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# Recruiting and Retaining Women in Undergraduate Computing Majors

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## Introduction

This paper recommends methods for increasing female participation in undergraduate computer science. The recommendations are based on recent and on-going research into the gender gap in computer science and related disciplines. They are intended to work in tandem with the Computing Research Association's recommendations for graduate programs (see [18] in this issue) to promote a general increase in women's participation in computing professions.

Most of the suggestions offered here could improve the educational environment for both male and female students. However, general improvements are likely to be of particular benefit to women because women in our society do not generally receive the same level of support that men receive for entering and persisting in this field. Parents, friends, and classmates seldom encourage women to choose and continue in a computing discipline. Those few women who declare a computing major tend to experience continued lack of support throughout their education. They have few female peers to call on for help. Furthermore, students in their own and other majors may consider them odd. Even faculty can discourage women with unthinking remarks or with expectations based on the assumption that men's behavior and experience are the basis for success in computing majors. This lack of support can block or weaken women's commitment to computing. Moreover, when conditions in a department are generally unfavorable, those with a weakened commitment to the discipline often leave at higher rates than those who have sufficient support to overcome the conditions.

## 1. Recruiting Women

Actively recruiting women into the major is the single most effective means of increasing female participation in computing programs. It has the twofold benefit of bringing more women into the discipline and into the recruiting department. In addition, it also helps retain women because having more women in a program facilitates the crucial peer support that all computing students need [4]. This point was illustrated by students who voiced the strongest theme heard in focus groups conducted across the United States: classmates can be the most effective means of helping undergraduates cope with the difficulties of being a computing major [2]. Support

from other female students helps to keep women in the program so that those recruited are also retained through graduation.

Understanding what attracts women to computing majors can help with planning a recruitment strategy. Qualitative research involving 18 large departments across the U.S. showed that undergraduate women who decide to major in computer science often do so for the following reasons:

- They believe that computing fits their personal strengths or abilities.
- They have friends and family who support and encourage their decision to major in this field.
- Computing offers an opportunity to be creative.
- They anticipate careers that pay well and offer a variety of ways to apply their skills [2].

A recruitment program that highlights these attractive features of computing can help draw more women into the discipline.

The same research also found that three important factors in undergraduate women's choice of a particular computing program are: the department's reputation for quality, cost, and location [2]. These factors suggest that an effective recruitment strategy would focus on the program's public image, value, and financing options, and it might include a component that targets women who live in the institution's geographic region.

### 1.1 Recommendations for Recruiting Women

The specific recommendations that follow identify productive approaches and likely sources of women who could be qualified and interested in studying computer science. Recommendations 1 through 6 focus on how and where departments or institutional representatives can reach out to these women. Recommendations 7 through 9 focus on internal policies and practices that can affect the numbers of women who enter computer science programs.

#### 1.1.1 Outreach

Given our society's image of computing as a male activity, few women are likely to consider a computer science major unless they are explicitly encouraged to do so. Colleges, uni-

versities, and their computing programs can provide this encouragement in a variety of settings. They can reach prospective students in high schools, community colleges, civic groups, and within their own institutions. Contact with high school and community college teachers, counselors, and students, as well as with civic groups and the local population can be a powerful recruiting mechanism. Through these contacts, baccalaureate-level programs can disseminate information that combats stereotyped images of computer scientists: they can provide female role models who demonstrate that women do enjoy computing and succeed at it; and they can exhibit creative computing products that help people or are particularly relevant to the lives of women. When computing departments or their representatives take the initiative in these ways, they can increase the numbers of women who enter both the discipline and their particular programs.

*Recommendation 1:*

*Work with high-school teachers.*

During high school, students make choices that affect their career options. These decisions are reversible, but they do influence students' subsequent choice of college major [7]. By working with high-school teachers to both improve their instructional techniques in computer science and sensitize them to relevant gender issues, colleges and universities can increase the flow of prepared and interested female students to the post-secondary level. The effectiveness of this approach can be seen at Carnegie Mellon University (CMU) [8]. At CMU, summer workshops instruct high-school Advanced Placement teachers in the C++ language and object-oriented programming while passing along techniques for recruiting and retaining girls. One result of this program is that "the percentage of [male and female] students in each class entering the School of Computer Science from [participating high schools] has more than doubled since the beginning of the project" [8].

