Using Peer-Led Team Learning to Increase Participation and Success of Under-represented Groups in Introductory Computer Science

Susan Horwitz
Univ. of Wisconsin–Madison
Madison WI, USA
horwitz@cs.wisc.edu

Susan H. Rodger
Duke University
Durham NC, USA
rodger@cs.duke.edu

ABSTRACT

This paper describes the implementation and evaluation of a program that uses *active recruiting* and *peer-led team learning* to try to increase the participation and success of women and minority students in undergraduate computer science. These strategies were applied at eight universities starting in the fall of 2004. There have been some impressive results:

- We succeeded in attracting under-represented students who would not otherwise have taken a CS course.
- Evaluation shows that participation in our program significantly improves retention rates and grades, especially for women.
- Students in the program, as well as the students who served as peer leaders, are uniformly enthusiastic about their experience.

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, PLTL, ESP, inclusion, introductory computer science course

1. INTRODUCTION

Eight diverse colleges and universities have worked together since the fall of 2004 to implement and evaluate a program designed to attract and retain women and minority students in undergraduate computer science. The key ideas are *active recruiting* and *peer-led team learning*. The University of Wisconsin-Madison began the program in the fall of 2004; Beloit College, Duke University, Georgia Tech, Loyola College in Maryland, and Rutgers University started in the fall of 2005; the University of Wisconsin-Milwaukee joined in fall 2006; and Purdue University joined in fall 2007.

This paper describes our program plus the results of an extensive evaluation carried out by the UW-Madison's Learning through Evaluation, Adaptation, and Dissemination Center, and KD Consultants. The results are very encouraging: The evaluation shows that active recruiting is effective in convincing students, especially women, with no previous interest in CS to enroll in an introductory CS course. It also shows that peer-led team learning is effective in improving retention and student performance in that course. And finally, we found that students' perceptions of the program were uniformly positive. Therefore, this paper should be of interest to other CS departments that want to increase participation by under-represented groups, or to improve retention rates, performance, and enthusiasm of all students in introductory CS courses.

In the remainder of the paper, we give an overview of our program, discuss the recruiting process, and provide some details about the program evaluation and evaluation results. We conclude with pointers to materials available to others interested in running similar programs, and a summary.

2. OVERVIEW OF THE PROGRAM

Our program was 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 [2, 3, 5, 8, 9, 10, 11, 14].

PLTL 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. In addition to being beneficial to the regular student participants, PLTL has proved to be valu-

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able to the student leaders: they gain important leadership skills, develop a close relationship with the faculty members who teach the course and run the training sessions, and increase their interest in the discipline [15].

Our program, which we will refer to as ESP-PLTL, combined the two ideas and applied them in introductory CS courses [12]. It is worth noting a contrast between our results and those of one previous study of the use of ESP in CS [3]. While the previous study concluded that the approach could be effective for students in courses primarily involving analysis, they were not able to show effectiveness for courses involving large amounts of programming. In contrast, our combined ESP-PLTL program was successful for students in introductory programming courses.

Our eight participating schools are quite diverse (large, medium, and small; private and public) and there were some differences in the way ESP-PLTL was implemented; however, the similarities greatly outweigh the differences.

ESP-PLTL involves actively recruiting women and minority students to register for a standard introductory CS course. (We will refer to that course hereafter as the "main" course.) In addition to attending the regular lectures and labs of the main course, ESP-PLTL students meet in small groups (4 to 8 students) once a week for about two hours of group problem solving. Those groups are run by outstanding undergraduate "peer leaders" who in turn are trained and supervised by faculty. The exercises used in the small-group meetings are prepared by faculty and/or peer leaders. Our goal is to make the exercises fun, stimulating, and well-suited to group problem solving, as well as to target a wide range of learning styles [4]. Exercises are designed to help all students to understand the material taught in the main course in more depth, and to learn to work cooperatively in groups.

Following the models used in the ESP and PLTL programs, peer leaders act as facilitators rather than experts; their role is to help the students work together to solve the problems, doing their best to ensure that all students participate, and that everyone understands the material. End-of-semester surveys and interviews indicate that the peer leaders were successful at creating a cooperative and team-oriented environment.

A secondary goal of the ESP-PLTL program was to address potential misunderstandings that students might have about the opportunities that CS has to offer (for example, that a CS career means sitting alone in front of a computer all day, or that all computer-related jobs are being outsourced). Therefore, some of the institutions offered special events to participating students, including dinners or other gatherings featuring speakers who described their careers in CS related fields, and excursions to local companies or labs. In general, students who participated in these events found them worthwhile and enjoyable, reporting that they found the speakers interesting and that the events gave them a better idea of why they might want to study CS.

