Computer Sciences Department

Attracting and Retaining Under-represented Groups in Computer Science

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ABSTRACT

This paper describes new strategies (involving *active recruiting and peer-led team learning*) for encouraging women and minority students to enroll in introductory computer-science courses, and to go on to major or minor in computer science. The first year of the program had impressive results: we succeeded in attracting under-represented students who would not otherwise take CS courses, and in improving retention of those students in our introductory programming course.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: Computer science education

General Terms

Human Factors

Keywords

Women in computer science, Under-represented groups, Peer-led team learning

1. INTRODUCTION

Starting in the fall of 2004, the Department of Computer Sciences at the University of Wisconsin-Madison piloted a new approach to attracting women and minority students to computer science. The program was run by Professor Susan Horwitz, with help from Associate Professor Deborah Joseph, and Faculty Associate Deb Deppeler. The program is supported in part by NSF as part of a collaborative grant with seven other schools: Beloit College, Duke University, Georgia Institute of Technology, Loyola College in Maryland, Purdue University, Rutgers University, and the University of Wisconsin-Milwaukee, each of which will be trying similar programs starting in the fall of 2005. Evaluation is being done by Katherine Acosta of the UW-Madison's Learning through Evaluation, Adaptation, and Dissemination (LEAD) Center.

Our approach is modeled after two programs used successfully in a range of math and science courses across the country: the *Emerging Scholars Program* (*ESP*), and *Peer-Led Team Learning* (*PLTL*). ESP recruits incoming freshmen who are strong students, but are at risk for poor performance because they are in under-represented groups (women, minorities, and students from small rural high schools). In addition to regular lectures, ESP students meet in small groups to work on challenging problems designed to help them gain a thorough and in-depth understanding of the class material. Working in groups enhances student performance (ESP students typically earn higher grades than non-ESP students) and increases their enthusiasm for math and science [7, 6, 5].

Peer-Led Team Learning also involves students working in small groups, but has two important differences compared with the ESP program: It usually does not involve any active recruiting (instead, the program is offered to all students enrolled in a particular class), and the group meetings are designed and run by *undergraduate* student leaders, who are trained to facilitate group learning. This program has proved to be beneficial for the student leaders as well as the regular student participants; they gain valuable leadership skills, develop a close relationship with the faculty member who teaches the course and runs the training sessions, and increase their interest in the discipline [9].

The UW-Madison program (called WES-CS: Wisconsin Emerging Scholars – Computer Science) combines the two ideas and applies them in computer science for the first time. We actively recruit women, minorities, and rural students to register for our introductory computer-science course, CS302 Introduction to Java Programming, plus a special discussion section (for which students receive one additional credit). Those sections, which have 5 to 8 students each, meet once a week for two hours of group problem solving, and are run by outstanding undergraduate "team leaders" (at least half of whom are women and/or minority students), who in turn are trained and supervised by faculty.

The goals of WES-CS are to attract under-represented students who would not otherwise take computer-science courses, or who might take them and do poorly (and so drop out of the computer-science program). It is also expected that students who serve as team leaders will be more likely to become computer-science majors. WES-CS thus has a

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good potential to increase the number of under-represented students in computer-science courses and in the major.

This paper reports on the results of the first year of our program. Some of those results are very encouraging (the following data are from [1]):

- **Attracting under-represented students:** We enrolled 48 WES-CS students, 26 (54.2%) of whom were women, and 6 (12.5%) of whom were in under-represented racial-ethnic minority groups. (For comparison, 22.7% of the non-WES-CS students in CS302 were women and 8.1% were under-represented minorities.)
- **Attracting students who would not otherwise take computer-science courses:** Of the 24 female WES-CS students who completed an on-line beginning-of-semester survey, 13 (54.2%) said that they definitely or probably would not have enrolled in CS302 had they not been recruited for WES-CS.
- **Improving retention:** The drop rates for WES-CS students (26.9% for women and 15% for men) were considerably lower than those of non-WES-CS students in CS302 (82.3% for women and 30.7% for men)[1].

These numbers indicate that personal recruiting is effective in convincing under-represented students with no previous interest in computer science to enroll in an introductory computer-science course, and that peer-led team learning is effective in improving retention in that course.

