Does Outreach Impact Choices of Major for Underrepresented Undergraduate Students?

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ABSTRACT
Over the last decade, there has been a concerted effort to bring more diverse voices to the technology field, with much of this being done through outreach activities to girls and boys. Unfortunately, data demonstrating the long-term impact of outreach activities remains rare. To contribute to knowledge on the longitudinal effect of outreach programs, we used a quantitative methodology that followed a descriptive design approach to explore the impact of participation in outreach activities on the choice of undergraduate major. Of those surveyed, 45.3% of the 770 respondents recalled participating in these activities. The results indicate that these activities had a more positive impact on Asians and more negative impact on Hispanics. Blacks/African Americans were more likely to voluntarily participate in outreach activities than Hispanics, and whites were more likely to feel that they were a welcome part of the group than non-whites. The results also may indicate that when outreach programs are available in earlier grades, they are not reaching non-white participants to the same extent as white participants.

Categories and Subject Descriptors
K.3.2 [**Computers and Education**]: Computer and Information Science Education – *computer science education*

General Terms
Measurement, Experimentation, Human Factors, Verification

Keywords
Computing outreach, Underrepresented groups in computing, Impact, Effectiveness, Minorities, Choice of Major

1. INTRODUCTION
A lack of diversity has existed in the field of computer science for decades, although the issue has taken on new urgency in recent years as the popular press has drawn attention to the low numbers of ethnic minorities earning degrees in computer science in the U.S. For example, the 2013 Taulbee Survey shows that while 41.3% of computer science Ph.D.s granted by U.S. institutions are earned by American citizens, only 12.9% are granted to ethnic minorities with 9.5% to Asians and 3.4% to all other minorities combined [85].

The situation is similar for computer science Masters students, since 35% of Masters degrees are awarded to American citizens, but only 11.7% are awarded to non-white[1] students with 8.5% to Asian students and 3.2% to all other minorities combined [85]. The situation is slightly better at the undergraduate level since 91.7% of all computer science bachelor's degrees awarded at U.S. institutions are given to American citizens, and 30.5% are awarded to minorities with 18.4% to Asians and 12.1% to all other minorities combined [85].

Data from previous Taulbee Surveys shows the persistence of the problem. In 2003, 20.6% of Ph.D.s, 19.4% of Masters, and 34.6% of bachelors in computer science were awarded to American citizens belonging to an ethnic minority [84]. Of the 20.6% of Ph.D.s awarded to minorities, 14% were to Asians and 6.6% were to all other minorities combined. Of the 19.4% of Masters awarded to minorities, 15% were awarded to Asians and 4.4% to all other minorities combined. Of the 34.6% of bachelor's degrees awarded to minorities, 24.5% were to Asians and 10.1% to all other minorities combined.

Moving back another decade, 21% of PhDs, 23% of Masters, and 25% of bachelors in computer science were awarded to U.S. citizens who are ethnic minorities in 1993 [4]. Of the 21% of Ph.D.s, 15% were awarded to Asians and 6% to all other minorities combined. Of the 23% of Masters, 18% were awarded to Asians and 5% to all other minorities combined. Of the 25% of bachelors, 16% were awarded to Asians and 9% to all other minorities combined.

As this data shows, lack of ethnic diversity is not only a long-standing problem in computing, it is one that has become worse among advanced-degree holders. Computer science educators have been cognizant of this far longer than the popular press, and outreach programs for ethnic minorities have existed for decades. Many U.S. institutions of higher education have some form of outreach program for K-12 students, although finding centralized

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[1] The terms *whites*, *non-whites*, and *blacks* are used in this paper to align with the U.S. Census Bureau, the Computing Research Association, and previous studies of this nature, all of which informed the study and survey.

directories of the programs is difficult. Centralized efforts at outreach do exist, and the Association for Computing Machinery (ACM) has played a role in several of them. For example, the Computer Science Teachers Association was formed by the ACM in part to address the need for diversifying the computer science pipeline. The National Science Foundation has also actively encouraged outreach programs in the U.S. through the funding of various broadening participation initiatives.

In this work we consider the following question: is there a long-term impact of computing outreach activities for underrepresented minority students? To answer this, we first conducted a systematic literature review of previous studies with a long-term evaluative component. Based on these results, we then conducted a study of undergraduate students' past experiences with such outreach activities to understand the long-term impact of outreach programs, comparing white students and minority students. This paper presents the results of both.

2. BACKGROUND

In order to determine what others have found with regards to longitudinal results for outreach initiatives, we undertook a systematic literature review framed by Khan, Kunz, Kleijnen, and Antes [44]. The systematic review framework includes framing the question, identifying relevant work, assessing quality of the studies, summarizing evidence, and interpreting findings.

The free-form question we sought to answer was "Is there a long-term impact on under-represented minorities who have participated in computing outreach activities?" To answer this question, we looked for studies with the following characteristics:

- *The populations studied*—Students enrolled in computing outreach programs as defined by the researchers
- *The interventions*—Programs that exposed students to computing concepts that were outside of their normal required school work
- *The outcomes analyzed*—Interest in pursuing a degree in a computing field and/or actual enrollment and completion of a degree in a computing field
- *The study designs*—Quantitative, qualitative, or mixed methods studies that tracked the participants in computing outreach programs over a period of time that extended beyond the length of the intervention itself

We then identified relevant work of quality by considering ACM and IEEE journal and conference publications, which have a long history of publishing quality papers. We further refined that to venues within these organizations that emphasize education, including the following peer-reviewed journals and conference proceedings in electronic form: ACM SIGCSE Technical Symposium on Computer Science Education, Computer Science Education, IEEE Frontiers in Education, Innovation and Technology in Computer Science Education, International Computing Education Research Workshop, and Transactions on Computing Education from the years 2009 to 2014 inclusive. This effort resulted in 3,672 citations from which relevant studies were selected for the review. Their potential relevance was examined, and 3571 citations were excluded as irrelevant, leaving 101 articles.

To determine relevance, we started with an analysis of the title of each article. An article was determined to have a title associated with outreach by using keywords: outreach, K-12, elementary school, high school, secondary school, after school clubs, summer camp. Once a title was determined to be related, further examination was given to the article's abstract. If the abstract also included the keywords and indicated that an intervention that introduced computing to students outside of their required classroom setting and curricula took place, the articles were left for the review. These articles were then examined in detail. Each article was read and the following information was recorded:

- Target audience of the outreach
- Country in which the target audience lived
- Whether or not the intervention was designed to increase gender diversity
- Whether or not the intervention was designed to increase ethnic diversity
- If data was collected from participants
- Whether the study was quantitative or qualitative
- The number of participants in the study
- The gender of the participants in the study
- The ethnicity of the participants in the study
- What variables were assessed by the study
- Whether there was a longitudinal component to the study
- The number of years for the study (if longitudinal)
- The summary of the findings (if longitudinal)

Of the 101 articles considered, 28 were removed from further analysis because during this careful read stage, it was discovered that they did not fit the model for a discussion about the impact of a computing outreach activity. Many of these simply described an activity, gave advice for running an activity, gave example curriculum for activities, or were work in progress papers that did not include any reporting of results.

