Undergraduate Students' Perceptions of the Impact of Pre-College Computing Activities on Choices of Major

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A lack of diversity in the computing field has existed for several decades, and although female participation in computing remains low, outreach programs attempting to address the situation are now quite numerous. To begin to understand whether or not these past activities have had long-term impact, we conducted a systematic literature review. Upon discovering that longitudinal studies were lacking, we investigated whether undergraduate students believed that their participation in computing activities prior to college contributed to their decision to major in a computing field. From the 770 participants in the study, we discovered that approximately 20% of males and 24% of females who were required to participate in computing activities chose a computing or related major, but that males perceived that the activity had a greater affect on their decision (20%) than females (6.9%). Females who participated in an outreach activity were more likely to major in computing. Compared with females who chose to major in computing, females who did not were less likely to indicate that the majority of students participating in activities were boys and that they were a welcome part of the groups. Results also showed that female participants who do not ultimately major in computing have a much stronger negative perception of the outreach activities than male participants who also chose a non-computing major. Although many computing outreach activities are designed to diversify computing, it may be the case that, overall, boys receive these activities more favorably than girls, although requiring participation yields approximately the same net positive impact.

CCS Concepts: • **Social and professional topics → Computing education**; **K-12 education**

Additional Key Words and Phrases: Education, computing outreach, diversity, gender, pipeline

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1. INTRODUCTION

A lack of diversity in the computing field has existed for decades, and the lack of female participation has been of particular concern. The Association for Computing Machinery (ACM) has deemed the issue to be of sufficient importance to create the ACM-W, an organization "supporting, celebrating, and advocating for Women in Computing" [ACM-W 2015]. The ACM-W organizes events, offers scholarships and awards, and publicizes research about ways to improve gender diversity in computing. The ACM is not alone in its advocacy for female participation in computing. The National Center for Women and Information Technology (NCWIT) is a nonprofit community of more

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than 600 organizations "working to increase women's participation in computing and technology" [NCWIT 2015]. The NCWIT offers resources based on best practices and tools for a variety of audiences, including K-12 and university educators and companies and has worked with other organizations to identify factors influencing girls to study computing [Liston et al. 2008].

Individual computing educators and researchers have participated in efforts to improve female representation in the field through organizations mentioned previously and independently. These programs can be found in countries around the world and target women and girls at various levels of education, from elementary through graduate school. One success story was Carnegie Mellon University, where the admissions criteria were changed to remove an emphasis on previous programming experience and a host of support structures were put into place. In the wake of the changes, the percentage of female computer science majors jumped dramatically [Blum and Frieze 2005]. Another early study focused on high school students in Los Angeles, finding that students in high schools with large minority populations had consistently less access to engaging and relevant computing courses than students in more affluent and less racially diverse schools [Margolis 2008]. This work led to the development of the Exploring Computer Science curriculum, which has had a significant impact on secondary computing education in the United States [Exploring Computer Science 2015].

One measure of the success of institutions and educators in raising awareness of the lack of female participation in computing is the growth of articles in the popular press about the subject [Feltman 2015; Larsen 2014; Johnson 2015]. For example, National Public Radio, a public radio station in the United States, recently produced a story called "When Women Stopped Coding" [National Public Radio 2014]. In the piece, the current lack of women in computer science was contrasted with the early years of computing when women were well represented. Beginning in 1984, the percentage of women earning degrees in computer science first flattened and then dropped, and the percentages have never rebounded to their pre-80s levels [National Science Foundation 2011].

The interest of the popular press has resulted in increased attention for more recent academic initiatives at improving diversity. Harvey Mudd College in California captured headlines for dramatically increasing the percentage of women majoring in computer science [Miller 2014] and for several massive open online courses (MOOCs) created for professional development of middle school and high school teachers interested in teaching computer science [Klawe 2015]. Code.org gained a lot of attention when it enjoyed a highly successful rollout of its programs during the Hour of Code scheduled during Computer Science Week in 2013, which it continued in 2014 with a partnership with Disney [Code.org 2015]. A more recent launch is Girls Who Code, a nonprofit organization that seeks to close the gender gap in computing using a summer immersion program for girls [Buhr 2014]. Of course, many important programs escape the notice of the popular press, such as the CompuGirls program associated with Arizona State University [CompuGirls 2015]. All of these efforts remain important despite increasing undergraduate enrollments in computer science, since female engagement in computing remains lower than in other science, technology, engineering, and mathematics (STEM) fields [Monge et al 2015].

Efforts at outreach to K-12 students are not limited to the United States. European Code Week 2014 [CodeWeek Eu 2015] recently received media attention, particularly since programming has become mandatory in 7 European countries (Bulgaria, Cyprus, the Czech Republic, Greece, Poland, Portugal, and the UK) and optional in another 5 countries [European Commission 2014]. Another important outreach program, although not specifically focused on female students, is the Bebras Computing Challenge

[Bebras 2015]. The challenge introduces computational thinking to students in more than 30 countries by providing them with opportunities to compete in contests.

