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Emerging Scholars Program—A PLTL-CS Program That Increases Recruitment and Retention of Women in the Major

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ABSTRACT

The Emerging Scholars Program (ESP) in Computer Science is a Peer Led Team Learning (PLTL) approach to bringing undergraduates new to the discipline together with peer mentors to work on computational problems, and to expose them to the broad array of disciplines within computer science. This program demonstrates that computer science is necessarily a collaborative activity that focuses more on problem solving and algorithmic thinking than on programming. In spring 2012 the computer science department at an urban research university university completed the 9th iteration of ESP, with 104 women and 36 men completing the program. Our evaluation data indicates that ESP increased enrollment in the computer science major. 47% of students who took ESP along with the introduction to computer programming course at the university study site during this study majored in computer science. In addition, survey results indicated that a large majority of students intended to take another computer science course, were enthusiastic about the program, and found the workshop topics exciting and engaging. Participants reported that they learned more about computer science in ESP, and would recommend ESP to others.

Categories and Subject Descriptors

K.3.2 [Computers and Education]: Computer Science Education

General Terms

Human Factors, Measurement

Keywords

Computer Science Education, Recruiting, Emerging Scholars Program, Peer Led Team Learning, Women in Computer Science

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1. INTRODUCTION

Recent Taulbee data released in April 2012 shows that more undergraduates are opting for the computer science (CS) major [9]. For the second straight year, there was a double-digit percentage increase in bachelor's degree production. However women's share of bachelor's degrees in computer science dropped from 13.8 percent in 2009-10 to 11.7 percent in 2010-11. To address women's low participation, computer science departments are borrowing from methods proven successful in teaching calculus, the physical sciences and engineering.

In a 2010 SIGCSE paper, we described how we built the Emerging Scholars Program (ESP) at Columbia University to encourage first-year women students in the intro course to take the second course in the major sequence and to consider majoring in computer science [8]. Piloted in spring 2008 with one ESP workshop, the program was expanded to two ESP workshops each semester in fall 2008. Evaluation of the program after its 9th iteration in spring 2012 indicates that ESP achieved its goal of recruiting women into the computer science major. In this paper we describe our results, which demonstrate that the program works. Students who took ESP along with the introduction to computer programming course at the university study site in 2009-10 were three times more likely to major in computer science the following year than the students who took introduction to programming without ESP.

2. BACKGROUND

The Emerging Scholars Program was initiated by Uri Treisman at the University of California, Berkeley in the 1970s as the Math Workshop, and later renamed The Emerging Scholars Program at the University of Texas, Austin. Treisman originally designed ESP to propel the mathematics skills of African American students by providing them with an honors workshop adjunct to the first-year calculus course [10]. Through observing the study habits of African American students as compared to Chinese students, Treisman noticed that the African American students tended to study alone, while the Chinese students, many of whom experienced a high rate of success, tended to both socialize and study with their Chinese peers in the course after they had studied alone. In the group study sessions, the Chinese students explained and defended their calculus solutions to each other. Through ESP workshops, Treisman replicated the study environment of the Chinese students by setting up small problem solving groups (6 to 8 students) outside of class, in which students collaborated on a set

of challenging problems organized on a worksheet. Graduate students were trained to facilitate the problem solving process by using Socratic questioning and offering helpful hints when necessary. ESP workshops have been successfully adapted to propel student achievement in mathematics, the physical sciences and engineering by hundreds of university academic departments.

Peer Led Team Learning (PLTL) is another initiative similar to the Emerging Scholars Program in that students collaborate in workshops to solve problems in small groups. However the Peer Leader is an undergraduate who facilitates the workshop by presenting the problem, and guiding the students to solve it collectively by brainstorming, analysis and discussion. PLTL also differs from ESP in that the PLTL workshop program is an integral part of a course, and the problem sets are tied to the course curriculum. Undergraduate peer leaders are students who have been previously successful in the course, and who demonstrate superior interpersonal and leadership skills. PLTL has been especially useful in courses that do not offer recitation or discussion sessions [11]. In ESP workshops, students are recruited from a STEM course, but the workshop problem sets are not drawn from the course lectures or assignments. PLTL was first used by the City College of New York in 1991 as a workshop adjunct to a chemistry course [4]. The PLTL method has been adopted by over 100 universities to support student learning in STEM.

