is the general finding that when department publications portray women as integral members of the department, those departments have higher proportions of women students (see Appendix B). In addition, women rated department culture and impressions of faculty as moderately important to their choice of department (Cohoon and Lord 2007). Making prospective women students aware of collaborative aspects of the program and department community may portray a more appealing culture, since competitive social values appear to be especially unappealing to women (AAUW 2000; Margolis and Fisher 2001; Turkle 1984; Wright 1996). Therefore, recruiting efforts and materials, as well as actual departmental practices, should be carefully conceived to convey that diversity and community are valued.

Recommendation 5: Publicize the social applications of faculty research.

On average, females are more interested than males in the consequences of computing for the social world (Eccles 1994; Wigfield and Eccles 2000). Likewise, women more than men value careers that allow them to help others and work with people (Creamer, Burger, and Meszaros 2004; Margolis and Fisher 2001; Sax 1994). These findings may explain, in part, why Carnegie Mellon successfully recruited undergraduate women by highlighting the diverse applications and social contexts of faculty research (Margolis and Fisher 2001). Similar approaches could be used to attract women to graduate programs.

Recommendation 6: Assemble a broader applicant pool.

In general, recruitment that goes beyond the personal networks of current faculty members and actively seeks minority group members is likely to lead to more diversity. Outside of academia, open recruitment methods are associated with women holding a greater share of management jobs, while recruitment through informal networks increases the men's share (Reskin and McBrier 2000). Among CSE graduate departments, much greater effort could be put into recruiting outside of personal networks: 82 percent of faculty never or rarely actively recruit at women's colleges, and 71 percent never or rarely actively recruit at liberal arts colleges (Grad R&R data). Recruiting at these locations did not show strong effects on women's representation in this study, perhaps because such recruiting is seldom and sporadic.

Recommendation 7: Utilize diversity training to increase awareness of effective actions and ways to avoid bias.

On-line training resources describe specific actions likely to be effective in diversifying academic positions; these actions also could be applied to diversifying graduate students. For example, Virginia Valian offers a website with information about how to interview women or minority applicants, how to assemble a broader applicant pool, and how to evaluate candidates in an unbiased way.[1] An important caveat, however, is that diversity training may produce no discernible positive effects without concomitant organizational leadership on diversity issues (Kalev, Dobbin, and Kelly 2006; also see Appendix B).

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[1] Virginia Valian's website with links to recruitment resources and other resources is: http://www.hunter.cuny.edu/genderequity/equitymaterials.html. UVA also has suggestions for recruiting for diversity: http://www.virginia.edu/eop/hiring.html#TOPTEN. Another helpful source is "Diversifying the Faculty: A Guidebook for Search Committees" by Caroline Turner. Although these sources relate to diversifying faculty, some of the suggestions may be extended to diversifying graduate students.

3. RESEARCH-BASED PRACTICES FOR ADMITTING

Recommendation 1: Create leadership and oversight regarding women's representation.

In work settings, the most important factor in increasing diversity is organizational responsibility for diversity issues (Kalev, Dobbin, and Kelly 2006). Appointing staff members and/or committees to oversee diversity efforts, such as the rethinking of hiring and promotion structures, is the most effective method for addressing gender inequality in organizations (see also Bielby 2000). The creation of such oversight requires the authority, resources, and support of top management.

In academic departments, such leadership on the part of the chairperson and dean is necessary to instigate oversight on issues concerning the participation of women (Fox 2000). In some departments, a specific person or committee is assigned to actively promote gender diversity. This practice does not show a measurable effect using the Grad R&R data, but this finding could result because the assigned person is not actively overseen by the chairperson or dean, is not assigned specific duties such as evaluating admissions practices and goals, or is not a faculty member who has the authority/expertise to conduct such evaluations. Workshop participants recommend retaining the same person to oversee recruitment and admissions for an extended period of time (perhaps five years). This would make it easier to monitor the admissions process and identify trends in gender composition.

Recommendation 2: Broaden the admissions criteria to consider the applicant's life experiences.