Given that many activities aimed to increase the percentage of women in computing were created and implemented more than a decade ago, determining the long-term impact, if any, of these activities is important. To investigate this, we summarized findings from studies on gender outreach programs published in computing education conferences and journals between 2009 and 2014, focusing on the evaluative component of the work. The results showed that long-term evaluation of gender outreach programs remains rare despite the clear need for determining their long-term effectiveness through the tracking of participants.

Realizing that longitudinal data was lacking, we created a survey to determine if there was a long-term impact on activity participants based on recall. We were interested in determining students' previous experience with computing outreach activities, the context for the activities, and the impact that these students believed that the programs had, if any, on the selection of their present college major. Therefore, the overarching research question for this study is then this: Did students' participation in computing outreach activities have an impact on the selection of their present college major? The results of this study, along with the literature analysis, are presented in this article.

Creators of outreach programs typically have diverse goals, including improving awareness of computing in application to other fields, improving attitudes in students who may not major in computing, or removing institutional or cultural barriers that prevent students from engaging more fully in technology [Blum and Frieze 2005; Crutchfield et al. 2011; Dahlberg et al. 2011; Doerschuk et al. 2010; Guzdial et al. 2014; Klawe 2015; Miller 2014]. One unambiguous measure demonstrating a positive attitude toward computing is the number of students who choose to major in the computing field in postsecondary school. Further, if the positive impression of computing is aided by participation in the outreach program, a choice of a computing major can be seen as a measure of the success of the program. The impact of the outreach program may be broader than this single measure, but it provides a way of understanding its impact on participant impressions of the computing field. This measure is most accurate for the many programs that include broadening participation in computing as a goal.

Our two-part study is important, as it shows the lack of longitudinal studies demonstrating the effectiveness of these activities and provides initial insights into whether or not these activities are effective using choice of computing major as a metric. Given the time and resources being poured into improving diversity in the field through computing outreach activities, it is important to know whether or not the goals and objectives of these activities actually lead to more women studying computing. This study is useful for outreach activity developers and researchers, educational researchers interested in improving diversity in computing, and corporations and institutions that provide time and resources for these activities. This research offers a start to understanding whether or not these activities have the long-term impact that many desire to achieve.

2. BACKGROUND

To determine previous longitudinal results for outreach initiatives, we undertook a systematic literature review following the structure outlined in Khan et al. [2003]. Their systematic review framework includes five foundational steps: frame the question (step 1), identify relevant work (step 2), assess the quality of the studies (step 3), summarize the evidence (step 4), and interpret the findings (step 5).

2.1. Framing the Question

The free-form question (step 1) that we sought to answer with this review was, “Is there a long-term impact on females who have participated in computing outreach activities?” To answer this question, we established the following four overarching characteristics:

- *Populations studied:* Students enrolled in computing outreach programs as defined by the researchers
- *Interventions:* Programs that exposed students to computing concepts that were outside of their normal required school work
- *Outcomes analyzed:* Interest in pursuing a degree in a computing field and/or actual enrollment and completion of a degree in a computing field
- *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.

2.2. Identifying Relevant Work and Assessing the Quality of the Studies

We identified relevant work of quality (steps 2 and 3) by considering ACM and Institute of Electrical and Electronics Engineers (IEEE) journal and conference publications, which both have a long history of publishing quality papers related to computing education. We further refined that to venues that emphasize education, including the following peer-reviewed journals and conference proceedings in electronic form:

- *ACM SIGCSE Technical Symposium on Computer Science Education* (SIGCSE)
- *IEEE Frontiers in Education* (FIE)
- *Innovation and Technology in Computer Science Education* (ITiCSE)
- *International Computing Education Research Workshop* (ICER)
- Taylor & Francis’s *Computer Science Education* (CSE)
- *ACM Transactions on Computing Education* (TOCE)

Publications from the years 2009 to 2014 inclusive were considered. This effort resulted in 3,672 citations that were reviewed for relevance. Their potential relevance was examined using the following keywords: K-12, elementary school, high school, secondary school, after school clubs, and summer camp. An article was determined to be relevant if it had a title and abstract associated with outreach because it contained one or more of the actual or related keywords. At this point, 3,571 articles did not fit the criteria and were deemed irrelevant. This resulted in 101 articles left for a more thorough review.

These articles were then examined in detail, and the following information was recorded:

- Target audience
- Country in which the target audience lived
- Whether or not the intervention was designed to increase gender and/or ethnic diversity
- If data was collected from participants
- Whether the study was quantitative or qualitative
- Number of participants in the study
- Gender and ethnicity of the participants
- What was assessed by the study
- Whether there was a longitudinal component to the study
- Number of years for the study (if longitudinal)
- Summary of the findings (if longitudinal).