3. PREVIOUS WORK

ESP and PLTL have only recently been adapted to support students in computer science. In 2006 faculty at the University of Washington, Tacoma employed ESP to improve student learning as measured by grades in an Algorithms course and a Data Structures course [2]. Students at this school tend to be non-traditional in that most are transfers from community colleges and do not reside on campus. Therefore they do not have many opportunities to become acquainted with peers in a course and work in informal study groups. ESP workshops were offered as 2 credit courses separate from the lecture courses and enrollment was voluntary. Evaluation indicated that the method was more successful in the workshop adjunct to Algorithms than Data Structures. The authors concluded that the workshop format was more conducive to the intellectual content in algorithms.

In 2004, a seven university consortium funded by a four year NSF-ITWF grant applied the principles of ESP and PLTL for students in the introductory computer science course [5]. In this project, which is ongoing, workshops are made available to students in the introductory programming course but participation is voluntary, and problem sets are aligned with the course curriculum [6]. Women are targeted and actively recruited to the program, although men are also welcome to participate. The evaluators of this program cited gains in student completion of the introductory programming course. Students who participated earned better grades than the control group, and reported in surveys satisfaction with their experience in the workshops. Evaluation also showed that active recruiting is effective in convincing students, especially women, with no previous interest in CS to enroll in an introductory CS course.

From 2006 through 2008, faculty at Georgia Institute of Technology developed a modified PLTL workshop adjunct to the CS1 course [1]. While PLTL workshops usually have an 8:1 student to leader ratio, this study assigned fifty students to each workshop due to resource constraints. The traditional course recitations were converted to PLTL workshops, and recitation teaching assistants (TAs) were trained in the PLTL model. Students' grades, pass rates and persistence in the CS1 course for the study years were compared to those of students in the previous academic year who had traditional recitations. Analysis showed that students in the PLTL model earned higher grades and experienced higher pass rates, with fewer students dropping the course, and women were retained at a higher rate than men. An advantage of this program is that it successfully applied small group learning strategies without incurring the costs that accompany small group instruction, and gained positive effects of PLTL while extending it to all of the CS1 students.

4. METHOD

4.1 Program Overview

The program, referred to herein as CESP, started at Columbia University as a pilot program in spring 2008, supported by Women in Computer Science (WICS), with six participants from the Introduction to Computer Science course. A CS major in the role of Peer Leader led weekly hour-long workshops, with help from a workshop assistant who was a CS major or minor. The goal of the program was to increase the number of women in the computer science major at the university. Upon completion of the pilot program, the project was awarded a $15,000 seed grant from the National Center for Women in Information Technology (NCWIT) and Microsoft Research. With this grant, as well as strong support from the computer science department, CESP expanded to two sections in fall 2008, with a total of 15 enrolled students.

At Columbia University, students are admitted into a school, but they do not choose the major until the sophomore year. The computer science major is housed in the engineering school, but students in Columbia College, Barnard, and the College of General Studies can also declare the major. CESP has proven to be an excellent recruiting tool to attract students from the introductory computer science course, referred to here as CS1, into the major.

CS1 at Columbia is a Java programming course with enrollments of nearing 500 students each year. Since many students in CS1 have had little previous experience with computing, the large lecture-based class can be intimidating. There are no small group labs or recitations, and students have little opportunity to form small, structured groups, or become acquainted with peers or faculty. The programming assignments must be completed individually, perpetuating the notion that computing is a solitary endeavor. Even with an effort to include real world topics into the CS1 curriculum, it is hard to introduce the breadth of Computer Science in CS1. Typically algorithmic thinking is not emphasized until the second half of the computer science curriculum with programming taking the priority. Although CS1 is comprised of approximately 40% women, few selected the computer science major prior to CESP. In 2008, women comprised only 9% of the major.