Limiting the consideration of applicants' backgrounds to CS-related experiences may unnecessarily restrict the range of experiences that can indicate potential for success in a CSE graduate program. At the undergraduate level, emphasizing CS experience over broader academic and extracurricular skills is advantageous to male students; women's participation can be increased by shifting emphasis

to other important characteristics (Margolis and Fisher 2001). At the graduate level, consideration of life experiences has a strong positive impact on women's representation (Lord and Cohoon 2007). Such consideration need not replace high standards for grades in CS courses. Rather, it should replace an emphasis on computing experience gained as a volunteer or worker.

Recommendation 3: Employ diversity as an admission consideration.

Using membership in an under-represented group as a factor in admission to graduate CSE departments has a strong positive impact on women's representation even as stringent academic standards are maintained (Lord and Cohoon 2007). This finding is consistent with evidence suggesting that minority-sensitive admissions improve under-representation in education (Bowen and Bok 1998). Faculty members who support the use of minority status as an admission criterion do so to increase the quality of intellectual exchange (Grad R&R interview data). Again, when diversity is valued and used as a criterion in this way, there is no evidence that academic standards are compromised. Nevertheless, faculty members in some graduate CS departments expressed the belief that diversity efforts lower the academic quality of incoming students; in these departments, consideration of minority status in admission decisions is not associated with greater representation of women (Grad R&R data). Under these departmental conditions, it might be more effective to address the assumptions that associate diversity with lower academic quality than to include diversity as an admissions criterion.

Recommendation 4: Articulate clear and common goals for the outcome of the admissions process as a department.

Departments should discuss and attempt to reach consensus on admissions goals and the types of students desired. Developing consensus reduces bias in the evaluation process by bringing consistency and accountability to decision making (Long and Fox 1995). Once agreement is reached on admissions goals, appropriate criteria for admissions decisions can be developed. The determination of which criteria are appropriate should be established through systematic analysis (Bielby 2000). Discussion about the admissions process can especially contribute to diversity if it includes dialogue about how particular admissions criteria affect diversity (Gorman 2005; Karabel 2005; Margolis and Fisher 2001).

Recommendation 5: Use evaluations and admissions practices that reduce the use of unexamined or secretive judgment.

Besides being driven by consensus, criteria for admission should be formalized by being specific and explicit when possible. Formalized criteria reduce bias in selection and evaluation processes, in contrast to unexamined, vague, and ambiguous criteria that encourage the use of stereotypes and same-gender preferences (Fox 1991; Long and Fox 1995; Reskin 2000). Similarly, decision-making processes that are open to public scrutiny are likely to reduce bias because openness entails accountability (Fox 1991; Long and Fox 1995). Even so, formalized policies in isolation may be insufficient to reduce bias in the absence of oversight (discussed in #1 of this section) on issues of diversity representation (Bielby 2000).

Recommendation 6: Record data on recruitment and admissions practices and outcomes by sex, and report the results annually.

In work settings, plans that set goals and monitor progress for increasing diversity are more likely to actually increase diversity (Kalev, Dobbin, and Kelly 2006). Regular monitoring and analysis of gender patterns in hiring build accountability for minority representation (Bielby 2000). Keeping records also enables departments to examine the effects of their criteria on the gender balance and to assess admissions practices. Only 50 percent of CSE graduate departments routinely collect data to assess graduate recruitment and retention (Graduate R&R data).

Recommendation 7: Increase awareness of gendered effects from letters of recommendation.

References may be a good source of credentials for women under certain circumstances. One such circumstance is when letters from sources outside the personal networks of faculty members are given due consideration. Research in work settings shows that dependence on social networks for promotion and hiring among traditionally male occupations perpetuates women's under-representation (Reskin and McBrier 2000). A similar process could be at work in CSE graduate admissions. In addition, members of the admissions committee must be alert to biases that might affect letter content. For example, a study of recommendation letters for medical faculty showed systematic differences in letter content based on gender. In contrast to letters written for women, those written for men tended to be

longer, contain fewer doubt-raisers, and include more words of praise and mention of research skills (Trix and Psenka 2003). Because of the potential for such bias, admissions committees should be cautious when comparing letters written for men to those written for women.