Table I. Articles Reviewed by Venue and Year

Publication	Number of Articles Meeting the Criteria					
	2009	2010	2011	2012	2013	2014
SIGCSE	10	6	3	4	7	5
FIE	2	3	2	3		
ITiCSE	3	2	2		2	1
ICER				1		2
CSE			1	1	2	
TOCE			9	1		1
Total	**15**	**11**	**17**	**10**	**11**	**9**

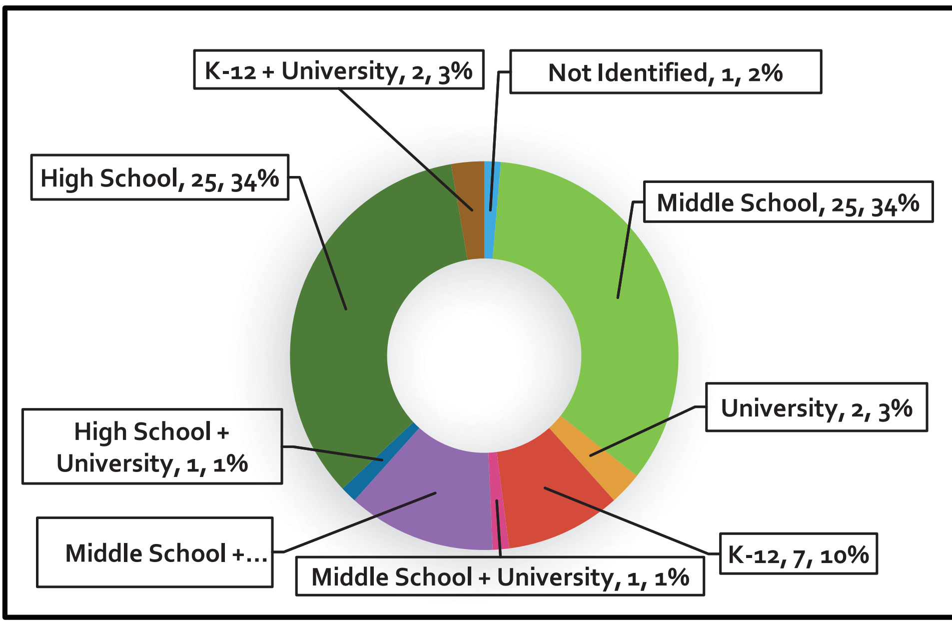

Fig. 1. When outreach activities were offered.

During this careful read stage, it was discovered that 28 of the 101 articles did not qualitatively or quantitatively evaluate the impact of associated outreach activities. 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 reporting of any results.

2.3. Summarizing the Evidence

The remaining 73 articles were then summarized (step 4) and are provided in Appendix A, with Table I providing a high-level overview.

The articles were dominated by results from interventions in the United States (75%). In general, the interventions included various levels of students. We converted the level of students in non-U.S. activities to the U.S. system, as that is where most of the interventions took place. A majority of the interventions (82%) were outreach efforts aimed at high school and/or middle school students. The others were aimed at various stages of students as outlined in Figure 1.

The methodology of the studies is shown in Figure 2. Most of the studies were quantitative in nature, but a significant amount of qualitative and mixed methods

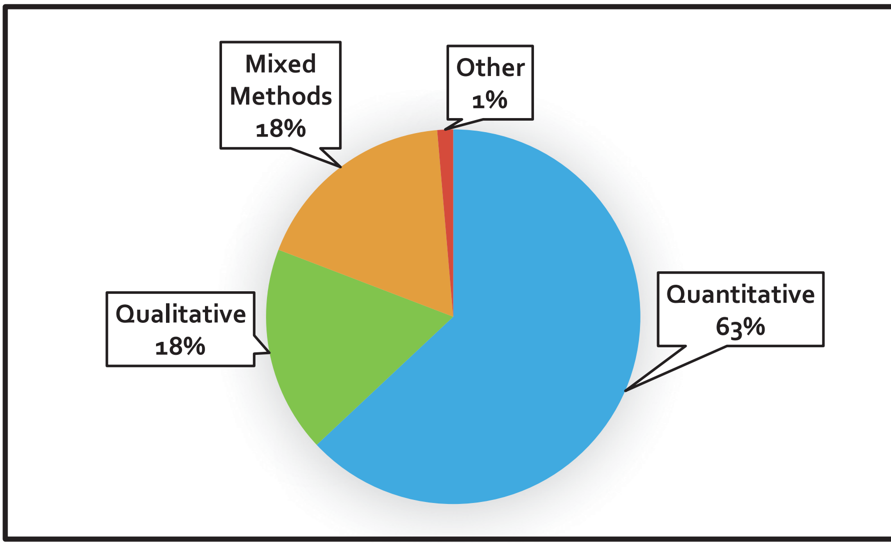

Fig. 2. Study methodologies.

studies were represented as well. The number of study participants was reported in 64 of the articles (87%), with the number of participants ranging from 2 to 9,956.