CESP was developed as an enrichment program to recruit more women into the computer science major [8]. CESP draws on PLTL in that a semester long series of workshops comprised of 6 to 8 students led by an undergraduate peer mentor meet weekly for an hour. Students are also recruited from the introductory computer science course. However unlike the described PLTL programs, the workshop topics are not connected to the course. CESP workshop

problems are drawn from a variety of CS disciplines, including natural language processing, artificial intelligence, cryptography, social networking and ethical issues in the field. Topics are chosen to demonstrate to students the breadth and variety of the computer science discipline. Problems range from designing algorithms, encoding and encryption, and machine translation to social network analysis and graph theory, and hard (NP complete) problems.

CESP engages the students in group problem solving activities so that students gain a first-hand understanding that computer science is a collaborative endeavor that is not solely programming. A goal of CESP is to develop a computer science community for first-year students, giving them the opportunity to interact through computing subject matter, develop friendships in the major, and bond with the computer science department. The CESP environment is relaxed and nonthreatening. There are no homework assignments, but students are expected to show up prepared to work in each session. Students receive one credit for participating in CESP; the workshop is graded as Pass/Fail.

Two PhD students manage the CESP workshops under the direction of the faculty who teaches CS1 and oversees selection of problem sets and workshop progress. Two CESP workshop series are offered each semester. A workshop team, consisting of an undergraduate peer leader and a workshop assistant who previously participated in CESP, facilitates each workshop series. Peer Leaders are paid a TA rate of $14 per hour. Workshop Assistants are not paid, but understand that they are "in training" to become Peer Leaders.

The CESP teams meet weekly with the PhD students to review problem sets and solutions. In these sessions, the peer leader and workshop assistant practice by leading a sample workshop. A workshop series consists of nine class meetings and culminates in a reunion party each semester for both current CESP students and students who took CESP in previous semesters. This reunion contributes to building the undergraduate computer science community, and provides an opportunity for the CESP team to recruit additional peer leaders and workshop assistants for subsequent semesters.

4.2 Student Recruitment and Selection

In the PLTL programs described earlier, all CS1 students are encouraged to participate in the program. The CESP program discussed here limits enrollment to 20 CS1 students each semester. Peer leaders recruit in the CS1 course by presenting CESP as an enrichment course and describing the benefits for participants. It is emphasized that CESP is in no way extra office hours or tutoring or remedial. Students are more open to the program when it is described by a peer who was involved in CESP first as a participant and later as a workshop leader. The workshop teams also recruit in the residence halls [8].

The ideal student for CESP is one who is interested in computer science but on the fence as to her choice of major. Students are invited to apply through an online questionnaire which gauges the applicant's interest in the major and prior experience with computing. Selections are made by the CS1 faculty along with the PhD program managers. Their criteria for selection are little previous programming experience, a strong interest in computer science and in the major, and an uncertainty about whether the major is a good fit for the applicant. Approximately 100 CS1 students apply for CESP each year, and up to 40 students are selected to enroll in four workshops series—two in the fall and two in the spring.

Application to CESP was open only to women from the spring 2008 pilot until the fall 2009 iteration, when men in CS1 were first invited to apply. However women are the targeted population, and approximately 70% of accepted students are women. 43% of ESP participants are from the engineering school, 50% from Columbia College and Barnard, and 7% from the College of General Studies. 70% are freshmen and 30% sophomores.

4.3 Program Evaluation

CESP students fill out three online surveys each semester: an application at the beginning, a midterm evaluation, and a final evaluation at the end of the semester. The application survey asks questions intended to gauge students' interest in the computer science major, as well as their appropriateness for a workshop intended to introduce students to the breadth of areas within the discipline, and to invite interested students to join a community of peers centered on an exploration of computing. The application asks "what major are you considering", as well as qualitative questions, including "why did take a CS1 course", "what makes you interested in computer science", and "what make you interested in the emerging scholars program".

The midterm evaluation gauges the success of the workshops thus far, asks students for suggestions for problem topics for future workshops, and asks students if their expectations of CESP are being met.