*Recommendation 2:*

*Communicate with high-school guidance counselors.*

Guidance counselors are a source of information for students making college choices. Educating these professionals about the rewarding opportunities available to women in computer science helps to counteract negative stereotypes and increases the likelihood that they will encourage their female students to consider a computing major. The CMU program encourages high-school teachers to pass along the information they learn about gender issues in computing to their counselor colleagues. As a result, girls participate in computing classes at higher levels, prompting one high-school teacher to credit her school's guidance counselor for the fact that almost half the enrollment in her advanced placement class was female [8].

*Recommendation 3:*

*Use role models to actively recruit high-school students.*

Role models can be quite effective at attracting more women

into computer science. Departments can involve their current undergraduate women in recruitment visits to high schools. While there, current undergraduates can talk about their experiences as computing majors and their career plans. These student role models help high-school students envision themselves working toward a similar future in the same way that female faculty role models help college students envision a future in computing. An example of such a program can be seen at Louisiana State University where recent alumnae of St. Joseph's High School serve as effective role models at their former high school [6].

*Recommendation 4:*

*Develop relationships with community colleges.*

Forty-six percent of the 11,233 associate degrees in Computer and Information Sciences at 2-year, Title IV-participating, degree-granting institutions in the U.S. went to women in 1997-98 [11]. Forty-six percent is much higher than the 27% of computer science degrees that went to women at the baccalaureate level. Certainly, many people who attend community colleges have different goals from those who attend 4-year colleges. Only a small percentage of associate degree recipients go on to study at a 4-year institution, and women are even less likely than men to do so [15]. However, the gender composition of computing associate degrees suggests that community colleges can be an excellent source of women with an interest in studying computing. When baccalaureate-computing programs work with community college faculty and counselors in a fashion similar to that recommended for high-school outreach, they can tap into an under-utilized source of women who are potential computing majors.

*Recommendation 5:*

*Make contact with the local community.*

Women, particularly those with children, may be less geographically mobile than men [12]. For this reason, the local community may include many women interested in earning a computing degree if that community also offers a strong job market for computing professionals. For example, preliminary results from a project designed to bring IT training, education, and employment to rural communities found that the majority of the interested individuals were women [16]. This project works with community leaders and the local population to distribute information about the project and the opportunities it provides for information technology training. Contacts of this nature between providers of computing education and local groups can tap into a source of potential female computing majors, disseminate information that counters negative stereotypes of the profession, and market available training and education programs.

*Recommendation 6:*

*Recruit first and second year students from within your institution.*

Recruiting from among first and second-year students within a university can be quite productive because many of the

women who major in computer science initially intend a different major. In fact, numerous female participants in our national study began as intended pre-med majors [2].

Many departments offer events for prospective majors that can include special components designed to target women. For example, a meeting where alumnae speak about their careers and female students speak about the computer science program and their experiences in it can help prospective majors decide whether computing is right for them. Women can be encouraged to attend these meetings with effective advertising, offers of food or other incentives, and, perhaps most importantly, personal invitations to promising students in introductory and service courses.

### 1.1.2 Internal Policies and Practices

#### *Recommendation 7:*

*Consider the impact that selection criteria for program admission can have on women's enrollment.*

In response to overwhelming demand for their programs, some departments have instituted application processes for admission into the major. These processes can have the unintended effect of filtering out interested women who might have done well in computer science, particularly if the process is not based on hard evidence of the characteristics necessary for student success. An example of how unintended filtering might occur is seen with experience criteria. Women often develop an interest in computing at a later age than men resulting in their having less computing experience than men at college age [9]. Thus, if selection criteria favor students who already have extensive computing experience, they are likely to disadvantage women. This disadvantage would be unwarranted if prior experience is not necessary for success (as it has proven not to be in Carnegie Mellon University's program [10]). Thus, rather than focus on experience alone, departments should look for strong female candidates among those who took challenging courses and earned high grades, even if many of these courses were not in computer science.

