6-1-2015

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Recommended Citation
Sabin, Mihaela, Paul Snow, and Mary Laturnau. 2015. "Evaluation of a Computing and Engineering Outreach Program for Girls in Grades 8–10." Journal of Computing Sciences in Colleges 30 (6): 119–26.

EVALUATION OF A COMPUTING AND ENGINEERING OUTREACH PROGRAM FOR GIRLS IN GRADES 8-10

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ABSTRACT

An outreach program of workshops and guided group activities for New Hampshire's eighth, ninth and tenth grade girls was offered to stimulate the girls' interest in computing and engineering coursework and careers. Attitude changes before and after participation were measured using a survey instrument adapted from one developed by the Georgia Tech's Institute for Computing and Education. Eight attitudinal themes were surveyed. With suitable adjustments for simultaneous testing of multiple hypotheses, statistically significant changes with moderate effect sizes were detected for three of the themes: enjoyment of technology-related activities, motivation to succeed in technical problem solving, and intention to persist in computing and engineering courses and careers.

INTRODUCTION

Diversity benefits the society and economy. It expands the qualified employee pool, improves the bottom line, enhances innovation, and promotes equality. The fast-growing Computing and Engineering (C&E) sectors have highly paid jobs, but relatively few C&E graduates. Women's participation in C&E occupations is remarkably low, 25% of the mathematical/computer scientists and 12% of the engineers were women in 2011. Women's share of C&E bachelor's degrees is also low, only 18% in 2010. Further, there is a worrisome trend of women leaving C&E jobs despite good job security and salaries [1, 2].

New Hampshire's goal of doubling the number of STEM educated graduates by 2025 [3] cannot be achieved without focused efforts to improve participation of women in STEM majors and careers. To respond to the challenge of closing the gender diversity gap in C&E, the Career Development Bureau of the NH Department of Education recruited a small group of C&E faculty and professionals from colleges and businesses in the fall of 2012. The group planned

and developed a full-day program, *Girls Technology Day* (GTD), designed to engage grade 8-10 girls in workshops with opportunities to learn about C&E academic and career pathways.

The first GTD was offered in Spring 2013 on the campus of NHTI, Concord's Community College. 147 girls and 27 teachers and counselors participated and shared their positive experience. That August, the GTD expanded into a larger annual event with a wider variety of workshops. This paper reports evaluation findings on the 2014 offering of the program.

PROGRAM DESCRIPTION

Objectives

The goal of the GTD program is to increase interest and engagement of 8th, 9th, and 10th grade girls in computing and engineering majors and careers. To achieve this goal, the GTD 2014 program's objectives were to:

1. Organize a full-day event of C&E workshops during spring break on the NHTI Concord's Community College campus.
2. Recruit 250 girls in grades 8-10 from 15 Career and Technical Education centers and their feeder middle schools.
3. Engage the girls in meaningful activities that feature C&E practices and showcase academic and career opportunities in C&E.
4. Assess changes in girls' attitudes towards C&E as a result of their participation in the program to evaluate and improve program's activities.

Implementation

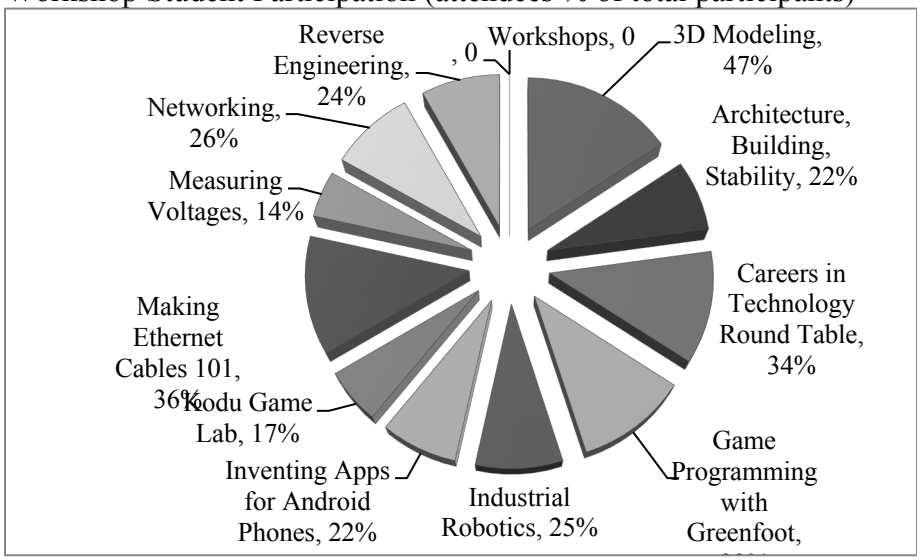
The GTD management team of six educators and industry and business leaders in 2013 expanded for GTD 2014 program's planning and organizing committee to 25 members, drawn from NH community colleges, University of New Hampshire, Career Development Bureau of the NH DOE, US Navy, and four local tech and business firms. The management team and other members met monthly and were responsible for developing workshop curricula and activities; raising funds from corporate donors; creating informational and recruiting materials, and defining evaluation protocols, instruments, and a data analysis plan. Recruitment of students started in January, reaching out to 15 Career and Technical Education (CTE) centers and two feeder middle schools, all within a two-hour bus ride of the event site, about an 85-mile radius.