In the final evaluation students are asked on a 5 point Likert scale to rate their peer leader and their interest in workshop topics; if they feel they learned more about computer science from CESP; and if the social aspects of the program helped them to meet peers. Students are also asked if they would take another CS course, their plans for a major, and if they would recommend CESP to others.

In addition we looked at the number of students who took CS1 without CESP in 2009-10 and joined the major in the following academic year, compared to the students who took CSI along with CESP in the same year and declared the major in 2010-11. We analyzed the significance using Fisher's exact test. At Columbia, approximately 55% of majors take CS1 the year before declaring the computer science major.

5. RESULTS

From spring 2008 through spring 2012, 140 students completed CESP, 104 (74%) women and 36 men. At Columbia, students do not declare their major before the sophomore year. From these 140 students, we have records of the selected major of 93 students, 67 women and 26 men. 47% of the 93 students who completed CESP and declared a major chose computer science or computer engineering: 29 or 43% of the 67 women and 15 or 55% of the 26 men (Table 1). As mentioned earlier, students selected for CESP are unsure of their choice of major at the time of application.

In evaluation surveys at the end of each semester, students were questioned on 5 point Likert scales about the impact of CESP on their decisions concerning computer science courses and the major. 81% of respondents indicated they would definitely or they

Table 1

Students Major Selection 2008-2012 after ESP			
	Female	Male	Total
Total ESP Students	104	36	140
ESP Students with Declared Major	67	26	93
ESP Students with CS or CE Major	43%	55%	47%

were very likely to take another computer science course; 87% would definitely or were very likely to recommend CESP to others; 47% indicated that they would definitely or were very likely to enroll in the major, which is the same percentage of students who actually declared the computer science or computer engineering major (Table 2).

Table 2

Impact of ESP on student selection of major, CS courses		
	Definitely	Very likely
Do you plan to take another CS course?	63%	18%
Do you plan to major in CS?	17%	30%
Would you recommend ESP to others?	72%	15%

CESP survey responses show that students were enthusiastic about their experience. 89% responded that they agreed or strongly agreed that they learned more about computer science from the CESP workshops. 94% agreed or strongly agreed that the CESP topics are fun, engaging and interesting. 71% agreed or strongly agreed that they liked the social aspects of CESP, meeting with other students and discussing CS topics with their peers (Table 3).

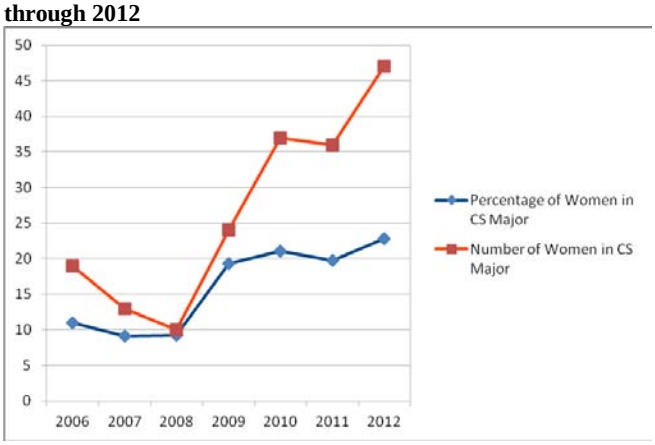
Table 3

Student experience in ESP		
	Strongly Agree	Agree
I learned more about CS in ESP.	40%	49%
ESP topics are fun and engaging	47%	47%
I liked the social aspects of ESP.	35%	36%

The increase in women's participation in the computer science major at Columbia correlates with the introduction of CESP in 2008. During the CESP project (2008-2012) women's enrollment increased from 9% to 23% of the major. Figure 1 shows that both the number and the percentage of women in the major increased, with women joining the major at a faster rate than men. With the introduction of CESP, women's participation rose to 19% of total enrollment in the major in 2009, while there was no increase in male participation in 2009. In 2012, women's enrollment reached 23% of total enrollment, along with an increase in male enrollment in the major.