Recommendation 8: Train admissions committee members in practices that mitigate gender bias and stereotypes.

Research shows that in-group preferences, stereotyping and evaluation bias contribute to the under-representation of women in traditionally male fields (Cohen, Broschak, and Haveman 1998; Gorman 2005; Correll 2001, 2004; Valian 1998). Nevertheless, organizational practices can either permit or prevent these sources of bias (Reskin 2000). Training resources provide information on diversity issues that can raise faculty awareness and improve organizational and individual practices. Training resources named above (Recruitment Recommendation #6) also pertain to admissions practices. Again, this recommended training may be ineffectual without the presence of leadership on diversity issues (Kalev, Dobbin, Kelly 2006).

4. RESEARCH-BASED PRACTICES FOR RETAINING

Recommendation 1: Create leadership and accountability towards issues related to retaining women.

Just as leadership is important for improving the recruitment and admission of women into programs, accountability through a person or group with delineated responsibilities for diversity efforts is important for addressing factors associated with the retention of women. Research strongly supports that accountability on diversity efforts is necessary for more specific practices (such as formalizing evaluation processes) to be effective at increasing diversity (Bielby 2000; Kalev et al. 2006; Kmec 2005). Once again, the creation of such oversight requires authority, resources, and support at the institutional level (BEST 2004), as well as leadership at the departmental level.

Recommendation 2: Develop a tracking, monitoring, and feedback system for doctoral students.

Just as admissions data can be recorded and monitored, so too can data on gendered patterns of retention. In addition, an annual survey can provide regular feedback from students about perceptions of barriers to degree advancement (as well as helpful practices) and perceptions of the faculty's commitment to diversity (Bielby 2000).

Recommendation 3: Support and reward faculty advising and retention of advisees through timely completion of degree.

Advisors are a key element in student retention, but advising relationships can be less helpful for women than for men (Fox 2001; Litzler, Lange, and Brainard 2005). Evidence shows that helpful advising relationships affect women's representation by providing assistance with designing research, writing grant proposals, coauthoring publications, and organizing people (Fox 2001). When women report adequate time with their advisor, and report receiving feedback on their progress towards their degree, indicators for retention are improved,

and this effect is much stronger for women than for men (Cohoon 2007; also see Appendix B). Advising may be improved by developing written guidelines outlining advisor responsibilities, including providing feedback on research and publishing as well as advice on careers and professional development. Means for supporting and rewarding faculty success as advisors should be explored.

Recommendation 4: Develop written guidelines with clear criteria for graduate student evaluations.

Bias can result from informal and flexible processes of evaluation (Fox and Colatrella 2006). Departments can mitigate bias by writing guidelines for sufficiency of work to earn the doctoral degree, and by setting the standard by which the work is judged. Departments that have clear, written, and transparent guidelines for advancement are more likely to have a higher representation of women (Fox 2000; Fox 2001; Fox and Colatrella 2006). Performance standards, and whether a student's work meets those standards, should also be communicated clearly to the students; research shows that women often underestimate their performance in traditionally male contexts (Correll 2004). This underestimation can lead to departure of qualified students.

Recommendation 5: Promote interaction between students and faculty, as well as among graduate students.

Women benefit from practices that facilitate their incorporation into networks because social networks facilitate research opportunities (Fox 2006). Women graduate students in CSE are less likely than men to have informal access to helpful contact with faculty, and they are less likely to report that faculty members are available for one-on-one advising (Cohoon 2007; Fox 2001). In departments where women do feel included in a social network with faculty, and where faculty stress the importance of strong communication and interaction between faculty and students, retention rates are higher (Cohoon 2007; Fox 2000).

Women in majority-male fields also have less access than men to networks of peers, which can lead to fewer collaborations with male graduate students (Fox 2001; Litzler, Lange, and Brainard 2005; Roth 2006). To increase peer support, departments can facilitate student community. Interestingly, faculty encouragement of *study* groups reduces women's thoughts of leaving more than does faculty support of *women's* groups (see Appendix B).