3. RECRUITING

Recruiting students to participate in ESP-PLTL involved a number of strategies including the following:

- Sending invitations (by e-mail and/or U.S. mail) to incoming freshmen in targeted groups (female students, minority students, and male students from small, rural high schools).
- Attending freshmen orientation sessions to provide information about the program.
- Sending information about the program to University advisors.
- Inviting all students, or all targeted students, already enrolled in the main CS course via e-mail and/or an announcement in the main course.

One of the goals of the program evaluation was to determine which recruiting strategies were most successful. In 2005 and 2006, ESP-PLTL students were asked on surveys how they were recruited into the program. Out of a potential 302 respondents, 125 opted to answer this question. Results are summarized in Table 1.

The majority of females (60.5%) indicated they enrolled in ESP-PLTL because they received a mailed invitation. The two most popular responses for males were a class announcement (38.1%) and a mailed invitation (37.5%). This gender difference is most likely a reflection of the recruitment process: since they were not a targeted group, most males would not have received a mailed invitation, but would have heard a class announcement. Interestingly, although many institutions indicated a presence at freshman orientations this response category was infrequently selected by any group of students (roughly 13% for each gender group).

From the small amount of data collected, it appears that a personal invitation via e-mail and/or U.S. mail may be the most effective recruitment strategy.

It is also interesting to consider whether targeted, active recruiting is successful at attracting female and minority students; i.e., do the ESP-PLTL groups have a higher percentage of women and minorities than the main course? Over all institutions, for the years 2005-2007, the data is as follows:

	ESP-PLTL		**Main Course**	
	#	%	#	%
Female	122	33.4%	673	29.0%
Minority	43	11.8%	218	9.4%

The percentage of both women and minorities is higher for ESP-PLTL students, indicating that targeted recruiting did have an impact.

A goal of our program was to attract women and minority students who would not otherwise have taken a CS course; i.e., to increase participation of those students in the main course. To judge our success in this area, a survey conducted in the fall of 2005 included a list of possible reasons for enrolling in the main course, and students were asked to select all that apply. Results for ESP-PLTL students are summarized in Table 2, sorted by the number of responses from female students.

Over all institutions, the reason most often selected by female ESP-PLTL students (chosen by 71.0%) was "I received an invitation to enroll". In other words, for 71% of the women in ESP-PLTL that semester, being invited to participate in that program was a factor in their decision to register for a CS course. The next most popular reason (selected by 67.7% of the female students) was "To see whether I enjoy CS or programming." By contrast, the most popular reason for male ESP-PLTL students was "I know I am interested in CS or programming" (79.6%). From this data, we conclude that active recruiting for ESP-PLTL does increase the number of women who enroll in an introductory CS course.

Reasons for Enrolling in ESP-PLTL, All Institutions Combined (2005-2006)						
	ESP-PLTL Female (n=41)		ESP-PLTL Male (n=84)		Total (n=125)	
	#	%	#	%	#	%
Recommendation from academic advisor	4	9.8%	20	23.8%	24	19.2%
Recommendation from friend	0	0.0%	1	1.2%	1	0.8%
Recommendation from parent	2	4.9%	2	3.6%	5	4.0%
Info during orientation	5	12.8%	11	13.1%	16	13.0%
Class announcement	4	9.8%	32	38.1%	36	28.8%
Mailed invitation	26	60.5%	30	37.5%	56	45.5%
Other	6	15.6%	9	11.4%	15	12.6%

Table 1: Reasons for enrolling in ESP-PLTL (students were asked to select "all that apply").

Reasons for Enrolling in Main Course, All Institutions Combined (Fall 2005)						
	ESP-PLTL Female (n=31)		ESP-PLTL Male (n=49)		Total (n=80)	
	#	%	#	%	#	%
I received an invitation	22	71.0%	11	22.5%	33	41.3%
To see whether I enjoy CS	21	67.7%	14	28.6%	35	43.8%
Meets requirement for my major	9	29.0%	20	40.8%	29	36.3%
I know I'm interested in CS	8	25.8%	39	79.6%	47	58.8%
Recommendation from academic advisor	6	19.4%	15	30.6%	21	26.3%
Parent thought I should take course	6	19.4%	9	18.4%	15	18.8%
Programming is a useful job-market skill	6	19.4%	9	18.4%	15	18.8%
I plan to major in CS	5	16.1%	28	57.1%	33	41.3%
Encouraged by CS consultant during orientation	5	16.1%	12	24.5%	17	21.3%
Other	3	9.7%	3	6.1%	6	7.6%
Recommendation from friend	2	6.5%	1	2.0%	3	3.8%

Table 2: Reasons for enrolling in the main course (students were asked to select "all that apply").

