Increasing High School Girls' Self Confidence and Awareness of CS through a Positive Summer Experience*

Lori Pollock, Kathleen McCoy, Sandra Carberry, Namratha Hundigopal, Xiaoxin You
Department of Computer and Information Sciences
University of Delaware
Newark, DE 19716
(pollock,mccoy, carberry,hundigop,you)@cis.udel.edu

ABSTRACT

This paper describes the design, implementation, and impact evaluation of of a summer program designed to attract high school girls to entering an information technology field for their college major. Our main contributions include an analysis of immediate and longer term surveys from both the student participants and the female teaching assistants, curriculum and pedagogy highlights of the program, and lessons learned from the planning and implementation experiences.

Categories and Subject Descriptors

K.3.2 [**Computers and Education**]: Computer and Information Science Education; K.4.2 [**Computers and Society**]: Social Issues

General Terms

Human Factors

Keywords

high school girls, cooperative learning, web programming

1. INTRODUCTION

The number of BA/BS degrees awarded to women decreased by 24.5% from 1983 to 1997[6], with only a slight increase in number (a smaller increase than men) since 1997[11]. Not only is the proportion of high school girls attracted to computer science low, but there is a clear narrowing of the pipeline from high school to college, graduate school, and through the ranks of academia and industry. While many have hypothesized about the potential causes for these trends [1, 3, 2, 9, 8, 7], additional research is needed to determine the kinds of programs that could aid in reversing this trend, particularly directed towards the middle and high school girls, who are considered to be at the mouth of the pipeline.

In this experimental project, we designed, implemented and evaluated a summer program targeted at high school girls, with the goal of attracting females into computer science. Based on the various findings reported in the literature [1, 3, 2, 9, 8, 7] and our own personal experiences as women in computer science, we hypothesize that girls are not attracted to computer science for several reasons including: misconceptions about the field itself, misconceptions about working styles of people successful in the field, lack of access to desirable role models, lack of interest in the field among their peers, and lack of confidence in the abilities perceived necessary for success in computer science. In order to overcome these problems, we designed a summer program, which we call *Girls' POWER (***P***rogramming* **O***f the* **WE***b* **R***ocks!) Summer Program* aimed at giving high school girls the tools necessary to have confidence about their technical abilities and feel positive about computer science, as well as providing them with an independent project experience with female university faculty mentors in computer science.

The program has a number of aspects that are innovative. We created a strong team of three senior female computer science professors who are noted for both their research and teaching excellence. The three faculty members collaborated in planning and teaching the summer program in order to provide role models for both the high school girls and female undergraduate teaching assistants. We designed what we believe is a "best case" scenario in this program, focusing on approaches to overcome the hypothesized barriers to attracting and retaining women at the high school and early undergraduate levels. The program leverages off of the technical strengths, excitement, and successes of the web for achieving the program goals. High school girls are given the opportunity to create interesting and useful web-based projects in a collaborative environment with female computer science undergraduates and university faculty. Female graduate and undergraduate computer science students are provided with a mentoring role as laboratory assistants.

The POWER program was evaluated on a short term and longer term basis, with careful design of the evaluation instruments. In addition to the regional impact, we believe that the results of our evaluation of this experimental program should have a significant impact on a wider audience, as they help to advance the understanding of what kinds of activities actually aid in attracting and retaining women,

*This project was supported by National Science Foundation Grant HRD-0086424.

SIGCSE'04, March 3–7, 2004, Norfolk, Virginia, USA.

as opposed to what aspects of society and computer science education inhibit women from choosing this field. These results provide insight into the kinds of activities that need to be initiated at other institutions, and the level of commitment that is needed by CS departments, universities, and industries to aggressively attract and retain women in computer science.

Section 2 describes the goals, design, implementation, and participants in the POWER program. Section 3 includes the methodology, results, and a discussion of the evaluation. Lessons learned from the experience are presented in Section 4.

2. THE POWER PROGRAM

2.1 Goals and Design.

The goals of the program were to introduce high school girls to college level computer science through a supportive, yet demanding, programming project and classroom experience, to clarify misconceptions of the field of computer science through exciting real-life projects directed to their interests and discussions about IT careers, to provide female role models in computer science, and to increase the girls' self-confidence in their abilities to succeed in this field.