Of the 73 interventions discussed in the articles, 39 (53%) indicated that they were designed to increase gender diversity, 30 (41%) indicated that they were not created to address gender imbalance, and 4 (5%) did not provide enough evidence to categorize the intervention. Participant gender was reported by 49 (67%) of the articles. Of the studies that were done on interventions designed to increase gender diversity, 32 (82% of that group) indicated the gender of the participants in the intervention and subsequent study of the intervention. From the group of interventions that were designed to increase gender diversity and reported gender of participants, half (16) were studies with only female participants. The other half had both male and female participants.

Many of the articles undertook some form of data collection about the participants of the programs. Out of the 73 articles analyzed, only 3 (4.1%) did not report on any systematic data collection and analysis.

The purpose of undertaking this literature review was to find articles that report on longitudinal impact of outreach activities. In our analysis, we were able to identify only 7 (9.5%) of the 73 articles that presented longitudinal data. Of those 7 articles, 4 discussed interventions designed to increase gender diversity, which is the question we set out to answer in step 1 of this literature review. Table II provides a summary of these four interventions and their reported results related to longitudinal impact only. The articles report on other results related to the outreach activities, but those results are beyond the scope of our literature review.

2.4. Interpretation

Once summarized, we considered the evidence from these studies holistically (Step 5) with respect to the free-form question. It is clear that there have not been many efforts to study the long-term impacts of computing outreach interventions. Many of the articles analyzed and discussed here indicate that a long-term study of the impacts

Table II. Summary of Longitudinal Studies of Outreach Activities from Literature Review

Activity	INSPIRED (Increasing Student Participation in Research Development)	Students and Technology in Academia, Research, and Service (STARS) Alliance	Berkeley Foundation for Opportunities in Information Technology (BFOIT)	Georgia Computes!
Reference	Doerschuk et al. [2010]	Dahlberg et al. [2011]	Crutchfield et al. [2011]	Guzdial et al. [2014]
Location (of Activity and Target Audience)	Lamar University (Texas, U.S.)	U.S.	UC Berkeley (California, U.S.)	Georgia (U.S.)
Target Audience	Undergraduate students	Undergraduate students	Elementary school, middle school, high school	Elementary school, middle school, high school and faculty
Number of Years for Study	2	4	10	6
Number of Participants in Study	7 in year 1; 10 in year 2	282	153	287 faculty; 5,089 students
Gender of Participants	Male and female (exact numbers not reported)	56% females, 26% males, and 18% who did not specify their gender	Middle school (data only reported for 2009): 44% female, 56% male High school (2005): 56% female, 44% male (2006): 59% female, 41% male (2007): 40% female, 60% male (2008): 64% female, 36% male (2009): 75% female, 25% male	Weekend and after-school activities: 88% female, 12% male Summer camps: 26% female, 74% male
Relevant Findings	90% retention of participating students; grades of participating students were higher and drop rates lower than nonparticipating students in their cohort.	Of students participating in the first 4 years of the alliance, 45.7% are still pursuing computing degrees at a STARS institution and at least 41.6% have completed their computing degrees. Appears to be most effective for female students who participate over multiple semesters.	Modest correlation between number of years participating and their mental rotation score on standardized tests. Of the 153 participants, 65 have matriculated high school and started college.	Number of schools offering computer science courses, and number of students taking the Advanced Placement computer science exam increased. Teachers receiving professional development were more successful at motivating female students to pursue computing at the college level.

of the intervention on the participants was needed. Even in the articles that had longer-term studies, the time constraints and other factors contributed to a sense that the true impacts of the computing outreach activities were unable to be fully studied and understood.

Each of these outreach efforts are hopeful that they are having an impact on the students involved in the activities, and many showed positive impact in the short term. Only four presented some evidence of longer-term impact. However, even within these four, none attempted to answer the question about what happened to participants after the outreach activities concluded. None of the studies can show what the long-term impact of participation was on the participants. Therefore, more systematic study of the long-term effects of outreach programs is needed to determine their impact in the long term. Sections 3 and 4 describe the methodology and the results of our study on the long-term impact of computing outreach activities on women.

2.5. Limitations of the Literature Review

The journals and conferences included in the literature review could be considered dominated by U.S. participation. There are additional venues and conferences that exist that include a more diverse and less U.S.-focused set of participants. Since the target participants of our study were to be in the United States, we deemed this appropriate. Furthermore, one of the conferences is explicitly never held in the United States (ITiCSE), one alternates between U.S. hosts and international hosts (ICER), and the journals are open for publications from non-U.S. authors.

3. METHODOLOGY

To follow up with the findings described in Section 2, we used a quantitative methodology that followed a descriptive design approach [Creswell 2008].