4. PROGRAM EVALUATION

The evaluation process included the following mechanisms for gathering data:

Surveys: During the fall semesters of 2005-2007, baseline surveys were administered during the first week of class to all students registered in the main course. At the end of the semester a similar survey was administered to all students. These surveys inquired about general demographic and attitudinal information regarding CS, as well as evaluative questions. Students who were in the ESP-PLTL program were asked to answer additional questions regarding their experience in that program.

Interviews: In 2004, ESP-PLTL students were interviewed, focusing on their experience with the program and in the main course, and their interest in taking more CS courses or pursuing a major in CS. In 2005 and 2006, peer leaders were interviewed to understand their perceptions of the program.

Institutional Data: During 2006 and 2007, each institution submitted data for all students enrolled in the main course, including gender, ethnicity, final course grades, and retention numbers.

It is difficult to provide an overall survey response rate. For example, questions regarding prior experience were asked on the baseline survey, which shows approximately 1718 responses. Evaluation of the main course was collected on the exit surveys only, which had approximately 1134 responses. In 2005 and 2006, baseline survey response rates were adequate, with most institutions indicating over a 50% response rate. Exit survey response rates were less than adequate with three out of six institutions showing less than a 50% response rate. In 2007, the response rates were more encouraging, with most reporting institutions showing well over a 50% response rate.

5. EVALUATION RESULTS

5.1 Student Perceptions: Peer Leaders

Peer leaders from all institutions reported on their experiences in telephone interviews. Most were extremely positive, with several common themes emerging as advantages of serving as a peer leader:

- Improved leadership skills.
- Opportunity to try out a leadership role.
- Reinforcement of own understanding of CS concepts, and increased confidence to continue in the field.
- Personal rewards of fostering student learning and of giving back to the University community.
- Friendships with students, including other peer leaders.

All of the interviewees said they would recommend the experience of being a peer leader, and that they would recommend ESP-PLTL to students enrolling in the main course.

5.2 Student Perceptions: ESP-PLTL Participants

On the exit surveys, students were asked questions about their peer leaders and their ESP-PLTL sessions. A six-point scale was used, with 0 representing "strongly disagree" and 5 representing "strongly agree". Across institutions, respon-

Retention Data, All Institutions Combined (2005 - 2007)						
	ESP-PLTL		Non ESP-PLTL		Total (All Students)	
	#	%	#	%	#	%
Completed	383	93.2%	2363	88.0%	2746	88.7%
Dropped	28	6.8%	323	12.0%	351	11.3%
Total	411	100.0%	2686	100.0%	3097	100.0%

Table 3: Retention rate comparisons.

Final Grade Data, All Institutions Combined (2005 - 2007)												
	All ESP-PLTL		All Non-ESP-PLTL		Total (All Students)		ESP-PLTL Female		Non-ESP-PLTL Female		Total (All Females)	
	#	%	#	%	#	%	#	%	#	%	#	%
B or better	219	80.2%	1130	68.4%	**1349**	**70.1%**	70	83.3%	295	70.1%	**365**	**72.3%**
Less than B	54	19.8%	522	31.6%	**576**	**29.9%**	14	16.7%	126	29.9%	**140**	**27.7%**
Total	**273**	**100.0%**	**1652**	**100.0%**	**1925**	**100.0%**	**84**	**100.0%**	**421**	**100.0%**	**505**	**100.0%**

Table 4: Final grade comparisons.

dents were positive about their peer leaders, indicating that they were: "An important part of the class" (mean = 4.31) "Knowledgeable about the course material" (mean = 4.52), and "Able to adequately answer questions" (mean = 4.31). Respondents also indicated they felt comfortable asking the peer leader questions (mean = 4.50), felt he/she encouraged everyone to participate (mean = 4.35) and managed classroom discussions effectively (mean = 4.09).