The remaining 73 papers [1, 2, 3, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 77, 78, 79, 80, 82, 83] were dominated by results from interventions in the U.S. (75%). We therefore converted results of non-US interventions to the U.S. education system. We found that a majority of the interventions (82%) were outreach efforts aimed at high school and/or middle school students.

Within our analyzed sample, 46 (63%) were quantitative studies, 13 (18%) were qualitative studies, 13 (18%) were mixed methods, and 1 (1%) was not characterized as either. The number of study participants was reported in 62 of the articles (85%), with the number of participants ranging from 2 to 9956. Of the 73 interventions discussed in the articles, 25 (34%) indicated that they were designed to increase ethnic diversity, 41 (56%) indicated that they were not created to address ethnic imbalance, and seven (10%) did not provide enough evidence to categorize the intervention.

Participant ethnicity was reported by 27 (37%) of the articles. Of the studies conducted on interventions designed to increase ethnic diversity, 18 (72% of that group) indicated the ethnicity of the participants in and subsequent study of the intervention.

Many of the articles undertook some form of data collection about the participants of the programs. Of the 73 articles analyzed, only three (< 1%) did not report on any systematic data collection and analysis. Since we are most interested in longitudinal studies as it relates to our work, we identified that only seven (9.5%) of the 73 articles that presented information about longitudinal studies. Of those seven, four articles discussed interventions designed to increase ethnic diversity.

Two of the four papers examined outreach programs provided to K-12 students. The Berkeley Foundation for Opportunities in Information Technology (BFOIT), a project of the International Computer Science Institute (ICSI), has two full-scale programs, one for middle school students: Science for Youth (SCI-FY), and one for high school students: Information Technology Leadership Program (ITLP), and a third fledgling program for elementary students, Early Techies (ET) [17]. The longitudinal aspect of this study was the tracking of BFOIT students' mental rotation ability and perspective-taking ability through the use of standardized tests. They found a modest correlation between the number of years that students have been in BFOIT and their mental rotation score. Of the 153 participants of BFOIT, 65 have matriculated high school and have gone onto college/university.

One article summarized findings from Georgia Computes!, a six year effort (2006-2012) designed to improve computing education in Georgia through summer camps for students and professional development for teachers [35]. The study investigated the impact computing outreach activities had on the number of schools offering computer science courses and the number of students taking Advanced Placement (AP) Computer Science exams over the course of the project and in the two years after the project. Findings indicate that early interventions appear to have an impact on whether or not students choose computing as a major.

The two remaining papers analyzed outreach activities' impact on undergraduate students, examining engagement, retention, self-efficacy, and several other related factors [19, 21]. One study, the INSPIRED (Increasing Student Participation in Research Development) Program, collected and analyzed two years of data [21], while the other, Students and Technology in Academia, Research, and Service (STARS) Alliance, covered three years [19]. Due to the limited span of time that the studies covered as well as their on undergraduate students rather than K-12 students, details of the studies are not included here.

Once summarized, we considered the evidence from these studies holistically with respect to our free-form question. Within the four studies that presented evidence of longer-term impact, none answered the question about the long-term impact on the participants after the outreach activities concluded. Therefore, we concluded that more systematic study of the long-term effects of outreach programs is needed. In the following sections we describe the methodology and the results of our study of the long-term impact on underrepresented minorities of computing outreach activities.

3. METHODOLOGY

In this study, we used a quantitative methodology that followed a descriptive design approach to investigate whether or not undergraduate students believed that their participation in computing activities prior to college contributed to their decision to major in a computing field. [16].

We created the Effectiveness of Technology Outreach Survey. In addition to basic demographic data, the survey required respondents to recall activities, thoughts, and feelings about their participation in these activities. In order to gauge validity and to limit recall bias, two additional steps were taken. First, respondents were asked to participate in retaking the survey to determine the recall bias and to establish validity of the results [16]. Second, we integrated recall prompts (aided recall) within the survey to serve as memory aids to respondents [76].

Respondents were recruited using three different methods. We recruited undergraduate students at three institutions, Bradley University, DePaul University, and Rochester Institute of Technology. Second, we asked colleagues and peers at a variety of other universities to send requests for participation to their undergraduate students. These universities were carefully chosen to be diverse in their geographic location as well as their institution type (size, private versus public, etc.) to help ensure a more representative sample of students. These institutions included University of California Santa Cruz, Ball State University, and University of Buffalo. Lastly, we used findparticipants.com to recruit additional undergraduate students.

Upon approval by our institutions' Institutional Review Board (IRB), the request to participate was sent to faculty and to students at the identified institutions. To gather the data, an electronic form of the survey instrument was created using the Qualtrics online survey tool. Only respondents who agreed to the letter of consent that appeared on the first page of the survey were able to complete the survey. The letter of consent required them to indicate that they were at least 18 years of age.

As an incentive, respondents at universities were offered entry for a prize drawing of a $50 Amazon gift card upon completion of the survey. To enter, respondents followed a link to a second survey thereby keeping the survey responses separate from the drawing survey that required respondents to enter contact information, thus removing the potential of linking personally identifiable data with survey responses. At the end of the survey, respondents were asked if they were interested in retaking the survey in approximately 2-4 weeks. As an incentive, respondents who retook the survey were offered entry for a prize drawing of a second $50 Amazon gift card.

To analyze the data, a test of equivalence among the initial and retake survey results was performed. A total of 770 respondents completed the initial survey indicating gender and ethnicity and 411 completed the retake. Only three respondents were from findparticipants.com, while the remaining were from the educational institutions previously noted.

A Kurskal-Wallis Test was performed on non-parametric data to determine equivalence between the results of the initial and retake surveys [81]. The results of the test indicated that for all non-parametric data, there were no differences found, with p values in the range of 0.75 and 1.00.

To determine equivalence between the two samples for the Likert-like items, an unpaired t-test was performed with a confidence interval setting of 90% using GraphPad Prism [75, 81]. The entire range of the 90% confidence interval was between the zone of indifference (0.35) for all but two items, "The majority of students participating in the activities were boys" (0.36) and "The majority of students participating in the activities were girls" (0.42). For this test of equivalence, if the entire range of the 90% confidence interval lies within the zone of indifference, then we can conclude that all other items are equivalent across the two groups with 95% confidence [75].

However, the recall for whether or not the majority of the participants were boys or girls was higher than for the other items, indicating that these values may not be as reliable. For example, the confidence interval range for "I enjoyed many of the activities" was 0.28, well below the 0.36 and 0.42 values for the items related to gender of the participants. Respondents recalled this item more consistently between the first and second survey. Therefore, extra caution should be taken when interpreting results related to the two items related to gender (see 4.4.2).

4. RESULTS

Using SPSS, we analyzed the data to evaluate similarities and differences among white and non-white respondents.

4.1 Respondent Demographics

The ethnicity survey item was modeled from the U.S. Census Bureau's list of ethnicities. We asked respondents to select the group(s) with which they most closely identify (Table 1). Guamanian or Chamorro, Other Asian (not previously mentioned), and Samoan are not included in the list, since each had 0 responses.