The *Girls' POWER* (**P***rogramming* **O***f the* **WE***b* **R***ocks) Summer Program* was designed for 20 high school girls to participate in an 8-week, 5-days-a-week, half-day summer camp. The first instantiation of the program was team taught by three senior female computer science professors in CIS at the University of Delaware, with one female graduate student, and a team of three female undergraduate computer science majors serving as teaching assistants. In addition to helping with the direction of the projects, the graduate and undergraduate females provided information about what it is like to be a computer science major and tips to succeeding in a computer science program, as well as answering questions about the whole college experience.

The program has the following key features:

- **Focus on web programming.** The web has almost everyone's interest as a user. However, we believe it also provides an excellent tool for attracting girls to become creators, in addition to users, of technology. Fisher et al. [5] described how the girls who they interviewed often described their interest in computer science in the context of "what they can do in the world" and "as a tool to use within a broader context of education, medicine, communication, art and music", whereas boys like to work on the computer almost for the sake of doing it. The web provides an excellent base for designing projects that will be exciting to girls, and they can see how the programming skills that they are learning are useful for interesting applications. It is easy to create beautiful and useful applications with a short learning curve, thus making it intriguing from the start. There is considerable opportunity for being creative and artistic with web programming due to the animation, multimedia, interactivity, and graphical user interfaces. The client-server model of the web creates opportunities to create applications that are social-oriented. Examples are electronic party rsvps, shopping carts, chat rooms, and games.

- **Cooperative learning and group projects.** Studies have shown that cooperative learning methods seem to have a larger positive impact on learning for females[4, 10]. In addition, we wanted the girls to become aware that software development is not necessarily an isolated, anti-social activity, but is typically performed in project groups. We believe that the group projects would also contribute to increasing their self confidence and help to create a sense of community.

- **Immediate hands-on experience in a familiar setting.** In order to solidify the learning of key concepts, the girls were provided with an immediate opportunity to perform small programming tasks after minilectures. The program took place in a laboratory setting with Windows-based PC's so the students were familiar with the computing environment. The format for teaching a given concept consisted of a sequence of minilecture and lab exercises, trading between group and individual activities. This active learning style of minilecture-activity was familiar to many of the students from their high school experiences.

- **Career awareness speakers and role models.** Each week, a local researcher (i.e., faculty member, government or industry researcher, or graduate student), or industry leader in computer science came to campus to speak to the girls about their daily jobs, working styles, and their career preparation for those jobs. This provided the girls with exposure to the various opportunities in computer science. Speakers included a project manager from Vanguard, research scientist from the Army Research Laboratory, systems engineering consultant from the local power company, a CIS professor in networking, senior PhD student in AI, the web design team leader from JP Morgan, a CIS professor in algorithm design, a CPEG professor in internet security, and a CIS professor in graphics. Many, but not all, of these speakers were female.

- **Career and education awareness sessions.** In addition to the invited speakers, we ran a few informal discussions to educate the girls about possible career directions, working styles of these career paths, and the college life of a computer science major. The discussions targeted questions including: What is undergraduate CS all about? How do I succeed as an undergraduate CS major? What careers are possible? What is research in CS all about?

- **Networking opportunities.** A number of activities provided the girls with opportunities to mingle with female CS undergraduate and graduate students and faculty. The goal was to encourage the establishment of peer groups across local high schools as well as provide opportunity for informal mentoring discussions. Activities included volleyball games, campus treasure hunts, contests, picnics, special theme days, and a field day. The girls were also given free access to the university pool and athletic facilities, which some groups enjoyed together in the afternoons.

2.2 Implementation

The first instantiation of the POWER program was held in the summer of 2001 on the campus of the University of Delaware. The program was a non-residential experience,

Week	Topic	Subtopics
1	Static and interactive web pages	HTML, Client-Server, Javascript
2	Electronic forms: rsvp, shopping cart, survey,...	Objects, Events, Functions, Loops
3	Java applets	Java environment, basic applet use and design
4	Animated web pages	Repetition, conditionals, calling methods with parameters
5	Server-side programming	Active server pages
6	More server-side programming	Indepth use of cookies
7	Databases	Creating Access databases, accessing databases through the web
8	Final open-ended, group projects	Project development and presentations

Table 1: Weekly Schedule of Topics

run similar to a day camp, in order to focus our efforts on the organization and content of the program and related activities rather than housing and nonlocal recruiting efforts. Active recruitment for the summer program focused on the regional high schools. To attract participants from all socioeconomic classes, the students were awarded a stipend of $1000 for completing the program. We sent a direct mailing to the head of the math and computer science departments, the guidance counselors, and the principals of each high school in Delaware as well as nearby schools in Maryland and Pennsylvania. Advertising was also done online and through local community and campus newspapers. The camp lasted for 4 hours each weekday from 8:30 AM through 12:30 PM in order to give the participants ample opportunity for their other activities during those weeks.