The remaining recommendations 6-11 provide additional steps that can be taken to increase graduate women's interaction with faculty and other students.

Recommendation 6: Integrate women students into the research culture of the department as early as possible.

Data from the Grad R&R study (see Appendix B) reveal that when women CSE graduate students say a research group readily accepted them and that they are satisfied with opportunities to do research, they are less likely to think of leaving. They also feel more networked with other students and faculty, and feel their department has a supportive environment. Therefore, integrating students into research early in the program should improve women's retention rates.

Recommendation 7: Facilitate graduate students' involvement in the professional community.

When CS faculty say graduate student participation in professional organizations is encouraged in their department, women in their department are less likely to think of leaving (see Appendix B). Similarly, when women graduate students say that faculty members help them make professional contacts, they are less likely to think of leaving. Faculty encouragement of student participation in professional organizations appears to be more important for women students than for men students, and thus may improve the gender difference in retention rates (Grad R&R data).

Recommendation 8: Standardize methods for delivering information in your department. Establish widely known procedures for seeking informal advice or filing grievances.

Standardizing the methods by which students receive information, advice, and help with problems means they do not have to be part of an informal social network to receive it. When women CS graduate students report more satisfaction with dissemination of important information, with administrative supportiveness, and with career mentoring, they are less likely to think of leaving (see Appendix B). Similarly, when women report that there is a departmental person or office they can turn to for help with addressing problems, they are less likely to think of leaving.

Recommendation 9: Facilitate mentoring.

When women say that faculty members other than their advisor take an interest in their degree progress, they are less likely to think of leaving (see Appendix B). One way to broaden students' networks is through mentoring programs. There is evidence that mentoring, especially for the purpose of increasing diversity, increases women's retention rates (Cohoon 2006).

The advisory board made the following recommendations for facilitating mentoring. Involve both men and women students and faculty in mentoring efforts. Make industry, government, and non-profit mentors available as appropriate. Allow a choice of mentors for students. Train faculty members how to mentor.[2] For example, train them in the types of information to pass along. Develop guidelines for mentoring (for both faculty and students). Allow faculty and students to have no-fault termination of the mentoring relationship. Avoid overburdening particular faculty (this often happens with women faculty). Provide mentors with incentives; in other words, departments or institutions may need to allocate resources to mentoring efforts.

Recommendation 10: Recommend methods faculty can use to promote the inclusion of women in the classroom and in the lab.

For women graduate students in CSE, comfort asking questions in class is a strong predictor of their confidence that they can complete their program; however, graduate women feel less comfortable than their male classmates asking questions in class (Cohoon 2007). One way to ameliorate gender differences in classroom experiences is to alter the communication styles in CSE classrooms (Garvin-Doxas and Barker 2004). Garvin-Doxas and Barker suggest cultivating a classroom atmosphere where passing judgment is avoided, all questions are treated with respect, students' ideas and thoughts are explored, and learning is collaborative.[3]

Similarly, women graduate students in STEM report less comfort speaking in research group meetings than do their male peers (Fox 2001). Recommendations

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[2] The National Center for Women and IT offers a Program in a Box to guide individual mentors. See: http://www.ncwit.org/practices.box.html.

[3] For more information on collaborative learning, see: http://tlt.suny.edu/originaldocumentation/library/cooperative.htm.

on how to lead lab meetings could be based on the findings regarding gender and classroom climate above.

Recommendation 11: Broaden the institutional culture of the department to accept a range of personal choices in balancing work and life.

Women are less likely to think of leaving if they feel the demands of their program leave them with adequate time for a social or family life (see Appendix B). Women are more likely to feel they have time for a social or family life in departments where: 1) faculty report they offer flexible timetables to complete a degree and they make personal leave available to students, 2) faculty disagree that successful students put studies ahead of all other commitments, and 3) faculty disagree that competitive behavior is rewarded. Acknowledging students' family commitments as legitimate, and making timetables for degree progress and completion flexible, is thus likely to lead to higher retention rates among women (see Recommendation 1 under Practices for Recruiting).