Table 1. Ethnicity demographics

	#	Percent
White	614	79.7
Hispanic/Latino/Latina	53	6.9
Asian	52	6.8
Black or African American	38	4.9
Multi-racial	26	3.4
Chinese	17	2.2
Filipino	12	1.6
Middle Eastern	12	1.6
Japanese	8	1.0
Asian Indian	7	0.9
Korean	7	0.9
Some other race	4	0.5
American Indian or Alaska Native	3	0.4
Native American	2	0.3
Vietnamese	2	0.3
Native Hawaiian	1	0.1
Other Pacific Islander	1	0. 1
Decline to Answer	23	3.0

For the remainder of this analysis, "whites" refer to all participants who only selected White as their ethnicity. Non-whites are participants who selected at least one ethnicity other than White.

4.2 Mandated versus voluntary participation

Respondents were asked to recall if they had participated in a computing activity prior to entering college. Though we loosely defined computing, we left the question open for interpretation by the respondent. Our loose definition prompted the respondent to recall clubs and activities in and out of school that included "…activities for learning about computers, such as programming, games, hardware, robotics, and more."

Results show that 45.3% of all respondents had participated in the activities, with 43.6% of white respondents and 50% of non-whites indicating that they had participated (Figure 1, Table 2).

Of those that participated in a computing outreach activity, 18.9% indicating that they were required to and 26.1% indicating that they participated voluntarily. With respect to white respondents, 18.1% indicated that they were required to participate and 25.5% voluntarily chose to participate. 50.4% of white respondents did not participate in any computing activity prior to college.

With respect to non-white respondents, 21.4% indicated that they were required to participate and 28.0% indicated that they voluntarily participated. 44.5% of non-whites did not participate in any computing activity prior to college. This data, along with the data from the three largest segments of non-white ethnicity, are shown in Table 2.

Table 2. Type of participation by subgroups

	White	Asian	Black or African American	Hispanic/ Latino/ Latina	All Non-white
Yes, required	18.1%	26.9%	21.1%	22.6%	21.4%
Yes, voluntary	25.5%	26.9%	39.5%	15.1%	28.0%
No	50.4%	40.4%	31.6%	58.5%	44.5%
Don't recall	4.6%	3.8%	2.6%	3.8%	3.8%
Unsure	1.4%	1.9%	5.3%	0.0%	2.2%

4.3 Timeline of Participation

Respondents who indicated that they had participated in a computing activity (336 or 45%) were asked to recall at what point in their education they had participated: elementary school, junior high/middle school, high school, or other.

Overall, 54.5% of respondents who participated in a computing activity did so while in high school, 30.2% in junior high or middle school, and 13.3% in elementary school. For whites the breakdown was 51.9%, 32.1%, and 14.1% respectively, while for all non-whites it was 60.8%, 25.7%, and 10.1% respectively. Table 3 provides the values for white, nonwhite, and the three largest segments of the non-white population. Figure 2 displays this data visually.

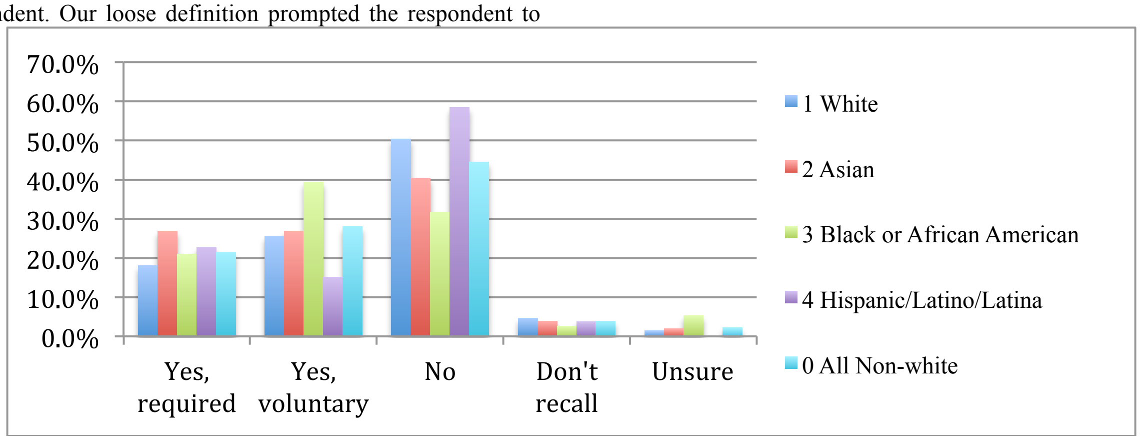

Figure 1. Participation in a computing activity prior to college

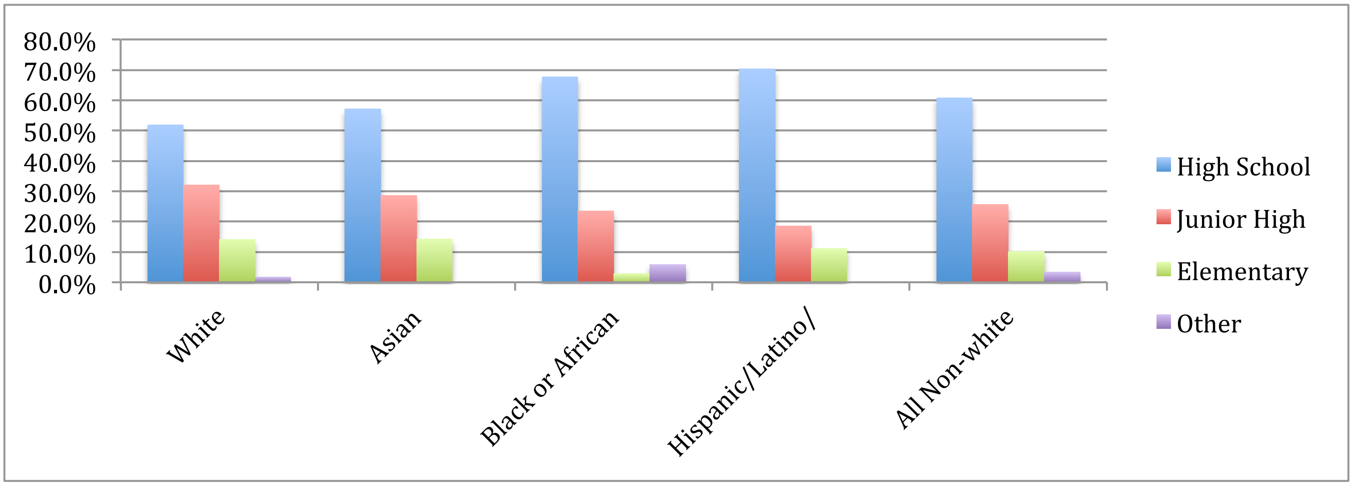

Figure 2. Period of activity participation

Table 3. Period of participation

	High School	**Junior High**	**Elementary**	**Other**
White	51.9%	32.1%	14.1%	1.8%
Asian	57.1%	28.6%	14.3%	0.0%
Black/African American	67.6%	23.5%	2.9%	5.9%
Hispanic/Latino/Latina	70.4%	18.5%	11.1%	0.0%
All nonwhite	60.8%	25.7%	10.1%	3.4%

4.4 Perceived Impact on Major

Respondents were asked how participating in these activities affected their choice of major. Of the respondents who answered this question (n=336), 22.3% indicated that it affected their decision to choose a computer science or related major and an additional 7.1% indicated it affected their decision to choose game design or development as a major.