Table 1 shows the weekly schedule of covered topics. The lectures, lab sessions, and most significantly individual and group projects were designed to be exciting, demanding, and directed with considerable built-in support to ensure a successful, positive experience for the high school girls. On the weeks devoted to projects, some time each day was reserved for the research/industry talks, organized social activities, and career and education awareness sessions.

2.3 Participants

Our recruiting targeted high school students just finishing either their sophomore or junior year. We believe that these students have the maturity and ability to participate, but hopefully are in the stage prior to deciding on a college major. The applicants were asked to complete an application form, and also submit a current transcript and two letters of recommendation. There were over 50 applications from interested girls. The applications were reviewed and ranked by all three faculty, based on their high school grades, academic and extracurricular accomplishments, courses taken in high school, and recommendation letters. Particular emphasis was put on grades in math and science courses. Prior courses and knowledge of computer science were not requirements for participation.

Twenty applicants were chosen for the summer program in order to keep the group small and be able to hold the program in a single, small laboratory setting. Twelve high schools (7 private or parochial and 5 public) were represented in the final set of selected participants. The participants were almost evenly distributed between completing their sophomore and junior year, with a few more completing sophomores and two of the girls completing only their freshman year. Over 2/3 of the participants had taken some computer course, but over 2/3 of them had never taken a programming course. One particular concern was to ensure that girls with more high school experience in computer programming were not favored over those who had not been given the opportunity to try programming at their high school.

The three undergraduate teaching assistants were CIS majors, just completed their junior year and with little to no teaching or mentoring experience.

3. EVALUATION OF THE IMPACT

In this section, we describe the methodology and results of our evaluation of the POWER program.

3.1 Methodology

The evaluation sought answers to the following research questions:

1. What impact did the summer program have on the participants' perceptions of computer science and the information technology field, their confidence in achieving their career goals, and decision making in course selection, major, and career choices?

2. What impact did the summer program have on the teaching assistants' confidence in achieving their career goals, decision making in postgraduation, and interest in future participation in such programs for increasing the number of women in computer science?

3. What aspects of the program were most effective, should be changed for more impact, or were not necessary to achieve the goals of the program?

In addition to the data and pre-program perspectives collected in the applications for the program, the participants and teaching assistants completed a survey on the last day of the program which focused on question 3, and then a survey focusing on questions 1 and 2 in summer 2003, 2 years after their participation in the summer program. The next subsection reports on our analysis and findings from these surveys.

3.2 Results and Discussion

3.2.1 Immediate Feedback on Program Design.

Eighteen participants and three teaching assistants completed the short term survey[1]. We report the feedback for each aspect of the program as percentages of the 21 respondents.

[1]Two girls were not present on the last day.

Content. While some of the participants had prior programming experience, none of them had done web programming in HTML, VBScript, or Java applets. In contrast to many experiences in introductory programming courses, the participants continued throughout the program to show great enthusiasm and interest in the web programming and the projects that they could create with the skills and knowledge they were learning throughout the program. When asked which topic was most interesting and fun, 38% chose HTML and JavaScript, 48% chose Java applets, 33% chose server-side programming, and 19% chose databases and their use through the web. 52% stated that the content was a little challenging, but doable, while 24% believed that the work was just at the right level for them, and 10% believed that the content was not too challenging. No one responded that the content was too difficult, or that the content was not challenging at all. This varied response reflects the wide variation in their backgrounds. For example, two of the participants had significant programming experience, including a C++ course, while others had never programmed. From these responses, we believe that this kind of web programming in a familiar PC setting is a good choice for such a program, in which the participants will most likely have a wide variation of skills and prior knowledge. We believe that the participants preferred the server and client-side web programming and applets to the database-oriented projects because they could relate more to those kinds of applications than database applications.