3.1. Survey

We created the Effectiveness of Technology Outreach Survey (Appendix B) to investigate the research question: Did students' participation in computing outreach activities have an impact on the selection of their present college major? There were three types of items posed, demographic items (based on U.S. Census demographic items), behavior/action items, and Likert-like items.

The behavior/action items focused on activities in which the respondents either participated in the past or present, or in which they plan on participating in the near future. These Likert-like items were designed based on previous work that shows that gender, interest, a sense of belonging, and enjoyment can affect perceptions of these activities [Guzdial et al. 2012]. To gauge validity and reliability, two additional steps were taken. First, respondents were asked to participate in retaking the survey to determine the recall bias and to establish statistical reliability of this nonparametric and parametric data [Creswell 2008]. Second, integrated recall prompts (aided recall) were integrated within the survey to serve as memory aids to respondents [Martin 2006].

Questions was included in the survey to provide for further analysis comparing the impact of formal education (required as part of the school curriculum) and informal education. This was intentionally included, as taking required computing courses alone could potentially be an influencing variable affecting a students' choice of major. However, more interesting is whether or not the computing activity was required or voluntary, as informal education can also be required as part of a group or other experience. Therefore, we designed the survey to include whether an activity was required or voluntary.

Table III. Respondent Demographics

	Frequency	Percentage
Female	432	56.1%
Male	319	41.4%
Transgender	9	1.2%
Decline to Specify	10	1.3%

3.2. Participants

Respondents were recruited using three different methods. We recruited undergraduate students at three institutions: Bradley University, DePaul University, and Rochester Institute of Technology. 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 vs. 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. Last, 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 who then forwarded it 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. At the three primary institutions of the authors, the survey was sent to all undergraduate students (Bradley, Rochester) or a representative, random sample (DePaul). At the additional institutions, the survey was sent to undergraduate students who were studying computer science.

Only respondents who agreed to the consent letter appearing on the first page of the survey were able to continue. The consent letter required them to indicate that they were at least 18 years of age. As an incentive, respondents 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 to keep the demographic data for the survey separate from the drawing survey that requires respondents to enter their contact information, thus removing the potential of personally identifiable information.

At the end of the survey, respondents were asked if they were interested in retaking the survey in approximately 2 to 4 weeks. As an incentive, respondents who completed the survey were offered entry for a prize drawing of a second $50 Amazon gift card. The survey was re-sent to those who indicated that they were interested in retaking the survey. We first performed a test of equivalence among the initial and retake results. We then used SPSS to analyze the survey data and evaluate the similarities and differences among male and female respondents.

A total of 770 respondents completed the initial survey, and 411 completed the retake. Only 3 respondents were from FindParticipants.com, whereas the remaining were from the educational institutions previously noted. For gender, respondents could choose Female, Male, Transgender, and Decline to Specify. Table III shows the breakdown of respondent responses.

For the results section, only those respondents who selected female or male were included in the analysis, reducing the number of respondents to 751. Although ethnicity data was captured in the survey, this article examines the results on the sole independent variable of gender, and ethnicity data is reported in another work [McGill et al. 2015].

3.3. Measures of Reliability and Validity

To gauge reliability, a Kruskal-Wallis test was performed on nonparametric data, individually, to determine equivalence between the results of the initial and the retake surveys [Wellek 2002]. The results of the test indicated that for each nonparametric data, there were no differences found among the initial and retake survey, with p-values in the range of .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 [GraphPad 2015; Welleck 2002]. 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 is within the zone of indifference, we can conclude that all other items are equivalent across the two groups with 95% confidence [GraphPad 2015].

However, we note that 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, indicating that respondents recalled this item more inconsistently between the first and second survey. Therefore, extra caution should be taken when interpreting results related to these two items.

3.4. Data Analysis

The primary means for data analysis on the collected data is as follows:

- Descriptive statistics are used to measure basic information about involvement with computing activities (Section 4.1).
- A chi-square test (Phi) was conducted to determine the strength of the relationship between participation in an activity before college and whether or not the respondent was majoring in a computing field (Section 4.2).
- An independent t-test was conducted to evaluate the responses to computing activity experiences (Section 4.3).
- An independent t-test was conducted to evaluate and compare the responses of the perspectives of males studying computing and those who are not for all males who participated in computing activities prior to college. A chi-square test (Phi) was then conducted to assess the strength of the relationship between males who participated in an activity before college and whether they believed that this participation affected their decision to major in a computing field. A second chi-square test (Phi) was conducted to assess the strength of the relationship between males who participated in an activity voluntarily, males who were required to participate, and males who did not participate (Section 4.4).
- An independent t-test was conducted to evaluate and compare the responses of the perspectives of females studying computing and those who are not for all females who participated in computing activities prior to college. A chi-square test (Phi) was conducted to assess the strength of the relationship between voluntary and required females who participated in an activity before college and the type of influence this participation had on their choice of major. A chi-square test (Phi) was conducted to determine the strength of the relationship between females who participated in an activity voluntarily, females who were required to participate, and females who did not participate (Section 4.5).