With respect to impact of participation in these activities on willingness to choose to take a computing course in college for those who did not major in a computing related field, 30.1% said it had a positive effect, and that they chose to take a course in computing because of the activities. 5.4% said it had a negative effect, and they choose not to take a course in computing in college because of the activities.

Drilling down into the data more, we found that there wide variances in the answers from the major subgroups. We provide the data both in table format (Tables 4 and 5) as well as graphically (Figures 3 and 4).

Table 4. Perceived effects of activities on choice of major

	White	Asian	Black or African American	Hispanic /Latino/ Latina	All Non-white
Affected my decision to choose a game design or development major	2.7%	10.7 %	17.4%	5.0%	4.4%
Affected my decision to choose a computer science or related major	9.3%	35.7 %	21.7%	10.0%	13.1%
Affected my decision to choose a major that does not require me to study computers or programming	2.8%	0.0%	17.4%	30.0%	5.3%
Did not affect my decision when choosing my major	24.0 %	35.7 %	30.4%	50.0%	20.9%
I am unsure what affect, if any, the activity had on me choosing my major.	4.8%	17.9 %	13.0%	5.0%	6.3%

4.4.1 Computing and activity participation

A Chi-Square test was conducted to determine if there was a correlation between participation in an activity before college and whether or not the respondent was majoring in a computing field. We discovered a weak relationship (ϕ = -0.12) between respondents who participated in an activity prior to entering college and are majoring in a computing field ($\chi(1) = 10.83$, p = .001). However, for nonwhite respondents, the relationship was not significant (ϕ = 0.104, X(4) = 2.24, p = 0.69). Breaking this down further, we find the following relationships between those studying computing and attending an activity:

- For Asians (N=49), we found no significant relationship (ϕ = -0.169) , X(1) = 1.41, p = 0.24).
- For African Americans (N=35), we found no significant relationship (ϕ = -0.12, X(1) = 0.54, p = 0.46).
- For Hispanics (N=51), we found no significant relationship (ϕ = -0.17, X(1) = 1.41, p = 0.24).
- For whites (N=576), we discovered a weak relationship, with ϕ = -0.12, X(1) = 8.24, p = 0.004.

4.4.2 Respondent Perceptions of the Activities

We collected responses on perspectives of the computing activities and evaluated them using an independent t-test. The Likert-like items consisted of the following:

- The majority of students participating in the activities were boys.
- I enjoyed many of the activities.
- I enjoyed learning about computers.
- I was interested in computers before I participated in the activities.
- I felt like I was a welcome part of the group participating in the activities.
- The majority of students participating in the activities were girls.
- Participating in the activities increased my interest in computers.

No significant differences between whites and non-whites for those presently majoring in computing were found. However, one significant difference was found in the responses of those who chose not to major in a computing field. "I felt like I was a welcome part of the group participating in the activities" yielded t(130.53) = -2.18, p = 0.046. Whites (M=4.04, SD=0.95) were more likely to choose this option over non-whites (M=3.76, SD=1.14).

We also compared the same five major groups against each of the perspectives with an analysis of variance (ANOVA). When comparing all five, the only item found to have a significant difference was the first, "The majority of participants were boys.", t(3)=2.85, p = 0.04. When examining the high and low means, we find that Blacks/ African Americans had M=4.68, SD = 0.99 while Asians had an M=3.68, SD = 1.19. For whites and Hispanics, the means were nearly similar, with M=4.14, SD=1.23 for whites and M=4.11, SD=1.05 for Hispanics.

Table 5. Perceived effects on computing outreach activities on choice of taking computing classes (Non-majors)

	White	Asian	Black/African American	Hispanic/ Latina/Latino	Non-white
Affected my decision to choose to take a computer related class in college	13.9%	56.0%	40.9%	29.4%	20.4%
Affected my decision to choose NOT to take a computer related class in college	2.3%	0.0%	4.5%	23.5%	3.4%
Did not affect my decision to take or not take a computer related class in college	32.9%	40.0%	27.3%	29.4%	29.6%
I am unsure what affect, if any, the activity had on my decision to take or not take a computer related class in college	9.1%	4.0%	27.3%	17.6%	11.2%

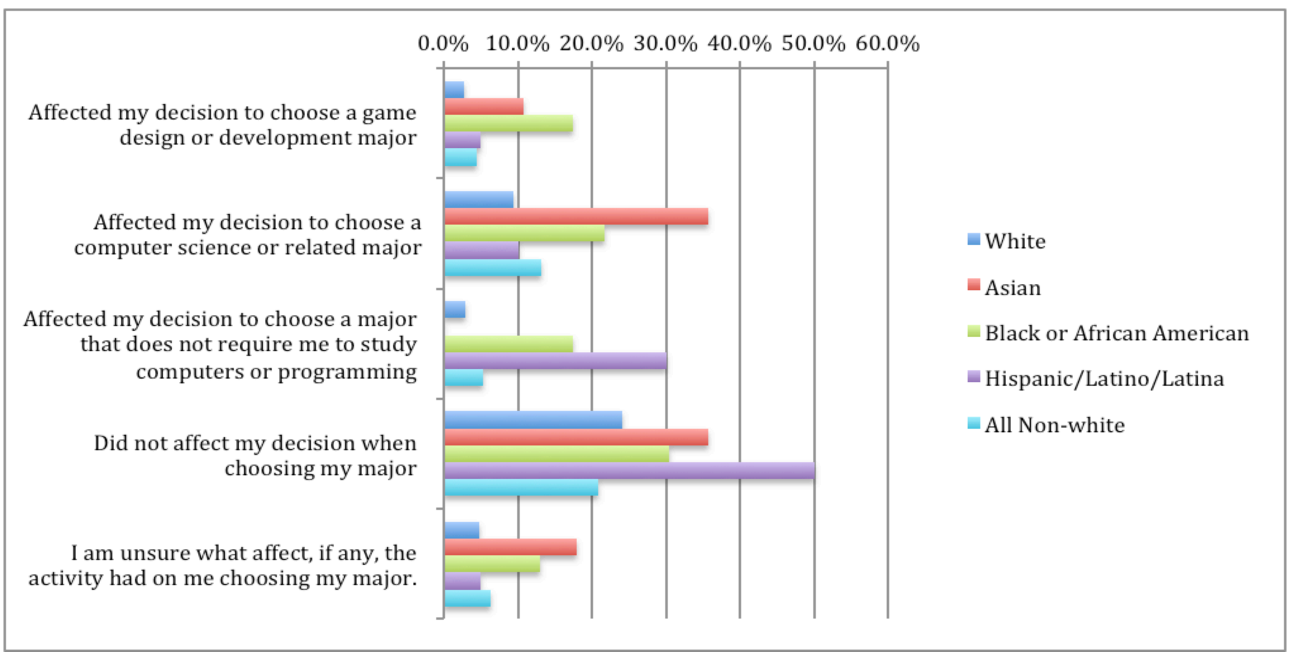

Figure 3. Effect of participation on choice of major (self-reported)