Pedagogy. The minilecture-activity format was preferred by all participants to longer lectures or all lab activities. When asked about their experience in collaborative groups, 67% said they had a very good group experience and that they learned from their group members, only 10% disliked the group activities (mentioning personality clash and burden on a single person as the reasons), and the rest remained neutral on the use of groups. The generally positive feedback on the collaborative groupwork is consistent with other studies[4, 10]. Both group and individual demo presentations of finished products were encouraged throughout the program. 47% of the participants stated that these presentations were a very good experience, while 43% were ambivalent about the presentations, and 9% suggested discontinuing student presentations. Because presenting one's own work can be intimidating and difficult for people who have low self confidence, it was a pleasant surprise to see that 91% of the girls found the presentations acceptable or a very positive experience.

Environment. When asked what they thought of the environment of having all females in the program, 42% said the experience was much better than a coed setting, while 38% stated that they believed the program would have had the same impact in either a coed or all female environment. This result was unexpected, as many of the girls commented how they were the only girl in their computer science course and how much more fun they were having in the program.

All but one respondent enjoyed having the program take place in the small lab setting as opposed to a classroom. All participants were comfortable with the Windows-based PC environment, which allowed them to easily focus their attention on the web programming in a familiar environment.

Duration. About 48% of the respondents suggested a duration of less than 8 weeks, with the majority of those suggesting 6 weeks instead; however, 24% of the respondents suggested keeping the duration at 8 weeks for only 4 days a week. About 57% believed that 4 hours a day was too long, while 33% were content with the 4-hour schedule. Almost half (53%) suggested a 3-hour timeframe as an alternative. While we were expecting a much lower number of weeks as the preferred duration (consistent with typical summer camps, for instance), it appears that 6 weeks might be a good duration, with possibly 3 hours per day.

Career Awareness, Networking, and Role Models. When asked how much they thought they learned about the computer science field from the invited speakers, 76% stated that they learned a fair amount, while others were evenly distributed between a lot, not too much, and nothing new. According to the student comments, the speakers who had the highest rankings for most interesting were those who related their topic to teens, were interactive, personable, and humorous. When asked their thoughts on having all female faculty and teaching assistants, the comments were overwhelmingly positive, several participants noting that these leaders provided them with female role models in computer science which they did not have at their high schools. The networking activities were a big hit, and many of the girls were anxious to take their peers' contact information to follow up with them after the program.

3.2.2 Longer Term Feedback on Program's Impact.

Seventeen of the participants completed the longer term survey, which focused on questions to determine the impact of the POWER program on the participants' perceptions of computer science and the IT field, self confidence in technology, and career-related decisions. Two of the three teaching assistants completed the longer term survey. In some questions, participants could choose any number of factors from the following list: high school computer courses, influence of a family member, work experience, high school teacher/advisor, friends, popular media, independent projects, career goals, extra-curricular high school activity, the POWER program.

Perceptions of CS and the IT field. When asked how much the POWER program contributed to their knowledge of programming, 71% responded "a lot", while 24% responded "some." 60% of the students stated that the program had a lot of impact on making programming seem more interesting, while 30% said it had some impact.

Factors indicated most often as positively contributing to the participants' knowledge about career opportunities in CS were the POWER program (16)[2], a family member (8), high school teacher/advisor (6), and high school computer courses (6).

When asked which factors provided encouragement to pursue a major or career in computer science or computer engineering, the most common answers were: the POWER program (12), a family member (10), and high school computer courses (9). When asked which factors discouraged them from pursuing a major or career in these fields, the most common answer was career goals (6), while high school computer courses, a family member, and extra-curricular high school activity were next, each with 3 responses.

The primary factors positively contributing to their view of the opportunity for women to succeed in technical careers were the POWER program (16), high school teacher/advisor

[2]Numbers in parentheses indicate the number of such responses.

(9), and influence of a family member (9). The primary factors negatively contributing to their view of the opportunity for women to succeed in technical careers were popular media (5), high school computer courses (4), influence of a family member (3), and friends (3).

Confidence. When asked to what extent their participation in the POWER program improved their confidence in their technical ability, 41% said "a lot" and 48% said "some", while 12% said very little to not at all. About 70% indicated that their participation improved their confidence some or a lot in their overall ability to be successful.

The primary factors that positively contributed to the participant's confidence in achieving their career goals were influence of a family member (13), POWER program (12), high school teacher/advisor (12), and friends (12). The primary factors that negatively contributed to the participant's confidence in achieving their career goals were influence of popular media (5), a family member (3), and high school computer courses (2). Both teaching assistants said that the program helped to increase their confidence in their technical ability. One teaching assistant also said that it significantly helped them in learning how to communicate effectively, take initiative, and gain leadership skills.

