Leveling the CS1 Playing Field

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ABSTRACT

This paper includes several reasons for the underrepresentation of women in computing, and then describes two low-cost project instances that address the reasons for the decline in women's enrollment in computing classes. One project spans seven semesters from fall 2000 to spring 2006 at a small liberal arts school; the other, the spring 2006 semester at a large research institution. Concluding sections provide anecdotal and statistical evidence that the project is successful over two time periods within two diverse schools.

Categories and Subject Descriptors

K.4.m   **[Computing Milieu]:** Computing and Society – miscellaneous

General Terms

Human Factors.

Keywords

Underrepresentation, gender, recruiting and retention

1. INTRODUCTION

The lead author has taught Computer Science 1 (CS1) for twenty-seven years, hearing the all-too-familiar stories, which women confide with depressing frequency. The stories concern lack of confidence in computing skills and unfamiliarity with possible computing careers, among other recurring themes. The authors seek to change the stories that women tell by inventing various recruitment and retention strategies. The paper discusses one such strategy: sending letters of invitation to first-year, undergraduate women, asking them enroll in CS1 when they register for classes. The authors describe two different sets of follow-up activities to the invitation. One provides instruction necessary to complete the first closed laboratory in CS1; the other, offers weekly tutoring.

2. STATISTICAL REPRESENTATION OF THE PLAYING FIELD

Two initial reports [3, 4] -- identifying and measuring the problem of recruitment and retention of women in computing -- continue to galvanize professionals who care about the ramifications of underrepresentation of women in computing. Figure 1 extends and updates the statistics from the two reports. The columns indicate the female percents of undergraduate women obtaining undergraduate degrees in corresponding academic years. Abundant additional sources [10] acknowledge these statistical data, and many call for improvements in specified areas in order to increase the representation of women in computing, as the following section suggests.
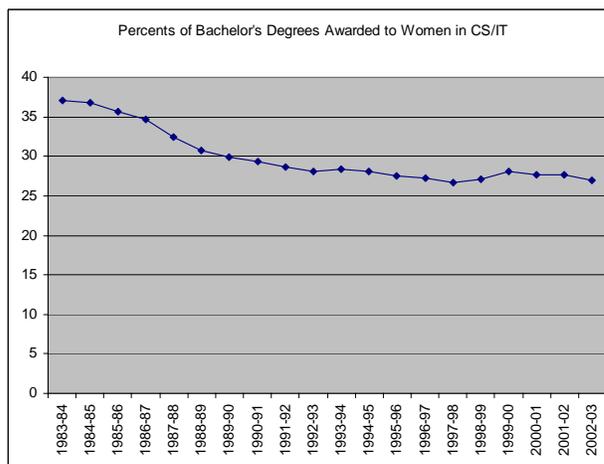

Figure 1: Percentage of Women Receiving Bachelor Degrees

Academic year 1983-84 lists the largest female undergraduate percent (37.1), followed by a fairly steady decline of almost ten percent to the most recently published 27.0 percent [12]. Furthermore, while the percents of bachelor's degrees awarded to women in computing-related fields decrease in the time period, overall enrollment and awarded degrees for women in all fields increase substantially [13]. The 2000 National Science Foundation (NSF) report notes mathematics and computer science as the only areas with declines for women. Also, computer science is the only scientific field to sharply drop in the percentage of women receiving bachelor's degrees in the last decade, and the NSF report singles out computer science, as an area of concern [14].

3. REASONS FOR THE UNLEVEL PLAYING FIELD

We list three reasons for the underrepresentation of women in computing. Additional explanations exist, but the following list represents three of the most salient reasons that women avoid computing degree programs.

3.1 Lifestyle and Priorities Misconceptions

Distorted visions of the priorities or lifestyles necessary to becoming a successful computer scientist [8, 9, 10, 15] can cause women to avoid the field. Women often indicate that they believe it will be necessary to work extremely long hours and to focus all energy on computing (to the exclusion of friends, family, hobbies, personal time, recreation, etc.) in order to succeed in the computing field. Furthermore, many women state that, although they enjoy computing, they often drop out of computer science programs, because they fear that they must adopt the computing-focused lifestyles that societal stereotypes and, often, male peers themselves embody.