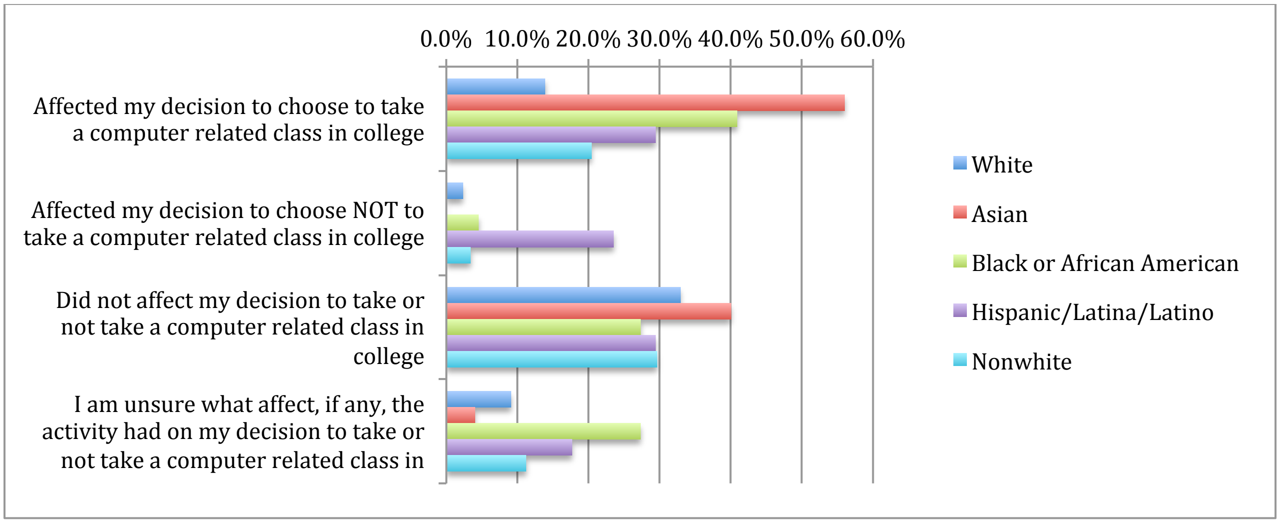

Figure 4. Effect of participation on choice of computing courses (non-majors) as self-reported by respondents

5. DISCUSSION

Despite constructing a sample group from both private and public institution in geographically diverse locations, we found that whites (79.7%) are overrepresented in our survey respondents and non-whites are underrepresented compared to enrollment data from all U.S. educational institutions (60.2%) [61]. Likewise, subgroups evaluated in this study (Hispanic, Asian and Black or African American) were underrepresented (Table 6). Respondents are also less diverse than the population of students in the U.S. earning computer science bachelor degrees [85].

Table 6. Survey response rates comparison

	Study	US Enrollment	2013 Taulbee
Whites	79.7%	60.2%	60.6%
Non-whites (major groups)	18.6%	36.3%	29.8%
Hispanic/Latino/Latina	6.9%	15.2%	6.5%
Asian	6.8%	5.8%	18.8%
Black/African American	4.9%	15.3%	4.5%

This may be partially explained by the distribution of the survey. At some institutions, email addresses from a sample of all students at the university were obtained and those students were contacted about survey participation. At other institutions, the survey was distributed only to students majoring in particular colleges or majors, which may explain the breakdown of the population receiving the survey, although we rely only on self-reports and we are unable to confirm this hypothesis. We also note that the response rate of different subgroups may also have influenced the number of responses.

This should be noted as a limitation of the study, and care should be taken in interpreting the results. We also note that there may be self-selection bias, since survey participation was voluntary, and the consideration of accurately recalling activities that took place over ten years ago, despite constructing to the survey with recall prompts. Though this study cannot replace a properly constructed longitudinal study, we present the following for consideration based on these results.

5.1 Activity Participation

Just under half (45.3%) of the responses indicated that they had participated in an outreach activity prior to entering college. Slightly fewer whites (43.6%) than non-whites (50%) indicated that they participated. Given that many outreach programs focus on underrepresented populations, this result is not surprising.

More respondents (26.1%) indicated that they voluntarily participated in the activities than that they were required to participate in the activities (18.9%). The difference in type of participation was nearly equal for white respondents (25.5% voluntary versus 18.1% required) than for non-white respondents (28.0% voluntary versus 21.4% required).

In a U.S. study, Guzdial, et al, provide the results of a survey administered to undergraduate students enrolled in an introductory computer science class in Georgia [34]. Though not strictly longitudinal in nature, the results of this recollective study found that 28% of the undergraduate respondents (N=1,434) had participated in computing activities in middle school and 14% had participated in out-of-school activities. In high school, 32% of the respondents indicated participation with computing activities, with 16% participating in out-of-school activities.

Our study found that a majority of all respondents had participated in the activity while in high school (54.5%). This is slightly higher than previously reported by Guzdial, et al [34], who found that 32% had participated in such activities in high school and 16% participated in activities outside of school. Combined, this might reflect a maximum of 48% if there were no duplications in the other study's responses.

Our study also found that 30.2% participated in junior high/middle school, which may be lower than the 28% in school plus 14% out of school (maximum of 42%, again if no duplications in reporting) as reported in the Georgia study [34]. This could indicate a regional component to availability of outreach activities, or it could indicate that there are more activities available in the last few years to K-12 students than there were in previous years. However, one vital difference is that participants in our study were not limited to those currently enrolled in a computing course, while the Georgia study was.

Non-whites were more likely to have participated in high school (60.8%) than whites (51.9%) and less likely to in junior high (25.7% for non-whites and 32.1% for whites) or elementary school (10.1% for non-whites and 14.1% for whites). Historically outreach programs have been more common for high school students than for younger students. These results may indicate that when outreach programs are available in earlier grades that they are not reaching non-white participants as much as they are reaching white participants.

5.2 Perceived Impact on Major

There were 336 respondents who indicated whether the computing outreach programs had impacted their choice of major. Of these 22.3% indicated that their participation had impacted their choice of a computer science major and another 7.1% indicate that it had impacted their choice of a major in game design or development. More (30.1%) indicated that it had a positive effect than that it had a negative effect (5.4%), which is a positive result for outreach programs as a whole.

When the results were considered by race, there were wide variations in the responses. There was a weak correlation for all respondents between having participated in an activity before college and choosing to major or not major in computing, although for non-white respondents the result was not significant. When each subpopulation was considered separately, the only subgroup for which the relationship between participation and a choice of a computing major was significant was white respondents. This is a discouraging result for outreach programs, since the goal of many is to influence the choice of major among participants toward computing. These results suggest that those programs may not be as successful as the organizers might desire.

Another discouraging result was the difference between responses for the statement "I felt like I was a welcome part of the group participating in the activities." Whites were more likely to agree with this statement (M=4.04) than non-whites (M=3.76). Given that many outreach programs are designed with non-white participants in mind, this suggests that they may not be successful in making all participants feel equally welcome.

There were also significant differences for responses to the statement "The majority of participants were boys." Blacks and African Americans were more likely to agree with the statement (M=4.68) than Asians (M=3.68), whites (M=4.14), or Hispanics (M=4.11). It is difficult to determine without further information whether these differences were an accurate reporting of the populations represented, which would indicate that programs with African Americans were more likely to have male participants and Asians were more likely to have girls in their programs, or whether the various groups simply had different perceptions of the participants in the programs they attended.