5. APPENDICES

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B. COMPARISON OF CRA REPORT RECOMMENDATIONS TO GRAD R&R FINDINGS

The following table shows each recommendation from the Cuny and Aspray report (2001), "Recruitment and Retention of Women Graduate Students in Computer Science and Engineering," in relation to evidence from the Grad R&R study (based on correlations among variables in the chair, faculty and student surveys). All correlations control for department rank (a significant factor in women's thoughts of leaving). All analysis is for students intending to earn a doctoral degree. For each recommendation, Grad R&R findings from student-level data are listed first (based on student surveys), followed by findings from data aggregated to the department level (includes faculty, student, and chair data). Unless otherwise noted, the factors identified as relevant to women's thoughts of leaving have stronger effects for women students than for men students.

Note: Some findings of the Grad R&R study show no support for certain Cuny and Aspray (2001) recommendations. It is important to keep in mind, however, that our evidence is limited to finding effects of practices as they currently exist in departments. The possibility remains that a recruiting or admissions practice shows no effects because it is not applied appropriately, or widely, or extensively enough to be found effective using the statistical methods we employed. As a result, we have great confidence that the supported recommendations are generally effective, but we also remain open to the possibility that the unsupported recommendations are worthwhile.

Goal: Increasing the Number of Women Enrolling in a Given Department

CRA Report Recommendation	*Relevant Grad R&R Findings*
1. Broaden the recruitment pool beyond students with undergraduate CSE majors.	The average department does not consider holding an undergraduate CS degree to be among the most important factors for admission. Much more importance is placed on general quality of academic record, motivation, and letters of recommendation, none of which would disadvantage applicants without CS degrees. Evidence suggests that the effect of placing importance on holding a CS degree depends on the department. In departments where faculty members are less likely to endorse stereotyped views about women and computing,[1] requiring a CS undergraduate degree appears to decrease women's participation, but in departments with more bias, emphasizing CS degrees improves women's representation. The 2001 report suggested considering CS work or CS volunteer experience. We found, however, that such consideration generally has a negative effect on women's representation, perhaps because it is much more common among men.
2. Broaden the criteria used in admissions and be flexible in their application.	Strong supportive evidence. Specifically, emphasis on "life experiences" is a strong predictor for higher proportions of women among PhD students. Also following this CRA report recommendation, we found that emphasizing life experiences does not mean lowering standards. Neither life experiences nor women's proportion is correlated with criteria regarding academic or CS stringency, such as grades in CS courses, math background or GRE scores. Even in departments where faculty hold stereotyped views about women and computing, admission criteria that include consideration of life experiences predicts women's representation. Note: Most departments feel that motivation, communication skills, and maturity are

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[1] Endorsing a stereotyped view about women and computing was measured by level of agreement with the statement: "CS/CE as a discipline is inherently unattractive to women."

CRA Report Recommendation	Relevant Grad R&R Findings
	very or extremely important criteria for graduate admission. These criteria have no discernible effects on women's representation.
3. Encourage reentry students.	No supportive evidence yet. We found no measurable effects from the importance departments place on students having been away from formal education for a time. Among student respondents, there are also no significant differences between men and women students in the number of years since they received their bachelor's degree, in whether they worked full-time previously, or in whether they held a computing job previously. This finding suggests either that male and female potential students share these characteristics or, perhaps more likely, that those who differ are filtered out.
4. Provide bridging opportunities to entering graduate students.	No supportive evidence yet. Faculty members generally agree that incoming graduate students should have the opportunity to fill gaps in their computer science background without prejudicing evaluations of their progress. In departments where faculty hold stereotyped views about women and computing, however, agreement with this recommendation is actually associated with lower representation of women.
5. Explicitly include diversity considerations in your admissions process.	Strong supportive evidence. In departments where few faculty members endorse stereotypes about women and computing, placing importance on membership in an under-represented group has a strong positive effect on women's representation. In other departments, however, placing importance on such membership has no measurable effect.
6. Be proactive in making recruiting contacts.	Some weak evidence. In general, faculty members are not proactive in making recruiting contacts. On average,