3.2 Lack of Information Regarding Potential Career Paths

Narrow perceptions of available career paths [5, 6, 7] create an imposing barrier for many women. Many women lament that they do not want to spend their lives "programming in a cubicle," as the myth of the assured cubicle outcome proves to be particularly resistant. These same women indicate that they wish to have jobs that involve people or helping people. The "cubicle" and "people" concepts occur with nearly guaranteed frequency in undergraduate women's conversations about futures in computing.

3.3 Need for Role Models

Scarcity of role models [1, 2, 11, 14, 16] causes females to avoid and abandon undergraduate computer science programs because they fail to identify with the older male students and the male professors who teach their classes. Identification with slightly older women inspires and motivates a younger woman, as she can imagine herself in the role model's position and is reassured that someone similar to her has succeeded in her school's program.

4. PROJECT IMPLEMENTATION: SMALL LIBERAL ARTS INSTITUTION

Here we describe a project that is appropriate for a relatively small college student population. We demonstrate how the project components correct the three reasons that cause women to avoid computing. Subsequent sections illustrate an application suitable for a large university student population and then measure success of both project implementations.

4.1 Mail Descriptions

During each of seven semesters, we obtained mailing labels for every first-year woman (approximately 325) attending our undergraduate institution. We mailed a one-page letter (which was purposely informal), wrapped around a color brochure, stapled and affixed with the mailing label. Female students received the packets on the first day of advising for registration. We spent only thirty-five cents per woman and could have spent much less by foregoing professional printing of the brochure.

Abbreviated text of one of the letters to first-year women follows:

Hi! I am writing to encourage you to consider taking "Computer Science I" (CSC121), as you think about registration. Computer Science is a wonderful major for women. There are tons of opportunities for women in computing: finding jobs after graduation or going to graduate school or professional school. I have never been sorry that I majored in Computer Science. Many computing jobs (like consulting, project management, and teaching) work entirely with **people**.

We have an unusually strong "Women in Computing" group here at DePauw. Our women attended a retreat with other Indiana women recently. (picture above) We also meet once a month; next month's lunch is... I would like to encourage you to sign up for one of my two classes... I would love to have as many women in my classes as possible!

The brochure addresses career paths, role modeling and lifestyle misconceptions (as indicated by the literature described in section 3 above), while the informal letter stresses social support and giving specific information for the impending registration process. The front cover of the brochure appears below. The back cover includes the author's words that continue the themes of interesting careers and balanced lives in computing. The final third of the outside cover gives contact information and endorses computing through the following list of advice:

A recent, extensive survey found the following reasons for women majoring in computer science:

- ➢ Intrinsic interest
- ➢ Classroom experiences
- ➢ The field has a sense of promise (job availability and salary incentives)

Additional motivating factors include:

- ➢ Flexibility of workplace location and hours
- ➢ Increased career options
- ➢ Working with people

The inside of the brochure provides pictures of two alumnae with their "computing stories". One of the two stories follows:

Like many college freshmen, Kelli wasn't sure which academic path to follow. After enrolling in CS1, she was persuaded by the benefits that computer science had to offer. She now leads a successful career as an application developer.

"It was an accident. In the fall of 1997, I was a freshman trying to get my act together and form a proper schedule for myself. At the time, I was taken by the notion of becoming a chemist or perhaps a writer. Torn between the opposite ends of the academic spectrum, my schedule better reflected a patch work quilt rather than a well formulated plan for the future. The only thing I was certain of was my interest in everything and an overriding preference for nothing (common affliction among college freshman).

For good measure, I threw CSC121 into my first semester freshman year schedule. In between the chemistry labs and creative writing, I thought it would be beneficial to learn more about Microsoft Office products and emailing. Was I in for a shock! Within a week Professor Gloria Townsend was teaching me about the ways of arrays and best methods for building algorithms. I was a newborn in the world of computers, and well aware of the sharp learning curve ahead if I chose computer science as my major. By midterms, however, I was spending more time in the computer lab and less in the chemistry lab. I concluded computer science was the ideal outlet for my creative energy, subsequently declared myself a computer science major, and in 2001 graduated with a degree in computer science.