Tracking computer science majors' course taking patterns provided us with another way to analyze the impact of CESP. Approximately 55% of computer science majors at the university study site take CS1 before they declare the computer science major. 280 students took CS1 in 2009-10. 30 of these 280 students took CESP along with CS1. 11.2% of the 250 students, who took CS1 without taking CESP, joined the major in 2010-11. 33.3% of the 30 students who took CS1 along with CESP in 2009-10 joined the major in 2010-11. The significance, analyzed using Fisher's exact test, showed a t-tailed p value of 0.0027. Although students self selected to apply for CESP, indicating their interest in the major, a selection criteria for CESP admission is that a student "be on the fence" about choice of a major. Students who took CS1 along with CESP joined the major at a 3 times greater rate than students who took CS1 without ESP.

FIGURE 1: Number and Percentage of Women's Enrollment in the Computer Science Major at the University Study Site 2006 through 2012



5.1 Qualitative Student Feedback

In the CESP application, students' responses to the question, "Why are you interested in CESP?" reveal that they recognize that CESP will help them to determine if the computer science major is a good fit for their interests and abilities. One student wrote, "I find computer science to be intriguing, but I haven't yet determined whether it is something that I want to pursue studying, and perhaps consider majoring in. Therefore, I'd like to explore the field more broadly and get a better sense of what it entails, in order to better inform my decision." Another student echoes this attitude. "As a person who has never really been exposed to the study of computer science before and currently set on studying as either a major or a minor, I felt that it was necessary for me to explore the discipline from different perspectives before making my choice. It [CESP] would hopefully provide some answers to questions I have about the discipline, and satisfy my curiosity about its core principles."

Research has found that peers exert the greatest influence on persistence in computer science, and some academic computer science departments retain women at the same rate as men [3]. Cohoon looked at measures of the relationship between various factors and women's enrollment and retention, and found that available same-sex peer support, measured as the female portion of enrollment, has the strongest relationship to gendered attrition rates.

Therefore a critical mass of women in a program will positively influence women's persistence.

With computer science course enrollments exploding in intro courses, student comments indicated that an especially attractive aspect of CESP is the opportunity to investigate computer science in small groups with their peers. One student wrote, "I am interested in the Emerging Scholars Program because I would love to further explore what I can do with computer science in a smaller, more intimate setting as opposed to the extremely large lecture setting of my Java class. I see this field of study as one in which the student benefits most from personal discussion and back-and-forth exchange of ideas rather than words on a series of slides."

Students' desire to connect with their peers in small groups over computer science topics resonated throughout the CESP applications. Another student noted, "I want to learn about computer science in a more non-traditional environment - one that focuses more on collaborative problem-solving and on finding creative solutions and applications….I think the Emerging Scholars Program offers a very rich environment for this type of discovery, more than a traditional computer science lecture can. I thrive in group settings and love to take a hands-on approach to learning." A nontraditional college student saw CESP as a means of fitting in. "As I am a commuter, I don't get to spend as much time on campus as most of the other students. I think the Emerging Scholars Program would be an excellent way for me to get to become more familiar with both computer science as a general field of study and the computer science department."

5.2 CESP Benefits for Peer Leaders

In the paper describing the process of starting CESP at Columbia, Murphy et al pointed out that the students who benefit most from CESP tend to be the peer leaders [8]. The program provides tremendous opportunities for them to gain leadership experience and to build confidence in themselves as computer scientists and educators. After their experience as peer leaders, several students have excelled in the major and in the discipline. Several are software engineers at top-tier companies such as Microsoft, Goldman Sachs and Barclays, as well as startups. Two others have used CESP as a stepping stone to further involvement in CS, participating in CRA-W Distributed Research Experiences for Undergraduates programs at top-tier research schools. One has gone on to win the Churchill fellowship and pursue graduate studies at Cambridge. Another student won the Google Anita Borg Fellowship and the NSF Graduate Research Fellowship.