Respondents generally agreed that the ESP-PLTL sessions were a lot of fun (mean = 3.87) and were neutral about the sessions being a lot of work (mean = 2.42). When asked if they would recommend ESP-PLTL to a friend, the majority (94.9%) responded that they would, although half included the caveat that they would recommend it only to someone already planning to enroll in the main course.

In the interviews, several students noted how quickly the time went by in the ESP-PLTL sessions [1]:

> 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.

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.

Both ESP-PLTL and non-ESP-PLTL students were asked about their experience in the main course. ESP-PLTL students were more favorable in their evaluation of the instruction they received overall; two items show statistically significant differences between the two groups:

1. ESP-PLTL students disagreed more strongly than non-ESP-PLTL respondents that the instructor covered the material too quickly (ESP-PLTL mean= 1.93; non-ESP-PLTL mean = 2.15).
2. ESP-PLTL students agreed more strongly that the instructor adequately communicated goals and expectations to students (ESP-PLTL mean = 4.03; non-ESP-PLTL mean = 3.81).

Although not statistically significant, the same trend is seen regarding whether the instructor adapted his or her teaching to accommodate students without prior programming experience (ESP-PLTL mean = 3.61; non-ESP-PLTL mean = 3.51), with ESP-PLTL students agreeing more strongly than non-intervention counterparts. This gives us some indication that the ESP-PLTL program has an influence on students' ability to navigate through the main course with a bit more ease than non-ESP-PLTL students.

5.3 Effects of ESP-PLTL on Retention Rates and Grades

Significant differences (*Pearson Chi-Square* = 9.652 and $p = 0.002$) in retention rates were found between ESP-PLTL and non-ESP-PLTL students: 93.2% of ESP-PLTL students, compared with 88.0% of non-ESP-PLTL students, completed the main course. Details are given in Table 3.

Significant differences (*Pearson Chi-Square* = 15.604 and $p < 0.001$) were also found in the percentages who earned a grade of B or better: 80.2% for ESP-PLTL and 68.4% for non-ESP-PLTL. This grade data is shown in the left half of Table 4. As seen in the right half of this table, results for success at earning higher grades were even better when comparing only female students from each group: 83.3% vs 70.1%.

While there was a positive association between participation in ESP-PLTL and completing the main course for female and minority students (88.2% for female ESP-PLTL students vs 86.6% for non-ESP-PLTL, and 87.9% vs 86.4% for minority students) these results were not statistically significant. Similarly, 64.5% of ESP-PLTL minority students received a B or better compared with 53.1% of non-ESP-PLTL minority students, but this result was not statistically significant.

6. AVAILABLE MATERIALS

Exercises used at participating schools, as well as the final report prepared by our evaluators [7] can be found via links from our ESP-PLTL website: *www.pltlcs.org*. The website also includes links to materials prepared for a workshop

on ESP-PLTL that was held at Duke University in April 2007. Those materials include student perspectives, advice on peer-leader selection and training, and some guidelines on using the handbooks published by Prentice-Hall [6, 13].

7. SUMMARY

Our experience with ESP-PLTL is very encouraging. It provides strong evidence that active recruiting combined with peer-led team learning is an effective approach to attracting and retaining under-represented students in an introductory CS class. Across institutions, ESP-PLTL respondents evaluated their small-group sessions and their peer leaders quite favorably, and we know of a number of cases of female students who decided to major in CS or to add CS as a second major due to their positive experience in ESP-PLTL.

Evaluation shows that our ESP-PLTL programs have had the following benefits:

- Attracting female students who would not otherwise have taken a CS course.
- Increasing retention rates for all students.
- Increasing final grades for all students, especially for women.
- Providing students with a positive experience.
- Providing leadership experience and opportunities for personal growth to the peer leaders, who were often chosen from the target population.

We conclude that ESP-PLTL is successful at convincing under-represented students to get a taste of CS, to do well in the course, and to enjoy the experience.

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9. ADDITIONAL AUTHORS

Additional authors: Maureen Biggers College of Computing, Georgia Institute of Technology; David Binkley Dept. of Computer Science, Loyola College in Maryland; C. Kolin Frantz KD Evaluation Consultants; Dawn Gundermann KD Evaluation Consultants; Susanne Hambrusch Dept. of Computer Science, Purdue University; Steven Huss-Lederman Dept. of Mathematics and Computer Science, Beloit College; Ethan Munson Dept. of EECS, University of Wisconsin – Milwaukee; Barbara Ryder Dept. of Computer Science, Virginia Tech (formerly at Rutgers University) Monica Sweat College of Computing, Georgia Institute of Technology;

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