#### *Recommendation 8:*

*Offer multiple points of entry.*

An introductory curriculum that helps overcome differences in student backgrounds and experience can be an effective way to welcome women into a program. Offer multiple course sections when possible or incorporate pedagogical strategies that take into account the extent of beginning students' prior experience. These strategies can prevent introductory courses from being either too difficult or too easy, and they provide a gradual start for students who are uncertain about their interest and ability. As a result, they help retain students through the early stages of a program, the stages at which most attrition occurs [3].

#### *Recommendation 9:*

*Review public information for the image it projects.*

Do printed information and other media that represent the department and its programs portray women as only passive observers? Do they portray women at all? Public information can reinforce the image of computer scientists as obsessive nerds, or it can project an image of a program that welcomes students from all demographic groups who wish to engage in interesting, challenging, and creative technical work. Overcoming negative stereotypes is an important step toward drawing more women into computing majors. Projecting an inclusive image of the discipline contributes to accomplishing this task.

## 2. Retaining Women

Without adequate peer support, women are likely to leave computing programs at higher rates than men leave [4]. When a department's gender composition is unbalanced, women have less access to support from female classmates. This lack of support leaves women particularly vulnerable to unfavorable departmental conditions. However, lack of peer support can be overcome when the faculty and the larger environment create favorable conditions [4].

### 2.1 Recommendations for Retaining Women

The following recommendations intend to compensate for the lack of support experienced by most women in a computing major. Recommendations 10 through 16 focus on ways faculty can help to compensate for the support that is lacking. Recommendations 17 through 19 focus on ways institutional and community resources can help to compensate for the support that is lacking.

#### 2.1.1 Support from Faculty

##### *Recommendation 10:*

*Maintain a stable faculty.*

High turnover among the faculty is associated with a disproportionate loss of women computer science majors [4]. This outcome could result because departments with high faculty turnover might not be able to reliably offer the courses that students need to progress toward graduation. High turnover might also indicate that faculty have a weak commitment to teaching, or are dissatisfied with conditions in the department. Any or all of these circumstances could create a poor environment for students and contribute to the loss of women who lack sufficient support for overcoming unfavorable conditions.

##### *Recommendation 11:*

*Provide female role models.*

Role models can be a powerful aid in retaining undergraduate women. Faculty and upper-level student role models provide evidence that women can succeed in computing disciplines. This evidence inspires other women to enter and persist in computing programs. Research differs in its conclusions about the numbers and nature of role models necessary for this positive impact [4, 5]. However, there is consensus that under the right conditions role models are an effective

means of promoting retention. When implementing this recommendation, departments should consider that it might be difficult to retain a lone woman on the faculty in the same way that it is difficult to retain students with little peer support.

*Recommendation 12:*

*Employ faculty who enjoy teaching undergraduates.*

Pedagogical and curricular issues are the focus of much discussion about how to increase women's participation in computer science. Departments have low overall attrition rates when the average faculty member reports deriving a high degree of personal satisfaction from teaching undergraduates [3]. This intrinsic motivation to teach is also associated with comparably low attrition rates for women [4]. Likewise, female attrition is relatively low in departments where faculty members believe they play an important role in the success of their students [4]. These results underscore the important role teaching can play in retention of women in computing majors. Quality teaching can help overcome the disproportionately negative effect of otherwise unfavorable environments. We can retain students, especially those in the vulnerable early stages of their undergraduate program, when they primarily encounter their department's most accessible, motivated teachers.

*Recommendation 13:*

*Promote interaction among classmates, and develop learning communities and other forms of peer support.*

Some faculty facilitate the formation of friendship networks among students in their classes [2]. Their actions could foster the peer support that all students find essential to success in a computing major, but that women typically have more trouble finding. Given the strong effect of peer support, it seems well worth the effort to have students introduce themselves to each other and to the class (if size permits), to create a list of names and contact information for class members, and to promote student involvement in professional organizations. These actions encourage the formation of support networks that proved effective for the retention of under-represented groups in other science, mathematics, engineering, and technology disciplines [13].