5.3 Considering Program Type

It is difficult to compare our results due to the lack of studies that consider the long-term impact of outreach programs. Worth noting is that, unlike the Guzdial, et al, study [34], we did not collect data on the types of programs that were reviewed nor the impact on self-efficacy or knowledge that the participants may have experienced. In fact, we were unable to distinguish between programs that may have had a stronger influence than others. Previous research indicates that a culturally relevant pedagogy, including culturally diverse content, role models, teacher professional development, and recruitment, among others, all play an important role in creating a solid program that may have more immediate impact on students, which may lead to more long-term impact [6, 17, 21, 26, 32, 34, 35]. However, without any long-term studies tracking activity participants, we can only rely on indicators from anecdotal data or data collected from long-term memories of participants, both of which are poor substitutes for quantitative analysis on a variety of measures.

6. CONCLUSION

Given the duration of the problem of underrepresentation of racial and ethnic minorities in the computing field and the decades-long interest of the computer science community in addressing the issue, it is interesting to consider the long-term impact of computing outreach programs on ethnic diversity in the field. The Taulbee data suggests that things have improved at the undergraduate level [81]. However, a decline in AP computer science courses and the lack of test-takers who are ethnic minorities remains a problem in the U.S. [26]

Though a study that requires respondents to recall participation in an activity from roughly a decade ago cannot replace data collected during participation, this study found results that differed significantly among several ethnic groups. There are a variety of variables that may also impact accurate recollection, such as support of computing careers by parents and peers. However, based on the data, whites and non-whites recall different experiences with these activities that are worth further consideration.

The data reflects on activities put into place over the last decade and may not accurately reflect the impact that current activities may have. Despite these limitations, this study has two important implications. First, the data confirms a need for longitudinal studies to determine whether or not the countless hours put into such activities are not only effective, but also in how they are most effective across various ethnic groups.

Second, the data provides awareness of the potential inequities in activities across various ethnic groups. This alone can be very powerful when seeking to ensure that youth have equal access and opportunities to pursue computing careers. Knowing that there are large discrepancies in when different ethnicities participate in these activities and how different ethnicities perceive their impact may provide more motivation to create such programs that counter these past trends.

Further, future research requiring recall and/or is constructed as a longitudinal study can benefit by consideration of the following:

- Construct a sample size that more accurately represents the representation of the various groups in college,
- Students who participated in these activities but then did not choose to attend a four-year higher education institution,
- Variables of the computing activities (length of time, type of instruction, type of activity, etc.), and
- Self-efficacy as a variable in context with ethnicity.

Likewise, researching differences within ethnic groups and understanding why a black student, for example, chooses to major in computing while another black student chooses not to do so can more finely distinguish variables that may have influenced each students' decision.

7. REFERENCES

[1] Adams, J.C. 2010. Scratching middle schoolers' creative itch. In Proc of the 41st ACM tech symp on Comp Sci Ed. ACM, 356-360.

[2] Adrion, W.R., Fall, R. et al. 2010. Integrating evaluation into program development: benefits of baselining a NSF-BPC alliance. In Proc of the 41st ACM tech symp on Comp Sci Ed. ACM, 27-31.

[3] Al-Bow, M., Austin, D., Edgington, J., et al. 2009. Using game creation for teaching computer programming to high school students and teachers. In Proc of the 14th ACM SIGCSE conf on Innovation and tech in comp sci ed (ITiCSE '09). ACM, 104-108.

[4] Andrews, G. R. 1994. 1993-1994 CRA Taulbee Survey. http://archive.cra.org/Activities/workshops/broadening.participation/cra/Taulbee/1993-1994.pdf

[5] Basawapatna, A.R., Koh, K.H. et al. 2010. Using scalable game design to teach computer science from middle school to graduate school. In Proc of ITiCSE '10 ACM, New York, NY, 224-228.

[6] Bell, T., Rosamond, F., Casey, N. 2012. Computer Science Unplugged and Related Projects in Math and Computer Science Popularization. *Lecture Notes in Computer Science*, 7370, 398-456.

[7] Benotti, L., Martínez, M.C. and Chapachnik, F. 2014. Engaging high school students using chatbots. In Proc of the 2014 conf on Innov & tech in comp sci ed (ITiCSE '14). ACM, New York, NY, 63-68.

[8] Bruckman, A., Biggers, M., Ericson, B., et al. 2009. "Georgia computes!": improving the computing education pipeline. In Proc of the 40th ACM tech symp on Comp sci ed. ACM, 86-90.

[9] Burge, J.E., Gannod, G.C., Doyle, M. et al. 2013. Girls on the go: a CS summer camp to attract and inspire female high school students. In Proc of the 44th ACM tech symp on Comp sci ed. ACM, 615-620.

[10] Carter, E., Blank, G. and Walz, J. 2012. Bringing the breadth of computer science to middle schools. In Proc of the 43rd ACM tech symp on Comp Sci Ed (SIGCSE '12). ACM, New York, 203-208.

[11] Cavender, A.C., Ladner, R.E. and Roth, R.I. 2009. The summer academy for advancing deaf and hard of hearing in computing. In Proc of SIGCSE '09. ACM, New York, NY, USA, 514-518.

[12] Cheung, J.C.Y., Ngai, G. et al. 2009. Filling the gap in programming instruction: a text-enhanced graphical programming environment for junior high students. In Proc of SIGCSE '09. ACM, 276-280.

[13] Cottam, J.A., Foley, S.S. and Menzel, S. 2010. Do roadshows work?: examining the effectiveness of just be. In Proc of the 41st ACM tech symp on Comp Sci Ed (SIGCSE '10). ACM, New York, NY, 17-21.

[14] Craig, A., Coldwell-Neilson, J. and Beekhuyzen, J. 2013. Are IT interventions for girls a special case?. In Proc of the 44th ACM tech symp on Comp sci ed (SIGCSE '13). ACM, New York, 451-456.

[15] Craig, M. and Horton, D. 2009. Gr8 designs for Gr8 girls: a middle-school program and its evaluation. SIGCSE Bull. 41, 1 (March 2009), 221-225.

[16] Creswell, J.W. 2008. *Educational Research. Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. Pearson Education, Upper Saddle River, New Jersey.

[17] Crutchfield, O.S.L., Harrison, C.D., et al. 2011. Berkeley Foundation for Opportunities in Information Technology: A Decade of Broadening Participation. Trans. Comput. Educ. 11, 3, Art 15, 24 pg.

[18] Curzon, P., McOwan, P.W., Cutts, Q. I. et al. 2009. Enthusing & inspiring with reusable kinaesthetic activities. SIGCSE Bull. 41, 3 (July 2009), 94-98.

[19] Dahlberg, T., Barnes, T., Buch, K. et al. 2011. The STARS Alliance: Viable Strategies for Broadening Participation in Computing. Trans. Comput. Educ. 11, 3, Article 18, 25 pages.

[20] Daily, S.B., Leonard, A.E., Jörg, S., et al. 2014. Dancing alice: exploring embodied pedagogical strategies for learning computational thinking. In Proc of SIGCSE '14. ACM, 91-96.