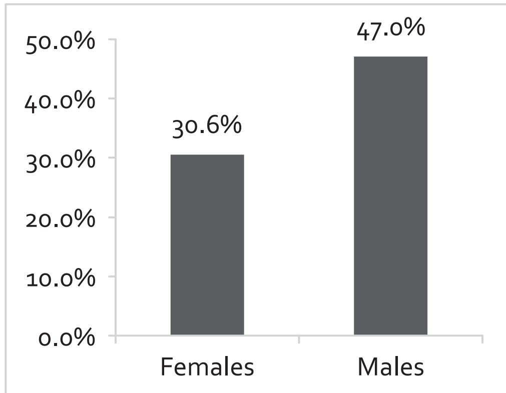

Fig. 3. Participation in a computing activity prior to college.

- Using the preceding percentages, we compared the perceptions among respondents of whether or not required or voluntary activities affected the respondents' choice of major with gender (Section 4.6).
- A Fisher's exact test was conducted to determine whether or not there was a correlation between the timing of the activity and the choice of computing major (Section 4.7).

Note that for ease in readability, we explain the analysis conducted, with further details, in each section of Section 4.

4. RESULTS

4.1. Descriptive Analysis

Respondents were asked to recall if they had participated in a computing activity prior to entering college. Although we loosely defined the term *computing activity*, 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 39.1% of all respondents had participated in the activities, with 30.6% of the female respondents and 47% of the male respondents indicating that they had participated (Figure 3).

Respondents (338) who indicated that they had participated in such an activity were then asked to recall when they participated in the computing activities. Respondents could select one or more of the following: elementary school, junior high/middle school, high school, or other. The raw data is presented in Figure 4. The data is presented as a percentage of the number of respondents in Figure 5, which shows that 39.1% of respondents who participated in a computing activity did so while in high school, 21.7% while in junior high or middle school, and 9.3% while in elementary school.

Nearly half (39.1%) of the 751 respondents either participated in a computing activity prior to college, with 20.4% indicating that they were required to participate and 26.7% indicating that they chose to participate (Figure 6). Male and female respondents were also evaluated. With respect to the female respondents, 20.4% indicated that they were required to participate and 19.4% voluntarily chose to participate. Additionally, 53.7% of female respondents did not participate in any computing activity prior to college, and neither did 43.3% of male respondents.

With respect to male respondents, 17.9% indicated that they were required to participate and nearly twice that (34.2%) indicated that they volunteered to participate.

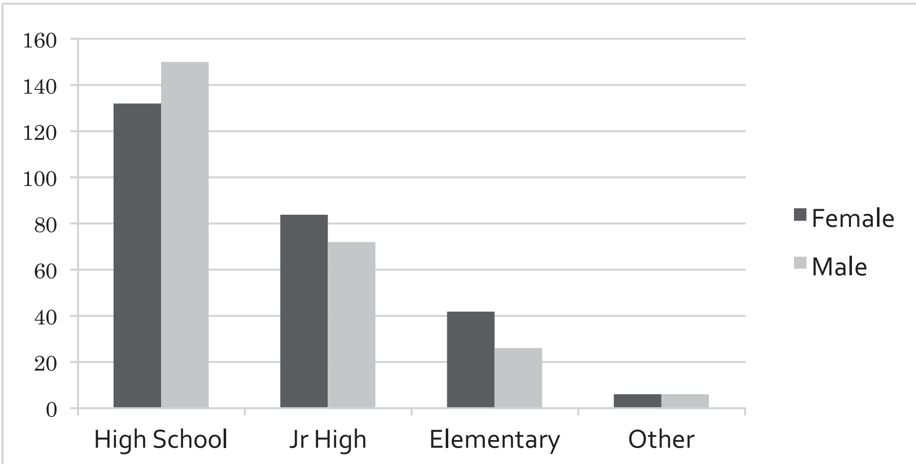

Fig. 4. Raw data of time frame of K-12 participation.