*Recommendation 14:*

*Mentor undergraduates.*

Faculty mentoring can help retain women [4]. The story of one student's experience with supportive faculty members illustrates how personal positive interactions with faculty can reduce uncertainty and improve self-confidence. Professor X was ... very encouraging. He was a really nice guy and a good teacher ... . You could go to his office. You wanted a letter of recommendation; he'd help you out. You wanted another book to read about something else; he'd help you out. And that kind of thing has been encouraging. I also had Professor Y last semester for [course XX], and in the beginning I was having such a hard time ... with the class

itself. And for me, she was encouraging because she was, "Just keep at it. You can do it. We need more women in the field." [Laughter from other members of the focus group.] And, yeah. You're laughing, but it's true. It made me feel better. At least she's ... aware that I'm trying, and I'm not just stupid, and she thought I could do it [2].

With mentoring from faculty members, this undergraduate woman eventually progressed to a point where she was engaged in research. When her own confidence failed her, she relied on her mentors' confidence in her. With their support, she was persisting.

*Recommendation 15:*

*Communicate positive opinions of female students' strengths.*

Expressing favorable opinions of female students' abilities and accomplishments might help overcome women's often noted [14] lack of self-confidence in their computing skills [17]. Some evidence suggests that departments retain female students at comparable rates to men when faculty members value their female students' strengths [4]. For example, in departments that retain women at comparable rates to men, faculty often praise the women in their program for being diligent, willing to learn, and organized. However, we could see these same characteristics in a different light and described as perfectionism, lack of confidence, and reluctance to make heroic efforts (i.e. work all night in the lab). Preliminary findings suggest that female retention is promoted in environments where the more favorable interpretations are prevalent [4], and where these favorable characterizations are expressed to students [17].

*Recommendation 16:*

*Involve women in research.*

Student engagement in faculty research has a strong positive effect on student retention in undergraduate science, mathematics, engineering, and technology majors [1]. Although most undergraduates have no research experience, those who do are quite enthusiastic about it [2]. Engaging in research has positive effects on undergraduate persistence in the same way it promotes graduate student persistence.

### 2.1.2 Support from Institutional and Community Sources

*Recommendation 17:*

*Build institutional support so the program will have adequate resources.*

Departments with strong institutional support are better able to retain women at rates comparable to men [4]. This finding is likely due to negative impacts from insufficient faculty, space, and equipment. It is a clear example of how conditions that deter students of both sexes can have a disproportionately negative effect on women's retention. Both men and women are frustrated and discouraged by lack of resources [2]. Women in these departments might leave at higher rates because of the extra assertiveness it takes to

compete for scarce resources and/or because difficulty obtaining resources lessens an already weakened attachment to the discipline.

*Recommendation 18:*

*Use the local job market to provide students with work experience.*

Employers can foster students' persistence in computing programs by their employment experiences. Employment offers students the chance to produce something of value and to see it used. Employment also offers expanded access to role models, mentors, and professional peers [2]. Likewise, internships with competent supervisors can have a positive influence on student persistence [2]. For these reasons, departments should work with local employers to facilitate an appropriate degree of student work experience (i.e., not so much that it interferes with students' academic responsibilities.)

*Recommendation 19:*

*Provide students with opportunities to volunteer their computing skills in service to the community.*

In the same way, that employment offers students a chance to apply what they have learned and produce something useful, community service can be a positive experience. In addition, service to the community is an opportunity to help others, an aspect of computing that many women appreciate [2]. In this way, volunteer experiences can demonstrate the value of computing skills and nourish women's commitment to the discipline.

### 3. Conclusion

The most important message offered here is that female under-representation in computer science is not an intractable gender difference. Departments can have a significant impact on under-representation through recruitment and retention of women at the undergraduate level. Outstanding results have been achieved by implementing recommendations similar to those described in this paper. (See [19] in this issue.) With thought and commitment, we can recreate these accomplishments in many computing departments until women's participation in the discipline reaches an equitable level.

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