[21] Doerschuk, P., Liu, J., and Mann, J. 2010. INSPIRED Broadening Participation in Computing: Most successful strategies and lessons learned. In 40th ASEE/IEEE Front in Ed Conf, Washington, DC, Oct 27-30, 2010, T2H-1-T2H-6.

[22] Doerschuk, P., Liu, J. and Mann, J. 2011. INSPIRED High School Computing Academies. Trans. Comput. Educ. 11, 2, Art 7, 18 pages.

[23] Doerschuk, P., Liu, J., and Mann, J. 2012. An INSPIRED game programming academy for high school students. 2012 Frontiers in Education Conf (FIE 2012), Seattle, WA, October 3-6, 2012, 1-6.

[24] Egan, M.A.L. and Lederman, T. 2011. The impact of IMPACT: assessing students' perceptions after a day of computer exploration. In Proc ITiCSE '11 ACM, New York, NY, USA, 318-322.

[25] Eglash, R., Krishnamoorthy, M., Sanchez, J., et al. 2011. Fractal Simulations of African Design in Pre-College Computing Education. Trans. Comput. Educ. 11, 3, Art 17, 14 pages.

[26] Ericson, B. and Guzdial, M. 2014. Measuring demographics and performance in computer science education at a nationwide scale using AP CS data. In Proc SIGCSE '14. ACM, New York, 217-222.

[27] Ericson, B. and McKlin, T. 2012. Effective and sustainable computing summer camps. In Proc of the 43rd ACM tech symp on Comp Sci Ed (SIGCSE '12). ACM, New York, NY, USA, 289-294.

[28] Feaster, Y., Segars, L., Wahba, S.K. et al. 2011. Teaching CS unplugged in the high school (with limited success). In Proc of the 16th conf on Innov and tech in comp sci ed. ACM, 248-252.

[29] Franklin, D., Conrad, P., Aldana, G. et al. 2011. Animal tlatoque: attracting middle school students to computing through culturally-relevant themes. In Proc SIGCSE '11. ACM, New York, 453-458.

[30] Freeman, J., Magerko, B. et al. 2014. Engaging underrepresented groups in high school introductory computing through computational remixing with EarSketch. In Proc of SIGCSE '14. ACM, 85-90.

[31] Gasser, M., Yung-Hsiang Lu, and Cheng-Kok Koh. 2010. Outreach project introducing computer engineering to high school students. In 40th ASEE/IEEE Frontiers in Education Conference (FIE 2010), Washington, DC, October 27-30, 2010, F2E-1-F2E-5.

[32] Goode, J. 2008. Increasing diversity in k-12 computer science: strategies from the field. In Proc of the 39th SIGCSE tech symp on Comp sci ed (SIGCSE '08). ACM, New York, NY, USA, 362-366.

[33] Goode, J. and Margolis, J. 2011. Exploring Computer Science: A Case Study of School Reform. Trans. Comput. Educ. 11, 2, Article 12 (July 2011), 16 pages.

[34] Guzdial, M., Ericson, B. J. et al. 2012. A statewide survey on computing education pathways and influences: factors in broadening participation in computing. In Proc of ICER '12. ACM, 143-150.

[35] Guzdial, M., Ericson, B., Mcklin, T. et al. 2014. Georgia Computes! An Intervention in a US State, with Formal and Informal Education in a Policy Context. Trans. Comput. Educ. 14, 2, Article 13, 29 pgs.

[36] Harriger, A., Magana, A.J., and Lovan, R. 2012. Identifying the impact of the SPIRIT program in student knowledge, attitudes, and perceptions toward computing careers. 2012 Frontiers in Education Conference (FIE 2012), Seattle, WA, October 3-6, 2012, 1-6.

[37] Hart, M.L. 2010. Making contact with the forgotten k-12 influence: are you smarter than your 5th grader?. In Proc of the 41st ACM tech symp on Comp Sci Ed (SIGCSE '10). ACM, New York, 254-258.

[38] Hulsey, C., Pence, T.B. and Hodges, L.F. 2014. Camp CyberGirls: using a virtual world to introduce computing concepts to middle school girls. In Proc of SIGCSE '14. ACM, New York, 331-336.

[39] Isomöttönen, V., Lakanen, A. and Lappalainen, V. 2011. K-12 game programming course concept using textual programming. In Proc of the 42nd ACM tech symp on Comp sci ed. ACM, 459-464.

[40] Kacmarcik, G. and Giral Kacmarcik, S. 2009. Introducing computer programming via gameboy advance homebrew. In Proc of the 40th ACM tech symp on Comp sci ed (SIGCSE '09). ACM, 281-285.

[41] Kafai, Y., Griffin, J., Burke, Q. et al. 2013. A cascading mentoring pedagogy in a CS service learning course to broaden participation and perceptions. In Proc of SIGCSE '13. ACM, New York, 101-106.

[42] Kafai, Y.B., Searle, K., Kaplan, E., et al. 2013. Cupcake cushions, scooby doo shirts, and soft boomboxes: e-textiles in high school to promote computational concepts, practices, and perceptions. In Proc of the 44th ACM tech symp on Comp sci ed. ACM, 311-316.

[43] Karp, T. and Schneider, A. 2011. Evaluation of a K-8 LEGO robotics program. In 41st ASEE/IEEE Frontiers in Education Conf (FIE 2011), Rapids City, SD, Oct 12-15, 2011, T1D-1-T1D-6.

[44] Khan, K.S., Kunz, R., Kleijnen, J., Antes, G. 2003. Five steps to conducting a systematic review. *J R Soc Med.* 96, 3, 118–121. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC539417/

[45] Lakanen, A. and Isomöttönen, V. 2013. High school students' perspective to university CS1. In Proc of the 18th ACM conf on Innov and tech in comp sci ed. ACM, New York, 261-266.

[46] Lakanen, A., Isomöttönen, V. and Lappalainen, V. 2014. Five years of game programming outreach: understanding student differences. In Proc of SIGCSE '14. ACM, New York, NY, USA, 647-652.

[47] Lakanen, A., Isomöttönen, V. and Lappalainen, V. 2014. Understanding differences among coding club students. In Proc of ITiCSE '14. ACM, New York, NY, USA, 159-164.

[48] Lakanen, A., Isomöttönen, V., and Lappalainen, V. 2012. Life two years after a game programming course: longitudinal viewpoints on K-12 outreach. In Proc of SIGCSE '12. ACM, New York, 481-486.

[49] Lang, C., Craig, A., Fisher, J. et al. 2010. Creating digital divas: scaffolding perception change through secondary school and university alliances. In Proc of ITiCSE '10. ACM, 38-42.

[50] Larkins, D.B., Moore, J.C., Rubbo, L.J. et al. 2013. Application of the cognitive apprenticeship framework to a middle school robotics camp. In Proc of the 44th ACM tech symp on Comp sci ed. 89-94.

[51] Lau, W.W.Y, Ngai, G. et al. 2009. Learning programming through fashion and design: a pilot summer course in wearable computing for middle school students. SIGCSE Bull. 41, 1 (March 2009), 504-508.