CRA Report Recommendation	Relevant Grad R&R Findings
	faculty report never or rarely recruiting at women's colleges or at liberal arts colleges, and they report only rarely or sometimes making contacts with undergrad CSE departments in general. However, when chairpersons say their department actively recruits from liberal arts colleges, there is a weak positive association with women's representation.*** Faculty believe the most effective action for increasing women's enrollment is meeting with prospective students who visit the department, and encouraging individual students to apply. However, meeting with prospectives has no measurable positive results for women's enrollment, perhaps because such meetings seldom specifically target women.
7. Review all departmental publications for both text and images containing overt or subtle messages that might discourage women from applying.	Supportive evidence. In departments where the chairperson says publications portray women as integral members of the department, there is a higher proportion of women students.***

Goal: Increasing the Number of Women in CSE Graduate Programs Nationally

(The Grad R&R instruments were not designed to test the effectiveness of these recommendations, but they provide relevant descriptive data.)

CRA Report Recommendation	Relevant Grad R&R Findings
8. Inform your undergraduates about the opportunities and rewards of a research career.	Faculty report that they frequently encourage promising undergraduates to go on to graduate school. Women graduate students* are significantly more likely than men to indicate that participation in a special program that encouraged graduate study was important to their decision to pursue a CSE graduate degree.
9. Provide undergraduate women with exposure to computing research.	Faculty report on average that they involve undergraduates in their research between sometimes and frequently. Women graduate

CRA Report Recommendation	Relevant Grad R&R Findings
	students* are significantly more likely than men to say that positive prior research experience was important to their decision to pursue a CSE graduate degree.
10. Give individual encouragement to your women undergraduates.	Women graduate students* are significantly more likely than men to say that an undergraduate instructor or advisor was important to their decision to pursue a CSE graduate degree.
11. Actively counter negative stereotypes and misperceptions of computer science and engineering.	No information.
12. Provide women role models for your undergraduates.	No information.

Goal: Retaining Women Through Graduation

CRA Report Recommendation	Relevant Grad R&R Findings
13. Be diligent at mentoring women graduate students.	Strong supportive evidence. High-quality advising includes some mentoring behaviors. When women say they are satisfied with the quality of advising, especially when they say their advisor gives them feedback on their progress towards their degree, they are much less likely to think of leaving. In many departments, when faculty say they encourage individual graduates to pursue research careers, describe how to get involved with research,** compliment a woman graduate student on accomplishments, advocate on behalf of students, and encourage a student's personal growth, women are much less likely to consider leaving.
14. Help to create a peer community for your women students.	Some supportive evidence. There is no evidence of fewer thoughts of leaving among women graduate students

CRA Report Recommendation	Relevant Grad R&R Findings
	who say their department offers official support groups for women. Nevertheless, when women feel their department has a supportive environment and a supportive student community, they are less likely to think of leaving.

Women are most likely to report social support in departments where faculty report that incoming graduate students are given the opportunity to participate in research, and when faculty disagree with the statement that 'competition among graduate students is a desirable part of graduate school.' |
| 15. Broaden the institutional culture of the department to accept a range of personal choices in balancing work and life. | Supportive evidence.

Women are less likely to think of leaving if they feel the demands of their program leave them with adequate time for a social or family life.

Women are more likely to feel they have time for a social or family life in departments where: 1) faculty report they offer flexible timetables to complete the degree and make personal leave available to students, 2) faculty disagree with the statement that 'successful students put studies ahead of all other commitments,' and 3) faculty disagree with the statement that 'competitive behavior is rewarded.' |
| 16. Provide women role models. | No supportive evidence.