However, we had some disappointments as well. In particular, beginning- and end-of-semester surveys revealed that interest in computer science declined among both male and female WES-CS participants, and only 5 of the 19 women who completed the program went on to take the second computer-science course (Introduction to Data Structures) in the spring.

This paper provides information about the WES-CS program that might be useful to others interested in trying something similar: We discuss the recruiting process, team-leader training, how the weekly group meetings were run, what the students' perceptions of WES-CS were and how their attitudes toward computer science changed over the course of the semester. We conclude by summarizing our experience to-date, and describing changes we plan to make to the WES-CS program to increase students' enthusiasm for computer science, and thus the likelihood that they will continue after the introductory course.

2. RECRUITING

Our goal for WES-CS was to enroll at least 40 students, 50% women and 25% minority. We learned from the calculus ESP program at UW-Madison that about 10% of the students invited to participate in that program actually enroll; however, calculus is a required course for many students, so students may participate in ESP because they know they have to take calculus anyway. We don't have that advantage in computer science, and so expected a much lower percentage of those invited to enroll. We also expected that a far lower percentage of the women we invited would enroll, and so to achieve our target of 50% women we decide to invite about three times as many women as men.

Following the ESP model, we wanted to invite strong students with good math/science skills. Thus, we selected students based on their high-school records. All invited students had the following qualifications:

- high-school GPA of at least 3.5
- at least one unit of math beyond algebra and geometry
- at least one unit each of biology, chemistry, and physics.

Additional requirements were as follows:

- be female with an SAT math score greater than 600 or an ACT math score greater than 26, or
- be male from a high school with a graduating class size of less than 200 (this requirement was intended to select male students from small, rural high schools) and an SAT math score greater than 600 or an ACT math score greater than 26, or
- be a targeted minority with an SAT math score greater than 550 or an ACT math score greater than 22.

These criteria gave us about 1350 students to invite, of whom about 74% were non-minority women, 16% were non-minority men, and 10% were targeted minorities.

These students received letters describing the WES-CS program by both U.S. mail and e-mail. In addition, when they came to campus in July or August for Student Orientation, Advising, and Registration (SOAR), a letter was placed in their SOAR folder, reminding them about WES-CS and asking them to stop by to talk with Professor Horwitz or Professor Joseph, one of whom was available for two hours each day to meet with prospective WES-CS participants. We believe that the personal contact during orientation was our most effective recruiting tool, especially for female students, as shown in Table 1, which gives data on the reasons students selected for enrolling in CS302. The data in that table are from an on-line survey that all CS302 students were asked to complete at the beginning of the semester, the results of which are documented in [2]. Note that for women in WES-CS, the most commonly cited response (selected by 58.3% of the respondents) was that they received an invitation in the mail or in their SOAR folder, and 33.3% cited being encouraged by a computer-science consultant at SOAR.

As mentioned above, we were generally successful in our recruiting goals; we enrolled 48 students, 54% women and 12.5% minority. Although we did not meet our goal of 25% minority students, that was probably unrealistic given the size of our pool of qualified minority students. On the other hand, we did exceed our goals for the total number of WES-CS participants, and the percentage of women.

3. WES-CS TEAM LEADERS: RECRUITMENT AND TRAINING

Six students who had taken CS302 in the fall of 2003 and were recommended by their instructor as good potential

[1]Students often register for "extra" classes, and drop some during the first 10 days (a grace period in which drops are not recorded on their transcripts) sometimes without ever attending the class. If we look at drops rates starting with the enrollments as of day 11, the percentages are as follows: For WES-CS, 13.6% of the women and 5.6% of the men dropped, while for non-WES-CS students, 73.1% of the women and 13.0% of the men dropped.