The program's curriculum and workshop activities sought to dispel beliefs that computing and engineering are "boring, difficult, antisocial or do not have much impact on solving the world's problems"[5]. Guided by the design principles of the computing summer camps run by Georgia Tech's Institute for Computing and Education (ICE) [6], GTD workshops were designed to demonstrate the creative, collaborative, and stimulating nature of C&E and to allow the girls to interact with each other, faculty, and C&E and business professionals.

The program scheduled 13 workshops during four time periods, two in the morning and two in the afternoon. All 17 schools participated in the morning sessions; one school had to leave after lunch, and 9 schools left after the 3rd time period. The last time period scheduled 7 workshops because only 7 schools could be in attendance at that time. The other three time periods scheduled all 13 workshops, three of which had two parallel sessions. In all, 54 sessions were offered in the program. 203 girls attended the event; 47 educators accompanied them.

Student choices among the workshops and program structure are summarized in **Figure 1**. All workshops featured project-based teamwork to stimulate interactions and communication among participants and workshop facilitators. A college and industry fair was held during the two lunch periods (from 11:00 - 12:20) to give students and teachers the opportunity to learn more about C&E academic programs and careers in NH.

Workshop Student Participation (attendees % of total participants)



Program Structure

# Workshops	13
# Schools	17
# Students	203
# Students/ session	10-25
Sessions attended by each school	2-5
Total number of sessions attended	54

Figure 1. Student participation in the GTD workshops and overall program structure.

Participants

203 girls from 17 schools attended GTD 2014. Most were White (85%). The rest (15%) Underrepresented minority (URM) students in STEM (Black, Hispanic, and of two or more races), which is more than twice the proportion of these groups in NH (6.6 percent) [11]. Most students were 9th graders (52 percent). **Table 1** summarizes participants' backgrounds.

Race/Ethnicity			**Grade**	
	GTD	NH	8th	34%
White	82%	91%	9th	52%
URM	15%	7%	10th	14%

Table 1. Participating student information

Evaluation Plan

To evaluate the program, student surveys were administered before and after the event within a week time interval. Participating teachers who registered their school's student groups assisted with having students take the surveys. The purpose of the evaluation was to determine the effectiveness of the program in producing positive changes in girls' attitudes toward computing, engineering, and technology. Students responded to 16 statements on a five-point scale (1 = strong disagreement, .., 5 = strong agreement).

The survey is an adaptation of the ICE survey [6] to reflect the C&E disciplinary content and technology-related activities of the GTD program (see **Table 2**). Georgia Tech's ICE surveys are available at http://home.cc.gatech.edu/ice-gt/310. The following changes were made

to the ICE survey:

1. The use of word *computing* or *computer science* was extended to encompass both *computing and engineering*. (Statements 5, 6, 8, 9, 12, 13, 14, 15).
2. One instance of the work *programming* was replaced with *computing and engineering* (Statement 2).
3. The reference to *computer scientists* was changed to include *engineers* (Statement 11).
4. Instances of the words *computer(s)* and *computing* in the context of "use/using," "do" and "field" became *technology* (Statements 1, 3, 4, 10, 12, 16).

As noted in [6], the constructs in **Table 2** have been psychometrically validated [7] and identified by literature in computing and engineering [8, 9] as critical to increasing the number of women and racially underrepresented students who persist in computing and engineering fields.

	Construct	**Statements**
C1	Enjoyment	1. Technology is fun. 2. Computing and engineering are hard. *
C2	Importance & usefulness	3. I'll be able to get a good job if I learn how to use technology. 4. I will use technology in many ways throughout my life.
C3	Confidence	5. I can get good grades in computing and engineering. 6. I'm not the type to do well in computing and engineering. *
C4	Motivation to succeed	7. When a technology problem arises that I can't immediately solve, I stick with it until I have the solution. 8. Computing and engineering are boring. *
C5	Identity &Belongingness	9. I feel like I belong in computing and engineering.
C6	Gender equity	10. Girls can do as well as boys in technology. 11.There are many females who are excellent computer scientists& engineers.
C7	Intention to persist	12. I can see myself working in a technology field. 13. I intend to take courses related to computing and engineering.
C8	Creativity	14.I am able to be expressive and creative while doing computing or engineering. 15. I enjoy solving problems in computing and engineering. 16. Using technology to help people is very important to me.