Margolis and Fisher explored women's lack of confidence that they can be successful, and the feelings of alienation that many women experience in the computer science classroom [7]. Comments on the online application to become a Peer Leader give insight into students' desire for a safe environment to explore computer science. "I took the CESP course the spring semester of my freshman year in conjunction with Java. CESP was truly an enriching experience for me. I loved that CESP had such a laid-back, group setting. Every week, [the peer leader] would introduce a topic, and slowly allow the group to figure out everything themselves. As a group, we discussed, considered, and problem-solved with the guidance of [the peer leader]. It was so cool to learn about the various fields of computer science in this homework-free environment with yummy snacks provided by CESP! I was an eager participant, and I quickly realized that computer science is not just about programming. My favorite workshops were about algorithms and facial recognition software. I would love to help share CESP with other students who are interested in Computer Science."

The desire to give back motivates students, who participated in CESP and subsequently chose the major, to become a CESP Peer Leader. In addition, CESP gives students a means to bond with the computer science department, which further supports their persistence. A Peer Leader applicant described how this worked for her. "I participated in CESP in my freshman year (Fall 2008) after Professor [ ] introduced it during his introductory Java course. CESP was a great experience for me because I was able to meet fellow female peers who were also curious about CS. Moreover, I was able to meet with more experienced undergraduate students, graduate students, and professors, all of whom were very amicable and answered questions that I had about pursuing a career in CS… I hope to be chosen as a peer leader for CESP for the spring 2012 semester so that I could give back to this program that has helped me to decide to pursue a career in CS."

One Peer Leader applicant described how CESP gave her the confidence to persist in CS1. "When I was a sophomore I was completely clueless when it came to my major. I took CESP when I took [CS1] and it helped me decide that Computer Science was the right major for me. I really enjoyed coming to the weekly meetings to learn about different areas of CS and interacting with my peers. I really believe in the effectiveness of CESP and want to help others get excited about CS and potentially choose it as their major. As [CS1] progressed, I sometimes worried that I wasn't good enough at programming to major in CS, but CESP always reminded me of my newfound passion for the subject. CESP also helped me establish a small network of familiar faces within my major. Working together in small groups helped us get to know each other pretty well, and we continue to get together to go over problem sets and programming concepts."

6. CONCLUSION

CESP has been offered since spring 2008 at Columbia University with the goal of increasing the enrollment of women in the major. CESP engages students in group problem solving to gain an understanding of the breadth of computer science topics, and that computer science is a collaborative activity and not solely programming. Therefore, CESP is a means to invite novice students into a computer science community, in which they can interact through computer science topics, develop friendships in the major, and determine if the major is a fit for them.

No previous study has tracked the impact of ESP on participants declaring the computer science major. Our results show that ESP taken adjunct to CS1 correlates with an increase in the number of these students that subsequently join the major. This feature makes ESP especially helpful in attracting women, who are underrepresented in the major at most schools. Although this study claims correlation with participation in ESP and declaring the computer science major and not cause, the correlation is convincing. Enrollment data available for 93 participants indicates that 47% joined the computer science major after their CESP experience. This trend has continued throughout the years of this study. A previous 2010 paper on the program documented that 45% of the participants had joined the major [8]. In addition, the actual number of CESP students who declared the computer

science major matches the survey data of CESP students who expressed the intent to join the major.

Less than 12% of CS degree recipients in research universities are women [9]. At our institution, the enrollment of women increased from 9% to 23% during the four years of this study. Students who took CS1 along with CESP joined the major at a 3 times higher rate than students who took CS1 without CESP.

Our study also documents the positive effect of ESP on both Peer Leaders and CESP participants. Peer Leaders appreciated their own CESP experience and want to impart this to the novice undergraduates. In addition, several Peer Leaders thrived in the major following their mentoring experience. CESP participants not only joined the major in substantial numbers, but the great majority expressed the intent to take another CS course following their CESP experience.

Offering ESP adjunct to a CS1 course gives computer science departments an opportunity to create an environment within which novice computing students can engage with peers over topics of mutual interest and reflect on the major's fit for them. It has been found to be a particularly effective tool for attracting women into the computer science major.

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