Reason for enrolling in CS302	WES-CS				Non WES-CS			
	Female (n=24)		Male (n=20)		Female (n=21)		Male (n=56)	
	n	%	n	%	n	%	n	%
I plan on majoring in CS or electrical and computer engineering.	9	37.5	12	60.0	5	23.8	29	51.8
It meets a requirement for my intended major.	9	37.5	15	75.0	11	52.4	29	51.8
I know I am interested in programming or CS.	10	41.7	14	70.0	7	33.3	38	67.9
I wanted to see whether I enjoy programming or CS.	9	37.5	12	60.0	6	28.6	15	26.8
Knowing how to program in Java is a useful skill to have in the job market.	9	37.5	9	45.0	7	33.3	22	39.3
It was recommended to me by an academic advisor.	2	8.3	7	35.0	2	9.5	6	10.7
It was recommended to me by a student or friend who took the course.	2	8.3	2	10.0	2	9.5	1	1.8
One or both of my parents thought I should take this course.	5	20.8	1	5.0	1	4.8	3	5.5
I have friends who were also enrolling in this course.	0	0.0	1	5.0	0	0.0	0	0.0
The course was more convenient for my schedule than other courses.	2	8.3	1	5.0	3	14.3	3	5.4
I received an invitation to enroll in the mail or my SOAR folder.	14	58.3	8	40.0	1	4.8	3	5.4
I was encouraged to enroll by one of the CS consultans at SOAR.	8	33.3	8	40.0	0	0.0	1	1.8
Other	1	4.2	3	15.0	4	19.0	5	8.9

Table 1: Reasons for enrolling in CS302. The numbers of responses sum to more than the total number of students who completed the survey because students were asked to select "all that apply".

team leaders were invited to interview for those positions (which paid $1000 for the semester). Our original intention was to hire four of them, but we were so impressed that we ended up hiring five (three female and two male). Two of them ran two group meetings each; the other three ran one group meeting each and had some additional administrative duties.

In the spring, Susan Horwitz, Deb Deppeler, and all five students attended a 1.5-day Chautauqua workshop on peer-led team learning (PLTL), run by Pratibha Varma-Nelson, Professor of Chemistry at Northeastern Illinois University, and Mark Cracolice, Associate Professor of Chemistry at the University of Montana. The workshop was very beneficial to the two faculty members, since it clarified the PLTL model, including the role of the team leaders, and included some specific examples of group-learning exercises. The students had mixed reactions. They did find some aspects of the workshop helpful, in particular, some role-playing exercises led by experienced team leaders. However, some of them were uncomfortable being the youngest participants (there were a few other students, but they were juniors and seniors, whereas our students were freshmen), and they felt that much of the material was oriented more toward faculty than students [1].

Just before the start of the fall semester, Horwitz and Deppeler provided two afternoons of additional training. Those sessions included practice with ice-breakers, discussions about the responsibilities of the team leaders and their goals and concerns, sensitivity to issues of race, gender, and disabilities, and examples of different learning styles. Two publications provided at the Chautauqua workshop, [3] and [8] were useful resources for those sessions.

Finally, Horwitz, Deppeler, and Joseph met with the team leaders for two hours each week during the semester to go over that week's exercises, to monitor the progress of the teams in terms of how well the students were learning to work together, and to address any issues that the team leaders brought up. Communication was also maintained by having each team leader send e-mail to the other team leaders and the faculty supervisors each week, summarizing what happened in their group meetings that week, what problems (if any) arose, and what feedback they were getting from their students (the group meetings always ended by having the students write a "one-minute paper" for their team leader: a quick, anonymous summary of what they liked and disliked about the meeting, what problems they were having with the material, and any other issues they cared to mention).

4. GROUP PROBLEM SOLVING AND STUDENT PERCEPTIONS

Each WES-CS group met once a week for two hours. Sessions typically started with some time for questions and announcements, but most of the time was spent working on a packet of exercises that had been prepared by Professor Horwitz, often based on ideas proposed by the team leaders (all of the exercises used in the fall of 2005 can be found via a link from our WES-CS website: *www.cs.wisc.edu/wes-cs*). Our goal was to make the exercises fun, stimulating, and well-suited to group problem solving. We included games (modeled after television quiz shows like Concentration and Jeopardy, or classics like Hangman), logical reasoning problems, code to be acted out (e.g., each student plays the part of one object and acts out that object's methods when they are called as the code is "executed"), and small programming problems that could be done either with just pencil and paper or on the computer (the rooms where the groups met had one or two machines available for the students' use).