In departments with higher proportions of women faculty, women students are no less likely to think of leaving. Also, when faculty say they routinely include women as visiting faculty or guest speakers, and that the successes of women in the department are showcased, we found no effect on women students' thoughts of leaving. |

CRA Report Recommendation	Relevant Grad R&R Findings
17. Integrate students into the research culture of the department as early as possible.	Supportive evidence. Departments where faculty say incoming students are given the opportunity to participate in research have higher proportions of women students. When women students say a research group readily accepted them, and that they are satisfied with opportunities to do research, they are less likely to think of leaving. They also feel networked with other students and faculty, and feel their department has a supportive environment. (We found no supporting correlations between faculty reports of early research involvement and women's thoughts of leaving, however.)
18. Help women graduate students become involved in the professional community as well as the departmental community.	Supportive evidence. When women students say they are satisfied with opportunities to attend professional conferences, and that faculty members help them make professional contacts, they are less likely to think of leaving. Similarly, when faculty say they help graduate students get involved with professional associations, women graduate students are less likely to think of leaving.
19. Standardize the methods your department uses for delivering information so students do not have to be part of an informal social network to receive it.	Supportive evidence. When women students say they are satisfied with dissemination of important information, they are less likely to think of leaving. (We found no supporting correlations between faculty reports of effective information dissemination and women students' reports of information dissemination, or women's thoughts of leaving, however.)

CRA Report Recommendation	*Relevant Grad R&R Findings*

20. Change the departmental infrastructure to better promote the equal participation of women.	Diversity committee – We found no evidence that a designated individual or committee to actively promote gender diversity in the department correlates with proportion of women, thoughts of leaving, or women's confidence.***
	
	Proactively addressing sexual harassment – We found no supporting evidence.
	
	Diversity training – We found no supporting evidence.
	
	Routinely collecting data to assess graduate recruitment and retention – We found no supporting evidence.***
	
	Clear and widely known procedures for seeking informal advice or filing grievances – We found support for this recommendation.
	
	    Women's reports that there is a departmental person or office they can turn to for help with problems, their satisfaction with administrative supportiveness, and their disagreement with the statement that 'there are too many bureaucratic hurdles' are all negatively related to thoughts of leaving. However, effects are stronger for men than for women.
	
	Structural mechanisms for good advising – We found some support.
	  • When women say they can switch advisors without negative consequences, they are less likely to think of leaving.
	  • (Related faculty variables are not correlated with women's thoughts of leaving at the department level.)

   * Native-born women only.
  ** Most influential factor in this list of factors.
*** Analysis is based on data from department chairs, which provided 40 cases or less.

RECOMMENDED PRACTICES
AT A GLANCE

A. Recruiting

1. Make timetables and programs flexible, and convey the degree of flexibility available through communications to prospective students.
2. Arrange contact between prospective women students and faculty knowledgeable about diversity issues.
3. Arrange for women graduate students to meet with prospective women students.
4. Highlight the inclusive aspects of department culture.
5. Publicize the social applications of computing.
6. Assemble a broader applicant pool.
7. Utilize diversity training.

B. Admitting

1. Create leadership and oversight regarding women's representation.
2. Broaden the admissions criteria to consider applicants' life experiences.
3. Employ diversity as an admission consideration.
4. Articulate clear and common goals for the outcome of the admissions process.
5. Use admissions practices that reduce the use of unexamined or secretive judgment.
6. Record and report data on recruitment and admissions outcomes by sex.
7. Be aware of gendered effects from letters of recommendation.
8. Train admissions committee members in practices that mitigate gender bias.

C. Retaining

1. Create leadership and accountability towards issues of retaining women.
2. Develop a tracking, monitoring, and feedback system for doctoral students.
3. Support and reward faculty advising and retention of advisees.
4. Develop written guidelines specifying clear criteria for graduate student evaluations.
5. Promote interaction between students and faculty as well as among graduate students.
6. Integrate women into the research culture of the department as early as possible.
7. Facilitate graduate students' involvement in the professional community.
8. Standardize methods for delivering information, for seeking informal advice, and for filing grievances.
9. Facilitate mentoring.
10. Recommend methods faculty can use to promote women's inclusion in the classroom and in the lab.
11. Broaden the institutional culture of the department to accept a range of personal choices in balancing work and life.