Table 2. Student survey constructs and statements. An asterisk (*) marks a "negatively worded" statement that was recoded for analysis.

EVALUATION AND RESULTS

Data Analysis

Pairs of pre- and post-surveys from 47 participants were used with permission of the students and their guardians. In all, 249 pre-surveys were distributed, one to each student who registered, and 203 post-surveys, one to each student who attended. 102 pre-surveys and 75 post-surveys were returned. Of those, 94 surveys, 47 pairs, were matchable and accompanied by the needed permissions, for a useable response rate of 23% of the 203 attending. No attempt was made to analyze attrition, nor the selection bias of including only those who complied with survey instructions and who gave and obtained the needed permissions. The 47 surveys analyzed in this study were nearly complete, with 8 missing responses out of 1,584 answers sought, leading to 8 missing construct-score change observations out of the 376 possible among 47 survey pairs.

In addition to identifying and demographic information, each survey presented 16 statements about attitudes towards computing, engineering, and technology-related activities, coursework, and careers shown in **Table 2** above. Three of the statements were worded "negatively," so that agreement would mean an attitude that would preferably be turned toward disagreement. For analysis, the responses to those three statements were recoded by subtracting the respondent's answer from six, so that "higher values are better" throughout the data set, with a shared 1-to-5 scale for each statement.

The recoded responses to the 16 statements were grouped according to the eight constructs. The score for each construct was the average (recoded) response among the statements in its group. If a student did not respond to a statement in the construct group on either survey, then no construct score was calculated for that student. That is, both pre- and post-survey values for that student and that construct were coded as "missing."

Major Findings

Three constructs showed statistically significant changes (each item's $p < .00625$), using a standard two-tailed t-test for matched-pair data (**Table 3**). The significance threshold of .00625 for each item results in a family wise significance level of .05 over the eight tests, according to the widely used Dunn-Bonferroni correction for testing several hypotheses at once [11]. All changes were in the desired direction.

	Construct	N	Average score before	Average score after	p-value	Effect size (d-value)
C1	**Enjoyment**	47	3.64	3.91	0.0014	0.49
C2	*Importance and usefulness*	*45*	*4.29*	*4.53*	*0.036*	-
C3	*Confidence*	*44*	*4.01*	*4.08*	*0.452*	-
C4	**Motivation to succeed**	46	4.00	4.21	0.0053	0.39
C5	*Belonging*	*47*	*3.53*	*3.68*	*0.109*	-
C6	*Gender equity*	*47*	*4.60*	*4.81*	*0.091*	-
C7	**Intention to persist**	45	3.69	3.99	0.0058	0.37
C8	*Creativity*	*47*	*3.95*	*4.06*	*0.149*	-

Table 3. Evaluation results.

Effect sizes were assessed by Cohen's "d" statistic [12], with root mean square pooling of standard deviations. For all three of the significantly changed constructs, effect sizes were in the small-to-medium range (conventionally regarded as d-values between about 0.2 and about 0.5).

CONCLUSION

STEM outreach programs for pre-college girls could impact their choices for disciplines and careers in fields that suffer from women underrepresentation. The GTD program is a statewide annual event for girls in grades 8-10, who participate in a variety of highly interactive and stimulating C&E activities.

The GTD program was designed with two guiding principles in mind:

- Offer diverse and engaging workshops that focus on projects in which girls create innovations instead of simply using technology products and services; and

- Involve educators from 2-year and 4-year colleges and professionals from local businesses with high STEM employment needs to share how C&E connects with the world of work and discoveries.

In the GTD program, statistically significant gains in girls' attitudes towards computing and engineering were found in the areas of enjoyment, intention to persist, and motivation to succeed, with the largest impact on enjoyment. These results suggest that workshop curriculum and activities can be further improved to increase girls' confidence, sense of belonging, and self-efficacy in doing C&E. A positive outcome of the program is continued support from the NHDOE and participating colleges to double the size of the program. To increase participation from more than 400 girls, workshops will be offered on two community college campuses in Nashua and Manchester in 2015.

ACKNOWLEDGMENTS

This material is based upon work supported by a NH EPSCoR grant. Special thanks go to the NH CTE centers' educators who participated in the GTD program and the many volunteers who shared their professional experiences with the girls.

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