Following the models used in the ESP and PLTL programs, the team leaders acted as facilitators rather than experts; their role was to help the students work together to solve the problems, doing their best to ensure that all students participated, and that all were understanding the material. End-of-semester surveys and interviews indicate that the team leaders were successful at creating a cooperative and team-oriented environment. Thirty-four (out of thirty-eight) WES-CS students completed the end-of-semester survey, and eleven participated in face-to-face interviews. Ninety-seven percent of survey respondents reported that their team leaders "always" (61.8%) or "often" (35.2%) encouraged everyone to participate. Nearly four-fifths (70.4%) reported

that team leaders never had trouble getting certain students to work with others, and more than three-quarters (76.5%) reported that discussion sections were "never" or only "occasionally" dominated by one or two individuals [1]. In the interviews, several students noted how quickly the time went by:

> I have [several] lectures that same day, and I originally thought, "Oh my God, by the time this comes around I'm going to be like, get me out of here." But it's actually really enjoyable. It has to be the fastest two hours of my day [1].

as well as the positive aspects of group learning:

> We really help each other out. Some people are better at certain things than others, so when someone has a question someone will step up and explain it. When that person who was originally explaining might have a question on something, another person can explain it to them, so it's really well-rounded in that aspect [1].

Overall, both students and team leaders expressed satisfaction with WES-CS. When asked on the end-of-semester survey whether the group meetings "are improving my grade", the mean response (on a scale of 0 to 5, where 0 means "strongly disagree" and 5 means "strongly agree") was 3.55, and 50% of the respondents indicated strong agreement. Similarly, when asked whether "interaction with the other group members increases my understanding", the mean response was 4.48, with 76.5% indicating strong agreement [1].

On the same survey, students selected from a list of benefits they had hoped to gain from participation in WES-CS (the numbers of responses sum to more than 34 because students were asked to select "all that apply"):

Benefit	n	%
An extra credit hour.	31	91.2
More comprehensive understanding of the course material.	28	82.4
Opportunity to learn the material in smaller groups.	27	79.4
A better grade.	27	79.4
To meet people to work and study with outside of class.	21	61.8
To make friends.	19	55.9
Other.	1	2.9

and indicated whether they got what they had hoped for:

Item Choice	n	%
No	3	8.8
Somewhat	15	44.1
Yes	16	47.1
TOTAL	**34**	**100.0**

However, although students enjoyed WES-CS and generally felt that they got the expected benefits from their participation, of the 34 students who completed the end-of-semester survey, 12 reported less interest in computer science than at the beginning of the semester, as shown in Table 2 [1] (the first and fifth responses, "I was considering a major or career in CS but have now decided against it" and "I wanted to see whether I would like CS, but now realize that it's not for me" reflect declining interest).

The 12 who reported declining interest in computer science were asked to indicate their reasons ("all that apply") from a list of seven choices. Their responses are summarized in Table 3. Students most often chose "I don't want a job sitting in front of a computer all day" and "I just didn't enjoy it". Face-to-face interviews revealed similar feelings; for example, one female student said:

> I've also come to realize that sitting in front of a computer all day is not necessarily what I want to do. I want to go into business law, like a corporate lawyer or something. I really like working with people, and interacting with people. So, I'm looking at maybe majoring in marketing and then going on to law school or something.

Some of this negative attitude (the "I just didn't like it" part) can be ascribed to the non-WES-CS part of CS302. Unfortunately, it was taught by a less than stellar instructor (with teaching evaluations considerably below average for the Department of Computer Sciences). Changes are being made to improve the course, including replacing the instructor and introducing weekly hands-on, pair-programming, TA-supervised labs; nevertheless, it is clear that we are not likely to succeed in convincing students, especially women and minorities, to continue in computer science as long as they have a narrow view of what computer science is, and what career opportunities it enables.

5. SUMMARY AND FUTURE PLANS

Our experience to-date with the WES-CS program is encouraging in that it provides strong evidence that active recruiting and peer-led team learning are effective at increasing participation and retention of under-represented students in an introductory computer-science course. However, it is also clear that convincing those students to *continue* in computer science requires something more. As discussed above, a major problem is that students have a narrow view of what computer science is, and what career opportunities it enables. We plan to try two strategies to address this issue: adding roundtable dinners to the WES-CS program, and combining WES-CS with a "Digital Divide" class.