Prior to CSC121, memory to me was something I wanted to keep in my old age. My knowledge of computers matured, however, as the resources of an outstanding computer science department at DePauw coupled with my own interest. To date I have built a successful career as an application developer. I developed applications for clients in such diverse industries as the Dairy, Engineering, and Food Distribution industries. Whether it be the calculation for the density of an adsorber vessel or writing a complex search algorithm, I face new challenges and exercise creative problem solving daily. For me, earning a degree computer science was the beginning of an fulfilling career."

"My Advice: Be confident in the pursuit of your dreams and make this time count."
-Kelli Wilson

Kelli Wilson '01
Application Developer

4.2 The Semesters

The first two semesters in which we mailed both the letter and brochure, we also offered a "tryout" or an orientation session to the women, whereby we invited them to a special session (before registration) in which the lead author and older majors helped the younger women work through the first week of CS1 notes and the first laboratory. After the orientation, we told the women that they knew exactly what to expect, that they were successful now and would be in the future, and that they had a "head start". Both semesters, a small number of the invited women accepted our invitation and enrolled in CS1. The paper does not focus on the special sessions, as the number of women who attended the tryouts was small. Nonetheless, the lead author wishes to endorse the method for recruiting women to CS1. At a small school, two or three additional women registering for CS1 makes a difference. The remaining five semesters, we sent letters and brochures to our first-year women and did not hold an orientation session.

5. RESULTS: SMALL LIBERAL ARTS INSTITUTION

We found a surprising 10% more women enrolled in CS1 classes after receiving the letter and brochure – in an era where Figure 1 shows a 10% decline in bachelor's degrees awarded to women in CS/IT. We came to this conclusion by comparing a control group from the late 1990s when women did not receive the letter and brochure (Table 2) with women who did receive the letter and brochure intervention in the early to mid 2000s (Table 1). The intervention and control groups are large and nearly equal in size: 116 and 120, respectively.

Table 1: Letter and Brochure Treatment Group

Semester	Women	Men
Fall 2000	8	3
Spring 2001	7	18
Fall 2002	7	5
Fall 2004	7	3
Spring 2005	8	11 (2 classes)
Fall 2005	10	14 (2 classes)
Spring 2006	7	8
Total	**54**	**62**
	47%	**53%**

Table 2: Control Group

Semester	Women	Men
Fall 1996	3	11
Spring 1997	19	27 (2 classes)
Fall 1997	6	7 (2 classes)
Fall 1998	6	9
Spring 1999	7	16
Fall 1999	3	6
Total	**44**	**76**
	37%	**63%**

In order to form Table 2, we examined data from four fall semesters and two spring semesters that preceded the brochure and letter invitation project. We paired this subset of data to four fall semesters and three spring semesters that had female students who received the intervention. Spring 2005 includes two classes taught by two female teachers, who both signed the letter of invitation. Although not a perfect match, we counter with the spring 1997 row in Table 2, when the lead author taught two classes of CS1. Likewise, fall 1997 correlates with fall 2005, because the author taught two CS1 classes both semesters.

Our quantitative data are reinforced by qualitative data. Several women report that the letter and brochure affected their decision to enroll in the course. The following is an unsolicited email:

> "I must admit that what really hightened [sic] my interest in Computer Science was the pamphlet that you sent out…"

Another woman, who took the initiative to create a webpage [17] to document the intervention said:

> "I participated in a pilot program for this project because I thought the session would give me the opportunity to find out if I was interested in CS without having to enroll in a course I might not like. I really enjoyed the lab we did, and the other women I met were extremely nice. I took CS2 with Gloria the next semester, and I am now a junior CS major. Had it not been for the session, I probably would have never taken CS1."