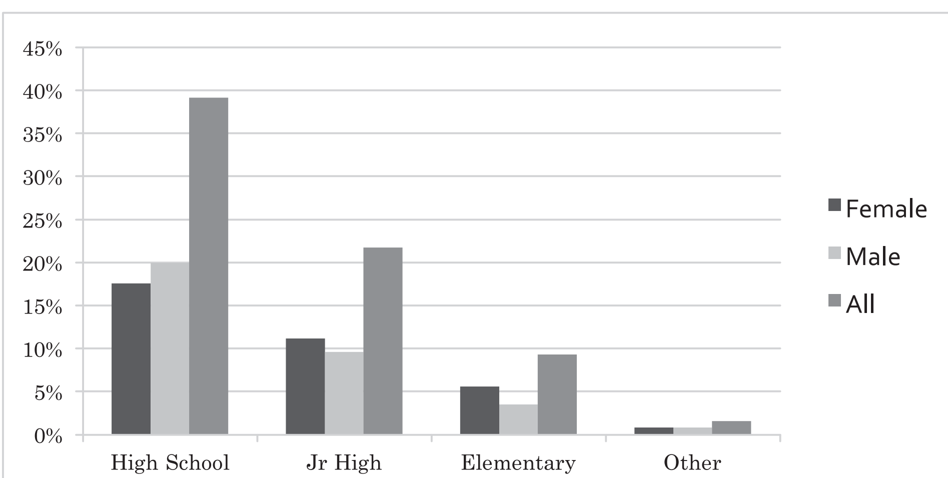

Fig. 5. Time frame of K-12 participation based on the number of respondents (338) who indicated that they participated in an activity.

In addition, 43.3% of male respondents did not participate in any computing activity prior to college.

Respondents were asked how participating in these activities affected their decision to choose their major. Of the respondents who answered this question ($N = 338$), 51.8% indicated that it had no affect on the choice of their major, comprising 29.3% female and 22.5% male. More than one fifth of respondents (21.9%) reported that participating in computing activities prior to college affected their decision to major in a computing field, with 7.1% (of total) female and 14.8% male (Figure 7).

4.2. Relationship Between Computing and Attending an Activity

A chi-square test (Phi) was conducted to determine the strength of the relationship between participation in an activity before college and whether or not the respondent was majoring in a computing field (Figures 8 and 9). As shown in the survey appearing in Appendix B, we noted that a respondent was majoring in the field if the respondent

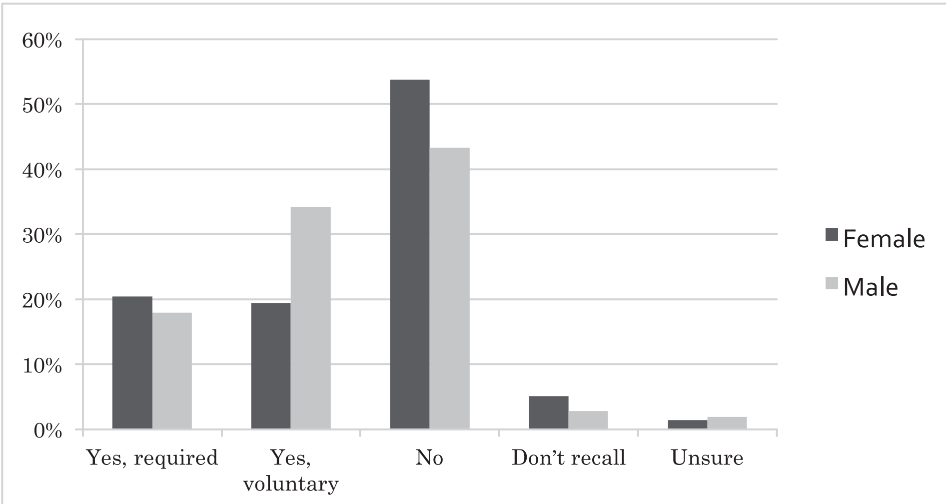

Fig. 6. Affects of computing activities on choice of majors (self-reported).

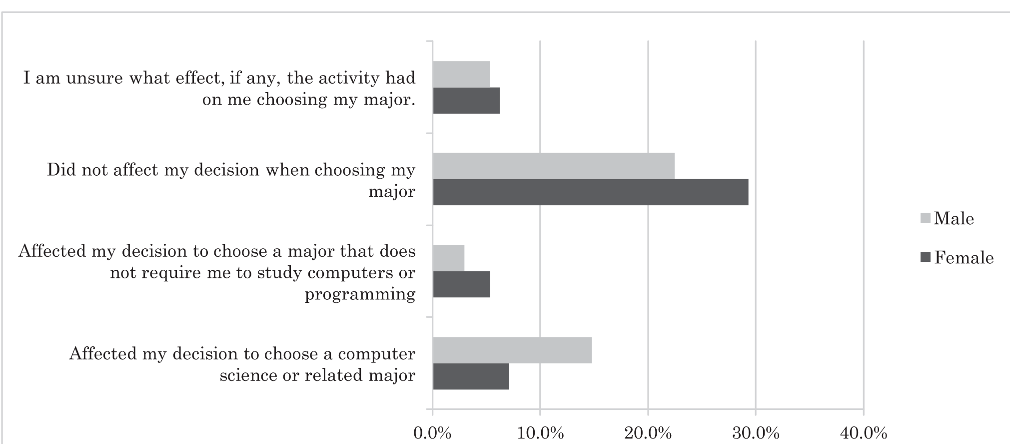

Fig. 7. Affect of participation on choice of major (self-reported).

indicated that he or she were majoring in "[c]omputing or related field (e.g. computer science, interactive media, human-computer interaction, information systems, information technology, etc.)."