Decision making. In decisions made during the 2 years since their involvement in the program, 70% of the participants said that the program had a positive impact on taking subsequent mathematics or computer science courses. When asked what kind of impact the program had on their interest in pursuing a career in a technical or scientific field, the results were 24% significantly increased interest, 35% increased their interest, 17% had no impact, 12% somewhat decreased their interest. Both teaching assistants responded that the program increased their interest in pursuing either a technical or technical education career, and also in participating in similar programs in the future.

4. LESSONS LEARNED

The combination of a small group in a lab setting, collaborative group projects, project presentations, minilecture-activity format, undergraduate female role models and faculty, and animated speakers in fields that teens can relate to all received good positive feedback and were shown by the surveys to have a positive impact on the participants' perceptions, self confidence, and interest in pursuing technical careers. The perception of the work being challenging, but doable, indicates that even the girls with no prior experience were able to feel confident about their ability to grasp the computer science concepts in this environment.

The focus on web programming provided a way to present computer science and programming concepts, with an interesting and fun twist that the girls could relate to easily from their daily use of the internet. Projects could be very open-ended to handle the variation in prior knowledge and skill level, and to allow for significant creativity. The large variation in backgrounds was actually a positive aspect as the more knowledgeable girls could peer-teach others. We believe that the freshmen level may be too early to participate in such a program with the older girls due to differences in the conceptual thinking skills and maturity levels. However, the small ratio of students to teaching assistants was the key to being able to successfully handle the variation.

This program was designed to be a best case scenario for raising high school girls' self confidence in and awareness of CS. The level of commitment by the three faculty was quite high for the organization and teaching of the first instantiation. Each faculty was responsible for planning and teaching 2-2 1/2 weeks of the program. Shortening the program duration and daily time period as suggested by the participants as well as reusing much of the material would significantly decrease this workload.

One striking pointed lesson from the evaluation concerns the participants' perception of the impact of high school computer courses. These courses were indicated as the second lowest factor (next to popular media) of the list of 10 potential factors in having a positive contribution to their confidence in achieving their career goals, and also second lowest (next to career goals) in positively contributing to there view of the opportunity of women to succeed in computer science. The implications of these findings on young high school women further stresses the importance of identifying programs and techniques directed toward these young female potential computer scientists.

5. REFERENCES

[1] S. Beyer and E. M. Bowden. Gender Differences in Self-perceptions: Convergent Evidence from Three Measures of Accuracy and Bias. *Personality and Social Psychology Bulletin*, 23:157–172, 1997.

[2] J. Brown, P. Andreae, R. Biddle, and E. Tempero. Women in Introductory Computer Science: Experience at Victoria University of Wellington. In *Proceedings of the SIGCSE Tech. Symp. on Computer Science Education*, pages 111–115, 1997.

[3] E. Byrne. *Women and Science: The Snark Syndrome.* Falmer Press, London, 1993.

[4] J. D. Chase and E. G. Okie. Combining cooperative learning and peer instruction in introductory computer science. *SIGCSE Technical Symposium on Computer Science Education*, 1999.

[5] A. Fisher, J. Margolis, and F. Miller. Undergraduate Women in Computer Science: Experience, Motivation and Culture. In *SIGCSE Symp. on Computer Science Education*, pages 106–110, 1997.

[6] D. Gurer. Expanding the Pipeline: Women Role Models in Computer Science History. In *Computing Research News*, September 1998.

[7] W. Haliburton, M. Thweatt, and N. J. Wahl. Gender Differences in Personality Components of Computer Science Students: A Test of Holland's Congruence Hypothesis. *SIGCSE '98*, 1998.

[8] S. H. Rodger and E. L. Walker. Activities to Attract High School Girls to Computer Science. In *Proceedings of the 27th SIGCSE Technical Symp. on Computer Science Education*, pages 373–377, 1996.

[9] G. Scragg and J. Smith. A Study of Barriers to Women in Undergraduate Computer Science. In *Proceedings of the SIGCSE Tech. Symp. on Computer Science Education*, pages 82–86, 1998.

[10] H. M. Walker. Collaborative Learning: a case study for CS1 at Grinnell College and UT-Austin. *SIGCSE Symposium on Computer Science Education*, 1997.

[11] C. Wardle. A stroll down memory lane: Reflections on women in computing in the last decade and a half. *CRA-W Career Mentoring Workshop*, 2003.