6. PROJECT IMPLEMENTATION: LARGE PUBLIC UNIVERSITY

Indiana University's version of the project was dubbed the "C211 TryIT", because C211 is the course number for our CS1. In fall 2005, there were nearly 30,000 undergraduates on the Bloomington campus. We selected a target pool of 1,025 students using the following criteria: female and (freshman or transfer student) and (Math SAT $\geq$ 600 or Math ACT $\geq$ 25). We also included women students currently enrolled in our non-major CS courses.

6.1 The Invitation

As in the small school model, we created an informal, welcoming letter from the C211 instructors and women faculty and students. We also created a colorful brochure that included our contact information, fun pictures of women at conferences and our Women in Computing group (WIC@IU) [22] events, and specific information about the TryIT schedule and C211 registration details. The letter and brochure were printed and mailed to the campus addresses of women in the target group. A week later, each woman received a follow-up email from a C211 instructor.

On the next page of the paper is a thumbnail of the front panel of our brochure and at its right is an abbreviated version of the TryIT invitation. We then describe two more components of our large school program to complete section 6. The cost involved in the large university version amounted to approximately one thousand dollars. One could easily omit t-shirts and (as in the small liberal arts rendition) forego professional printing, in order to adopt the label, "low-cost intervention".

Computer Science

Is IT for you?

C211 TryIT

For Women
Interested in
Computing

♀

October 14
9:30am or 2:30pm
Lindley Hall 102

Try IT… you'll like IT!!

Hi! We are writing to you because we think you have *the right stuff* to be successful in **Computer Science C211**. …

Some young women avoid studying Computer Science because they think they don't have the necessary background or skills to get started. But you'd be surprised. If you liked Math in high school, and you can use a web browser and navigate the file directories on a computer, then you've got the basic skills needed to take **C211**.

But just to prove you can do it, we are offering a "**C211 TryIT**", a 90-min crash introduction to **C211**. You'll get early tips on what's being taught in the course, and how to succeed. You'll meet the faculty who teach **C211** and have a chance to talk to students who've been through it. You'll also hear about …

Computer Science department and our dynamic and energetic Women in Computing (WIC) group that is here to help undergraduate women like yourself succeed in their computing careers. …

6.2 The Workshop

One week before registration for spring classes began, on a Friday, we ran two 90-minute workshops, one in the morning and one in the afternoon. Each workshop was divided into three 30-minute periods. During the first period, we met with the participants in a lecture room, introduced ourselves, showed a few *Just Be* slides (*Just Be* is our K-12 outreach program [18]), described our active Women in Computing group, provided information about scholarships for women in science available through our Office for Women's Affairs, and outlined the free peer tutoring program that would be in place for C211 students the following semester. Our undergraduate advisor gave a brief overview of the major requirements; we distributed a folder containing the C211 course syllabus and the first homework assignment and gave a quick demo of the Scheme programming environment and a live enactment of the program they would work with in the next period.

The middle period was held in a computer lab and advanced women undergraduates were available as assistants. After some preliminaries with the environment, the task at hand was to load, modify, and run a program that simulated the behavior of a blind mouse with no sense of smell on a long hallway. As shown in Figure 2, the mouse starts off somewhere in the middle of the hallway. At each stage, the mouse can move one location to its left or its right. If, at any point, the mouse encounters the cheese, the program ends happily. If the mouse encounters the cat, the program also ends, but not happily. We chose this particular example because it illustrates the execution of a simple program of left/right commands and it is an actual programming exercise we assign in week three of the course.

The final workshop period was an informal reception with delicious refreshments, where the participants could interact with advisors, faculty and students and discuss their individual goals. This part of the program was well attended by members of our

Figure 2: Visualization of the exercise students completed during the Try IT workshop.

faculty and WIC@IU. Each participant was given a t-shirt that we had specially printed for the event and asked to complete a workshop survey.