Starting in the fall of 2005, we will organize roundtable dinners featuring guest speakers with computer-science training who work in a range of jobs. Having the opportunity to talk to these speakers should help give our students a more balanced view of what they can do with a computer-science education, including the fact that it can lead to "people-oriented" jobs.

A priority for many college students is that their education be relevant to their community [4]; therefore, starting in the fall of 2006, we will offer a "Digital Divide" course that WES-CS students can take simultaneously with CS302. That course will examine the impacts of technology on different societal groups, and will include a community-service project.

We believe that by focusing on aspects of computer science other than just programming, involving students in community-service projects, and giving them the opportunity to interact with computer-science professionals outside academia, our students will gain a better understanding of the breadth of the field, the positive ways in which computer

Before taking this course:	Female		Male		Total	
	n	%	n	%	n	%
I was considering a major or career in CS but have now decided against it.	1	5.9	4	23.5	5	14.7
I did not plan on a career or major in CS, and this course did not change my mind.	4	23.5	2	11.8	6	17.6
I was considering a major in CS, and may still pursue that.	4	23.5	9	52.9	13	38.2
I wanted to see whether I would like CS, and found that I do.	2	11.8	1	5.9	3	8.8
I wanted to see whether I would like CS, but now realize that it's not for me.	6	35.3	1	5.9	7	20.6
TOTALS	17	100.0	17	100.0	34	100.0

Table 2: Question reflecting changes in students' interest in computer science over the course of the semester.

Why did you decide not to take more CS or pursue the major?:	Female		Male		Total	
	n	%	n	%	n	%
This course was too hard.	5	71.4	1	20.0	6	50.0
I don't want a job sitting in front of a computer all day.	5	71.4	3	60.0	8	66.7
Getting a program to run was not the thrill I thought it would be.	1	14.3	3	60.0	4	33.3
I want a job working with people.	4	57.1	1	20.0	5	41.7
I just didn't enjoy it.	6	85.7	2	40.0	8	66.7
I wasn't very good at it.	5	71.4	0	0.0	5	41.7
Other.	0	0.0	3	60.0	3	25.0

Table 3: Reasons for declining interest in computer science.

science can affect people's lives, and the range of interesting career opportunities.

6. REFERENCES

[1] K. Acosta. Emerging scholars program-Computer science, Pilot semester - Fall semester 2004, A formative feedback report. Technical report, LEAD Center, University of Wisconsin-Madison, March 2005.

[2] K. Acosta. Recruitment for the emerging scholars program computer science, Fall semester 2004, A formative feedback report. Technical report, LEAD Center, University of Wisconsin-Madison, February 2005.

[3] D. Gosser, M. Cracolice, J. Kampmeier, V. Roth, V. Strozak, and P. Varma-Nelson, editors. *Peer-Led Team Learning: A Guidebook.* Prentice Hall, 2001.

[4] R. Ibarra. Multicontextuality: A new perspective on minority underrepresentation in SEM academic fields. *Making Strides: Research News on Minority Graduate Education (MGE)*, 1(3), October 1999.

[5] S. Kosciuk. Impact of the Wisconsin Emerging Scholars first-semester calculus program. Technical report, LEAD Center, University of Wisconsin-Madison, July 1997.

[6] S. Millar, B. Alexander, H. Lewis, and J. Levin. Pilot Wisconsin Emerging Scholars Program: 1993-94. Technical report, LEAD Center, University of Wisconsin-Madison, March 1995.

[7] M. Myers. The Emerging Scholars Program at UT Austin program evaluation 1988–1993. Technical report, Dana Center, University of Texas, Austin, 1994.

[8] V. Roth, E. Gldstein, and G. Marcus. *Peer-Led Team Learning: A Handbook for Team Leaders.* Prentice Hall, 2001.

[9] P. Varma-Nelson and L. Gafrey. What happens next? A follow-up study of workshop leaders at St. Xavier University. *Workhop Project Newsletter*, 3(2), Winter 2002.