[52] Layer, R., Sherriff, M., and Tychonievich, L. 2012. "Inform, Experience, Implement" Teaching an intensive high school summer course. 2012 Frontiers in Ed Conf, Seattle, WA, Oct 3-6, 2012, 1-6.

[53] Lewis, C.M. 2011. Is pair programming more effective than other forms of collaboration for young students? Computer Science Education. 21, 2 (June 2011), 105-134.

[54] Liebenberg, J., Mentz, E. and Breed, B. 2012. Pair programming and secondary school girls' enjoyment of programming and the subject Information Technology (IT). Computer Sci Ed. 22, 3, 219-236.

[55] Ludi, S. and Reichlmayr, T. 2011. The Use of Robotics to Promote Computing to Pre-College Students with Visual Impairments. Trans. Comput. Educ. 11, 3, Article 20 (October 2011), 20 pages.

[56] Mano, C., Allan, V., and Cooley, D. 2010. Effective in-class activities for middle school outreach programs. In 40th ASEE/IEEE Front in Ed Conf, Washington, DC, Oct 27-30, 2010, F2E-1-F2E-6.

[57] Marcu, G., Kaufman, S.J., Lee, J.K., et al. 2010. Design and evaluation of a computer science and engineering course for middle school girls. In Proc of SIGCSE '10. ACM, New York, NY, 234-238.

[58] Maxim, B.R. and Elenbogen, B.S. 2009. Attracting K-12 students to study computing. In 39th IEEE Frontiers in Education Conference (FIE '09). San Antonio, TX, October 18-21, 2009, M1H-1-M1H-5.

[59] Meerbaum-Salant, O., Armoni, M. and Ben-Ari, M. 2013. Learning computer science concepts with Scratch. Computer Science Education. 23, 3 (Sept 2013), 239-264.

[60] Morreale, P., Kurkovsky, S. and Chang, G. 2009. Methodology for successful undergraduate recruiting in computer science at comprehensive public universities. In Proc SIGCSE '09. 91-95.

[61] National Center for Education Statistics. 2012. Digest of Education Statistics: 2012, http://nces.ed.gov/programs/digest/d12/tables/dt12_263.asp?referrer=report.

[62] Nugent, G., Barker, B., Grandgenett, N., et al. 2009. The use of digital manipulatives in k-12: robotics, GPS/GIS and programming. In 39th IEEE Frontiers in Education Conference (FIE '09). San Antonio, TX, October 18-21, 2009, M2H-1-M2H-6.

[63] Ouyang, Y. and Hayden, K. 2010. A technology infused science summer camp to prepare student leaders in 8th grade classrooms. In Proc of the 41st ACM tech symp on Comp Sci Ed. ACM, 229-233.

[64] Pivkina, I., Pontelli, E., Jensen, R. et al. 2009. Young women in computing: lessons learned from an educational & outreach program. In Proc of SIGCSE '09. ACM, New York, NY, USA, 509-513.

[65] Rheingans, P., Brodsky, A., Scheibler, J. et al. 2011. The Role of Majority Groups in Diversity Programs. Trans. Comput. Educ. 11, 2, Article 11 (July 2011), 15 pages.

[66] Robertson, J. 2013. The influence of a game-making project on male and female learners' attitudes to computing. Computer Science Education. 23, 1(Apr 2013), 58-83.

[67] Robinson, A. and Pérez-Quiñones, M.A. 2014. Underrepresented middle school girls: on the path to computer science through paper prototyping. In Proc of SIGCSE '14. ACM, New York, NY, 97-102.

[68] Rodger, S.H., Hayes, J., Lezin, G., et al. 2009. Engaging middle school teachers and students with alice in a diverse set of subjects. SIGCSE Bull. 41, 1 (March 2009), 271-275.

[69] Rosson, M.B., Ioujanina, A., Paone, T. et al. 2009. A scaffolded introduction to dynamic website development for female high school students. SIGCSE Bull. 41, 1 (March 2009), 226-230.

[70] Roy, K. 2012. App inventor for android: report from a summer camp. In Proc of the 43rd ACM tech symp on Comp Sci Ed (SIGCSE '12). ACM, New York, NY, USA, 283-288.

[71] Searle, K.A., Fields, D.A., Lui, D.A. et al. 2014. Diversifying high school students' views about computing with electronic textiles. In Proc of the 10th conf on Int comp ed res (ICER '14). ACM, 75-82.

[72] Sundaram, R. 2011.Set up and delivery of electrical and computer engineering projects at undergraduate engineering universities for outreach and partnership with K-12 STEM schools. In 41st ASEE/IEEE Frontiers in Education Conference (FIE 2011), Rapids City, SD, October 12-15, 2011, F4D-1-F4D-5.

[73] Taub, R., Armoni, M. and Ben-Ari, M. 2012. CS Unplugged and Middle-School Students' Views, Attitudes, and Intentions Regarding CS. Trans. Comput. Educ. 12, 2, Article 8 (April 2012), 29 pages.

[74] Taub, R., Ben-Ari, M., and Armoni, M. 2009. The effect of CS unplugged on middle-school students' views of CS. SIGCSE Bull. 41, 3 (July 2009), 99-103.

[75] "Testing for Equivalence with confidence intervals or P values." GraphPad Software, Inc. Retrieved 15 Dec 2015 from http://www.graphpad.com/guide/prism/6/statistics/index.htm?stat_testing_for_equivalence_with_c.htm

[76] US Census Bureau. 2006. Martin, Elizabeth. "Survey questionnaire construction." Survey methodology. 2006 (2006): 13.

[77] Van Wart, S.J., Vakil, S. and Parikh, T.S. 2014. Apps for social justice: motivating computer science learning with design and real-world problem solving. In Proc of ITiCSE '14. ACM, 123-128.

[78] Wagner, A., Gray, J., Corley, J. et al. 2013. Using app inventor in a K-12 summer camp. In Proc of the 44th ACM tech symp on Comp sci ed (SIGCSE '13). ACM, New York, 621-626.

[79] Webb, H. and Rosson, M.B. 2013. Using scaffolded examples to teach computational thinking concepts. In Proc of the 44th ACM tech symp on Comp sci ed (SIGCSE '13). ACM, New York, 95-100.

[80] Webb, H.C. and Rosson, M.B. 2011. Exploring careers while learning Alice 3D: a summer camp for middle school girls. In Proc of the 42nd ACM tech symp on Comp sci ed. ACM, 377-382.

[81] Welleck, S. 2002. Testing Statistical Hypotheses of Equivalence. Chapman and Hall, London/CRC, Boca Raton (in press).

[82] Wolz, U., Stone, M., Pearson, K., et al. 2011. Computational Thinking and Expository Writing in the Middle School. Trans. Comput. Educ. 11, 2, Article 9, 22 pgs.

[83] Zimmerman, T. G., Johnson, D., et al. 2011. Why Latino High School Students Select Computer Science as a Major: Analysis of a Success Story. Trans. Comput. Educ. 11, 2, Art 10, 17 pgs.

[84] Zweben, S., Aspray, W. 2003 Taulbee Survey, May 2004, http://archive.cra.org/statistics/survey/03/03.pdf

[85] Zweben, S., Bizot,B. 2013. Taulbee Survey, May 2014, http://cra.org/uploads/documents/resources/crndocs/2013-Taulbee-Survey.pdf