6.3 The Scaffolding: Peer Tutoring

The semester following TryIT, we instituted a Peer Tutoring program for students in C211. A three-hour Monday night homework help session is held each week in a comfortable room where students can gather to discuss and work on the current homework assignment. There are 3-5 computers in the room for the students to use, but most bring their own laptops. To increase participation and promote a congenial, informal atmosphere, refreshments (drinks, chips, fruit) are provided at the tutoring sessions.

The sessions are open to all students in the class and are staffed by two tutors. The tutors are female undergraduates who have recently completed C211 with a grade of A. We hire three tutors, at $10/hour, and each works two out of every three weeks.

A graduate student "manager" helps administer and oversee the program. We use a student who has previously assisted in the course, but is not currently associated with C211. We want the students who attend the homework help sessions to ask questions freely without worry about how they are perceived by a member of the teaching staff who may ultimately assign them a grade. The manager meets with the three peer tutors periodically throughout the semester, sets the weekly schedule, sends reminders, and conducts several information sessions about the proper way to help students reason through their programming difficulties. The manager also attends the sessions during the first half of the semester to ensure that students are discussing the homework amongst themselves at an appropriate level and the tutors are providing meaningful help and debugging strategies.

Both the tutor and the student learn and benefit from each other. The tutors are able to keep their programming skills fresh and also practice interpersonal communication and teaching skills. The student receives the benefit of the tutor's experience and guidance in a non-threatening manner, has someone to talk to when the going gets tough, and sees the tutor as an example of someone similar to themselves who has made it through the course successfully.

There are several unexpected benefits to the peer tutoring program. Computing is a gregarious enterprise and people naturally want to help their friends who are struggling with a programming problem. The homework help sessions provide a controlled environment where students can establish mutually-beneficial relationships with other members of the class and help each other out in meaningful and appropriate ways. This sharing of information builds confidence in both directions. Current students who find they have a knack for explaining difficult concepts in an accessible manner see the tutoring job as a very real, short-term, attainable goal for themselves the following semester.

7. RESULTS: LARGE PUBLIC UNIVERSITY

Twenty-three women participated in TryIT: 20 attended a TryIT workshop, 6 in the morning and 14 in the afternoon, and 3 others, who had conflicts with the workshop times, met with the instructor separately. Although several participants enrolled in C211 the following semester, all but two withdrew before the first class meeting. Five other participants were still registered in an IT course different from C211 after the first week of classes. One workshop participant enrolled in and completed C211 during the subsequent summer session. Interestingly, all three of these C211 women ultimately earned an A+ in the course and all three have been hired as peer tutors in the upcoming fall semester. Three women from our initial target pool are currently enrolled in C211 this fall. In total, six women have taken or are taking C211 who otherwise may not have considered trying a computer science course.

The peer tutoring program had an impact on retention. The attrition rates for C211 in spring 2005 and spring 2006 are comparable as shown in Table 3. There was one lecture section of C211 in each semester, both taught by the same instructor. We experienced an 11% decrease in the withdraw rate and a slight increase in the success rate of the students who completed the course. The summer 2006 course was also taught by the same instructor with a small-scale version of the peer tutoring program in place. The success rate is measured as a percentage of the number of "passing" grades (C- and above) out of the total number of GPA grades awarded.

Table 3: C211 Attrition and Success Rates

Semester	Start	End	% change	% C- and above
Spring 05	55	37	33%	78%
Spring 06	49	38	22%	80%
Summer 06	19	18	5%	88%

Based on these encouraging results, we are continuing the peer tutoring program this year.

8. FUTURE WORK

Please contact the authors, for help with replicating the project at additional institutions, in order to bolster our statistical evidence. With broader applications of the intervention at additional small liberal arts schools and large research institutions, augmented by conducting new experiments at regional and community colleges and other different institutional models, we can determine if the treatment is transferable to other environments and continue to collect data. If analysis of a large and diverse data collection strongly suggests that the intervention is effective, we will approach the National Center for Women in Information Technology (NCWIT) [19], the Committee on the Status of Women in Computing Research (CRA-W) [20], ACM's Committee on Women in Computing (ACM-W) [21] and/or additional organizations that serve as repositories of best practices in order to disseminate the results.

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