There was a very strong positive relationship between respondents who participated in an activity prior to entering college and are majoring in a computing field ($\Phi = 0.27$, $p = .002$, $N = 708$). However, this only existed for the male respondents ($p = .002$) and not the females ($p = .408$).

4.3. Respondent Perceptions of the Activities

As part of this study, we also collected responses on computing activity experiences. We evaluated the responses using an independent t-test. There were no significant differences in the responses between males and females for those presently majoring in a computing field (Table IV).

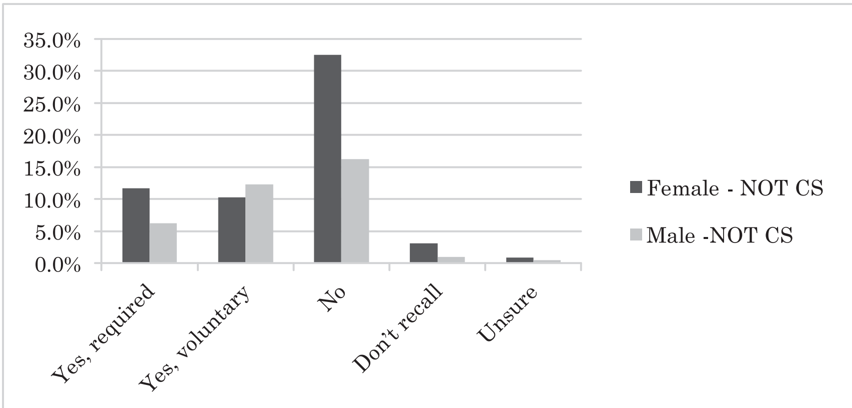

Fig. 8. Participation by non-computing-related majors.

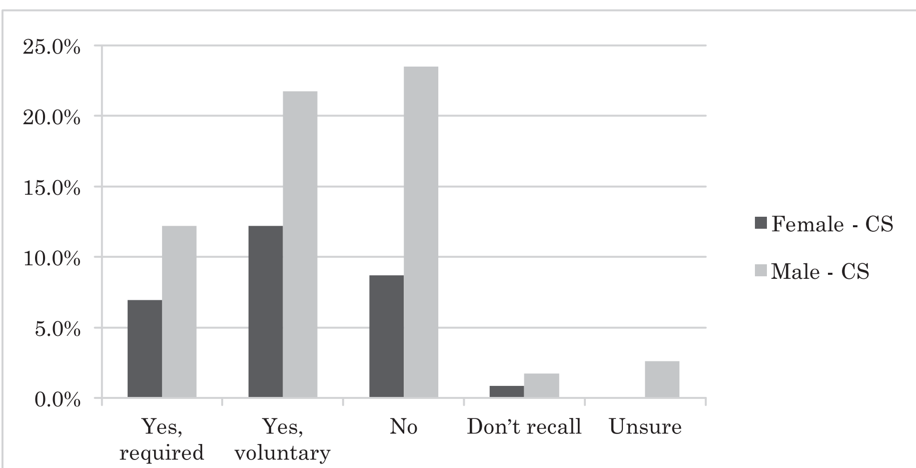

Fig. 9. Participation by computing-related major.

However, there were significant differences found in the responses of those who chose not to major in a computing field. All results yielded highly significant differences ($p \leq .001$) with the exception of "The majority of students participating in the activities were girls." The results of an independent means t-test on gender (female vs. male) are presented in Table V.

4.4. Comparison of Males Majoring in Computing Versus Males Who Are Not

We evaluated several variables, comparing males who are currently studying computing and those who are not, and then conducting the same analysis for the female respondents. A t-test was conducted to evaluate and compare the responses of the perspectives of males who participated in computing activities prior to college (Table VI). Significant differences were found in two of the items: "The majority of students participating in the activities were girls" ($t(164) = -2.13$, $p < .03$) and "Participating in the activities increased my interest in computers" ($t(163) = 2.15$, $p < .03$).

A chi-square test (Phi) was then conducted to assess the strength of the relationship between males who participated in an activity before college and whether they believed

Table IV. Gender Differences Among Perceptions of Computing Activities by Computing Majors

	Male			Female			*t*-Test		
	N	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*p*
The majority of students participating in the activities were boys.	24	4.21	1.21	50	4.50	1.04	1.07	72	0.29
I enjoyed many of the activities.	24	4.63	0.88	50	4.40	0.93	−1.00	72	0.32
I enjoyed learning about computers.	24	4.67	0.70	50	4.50	0.89	−0.81	72	0.42
I was interested in computers before I participated in the activities.	24	4.17	1.20	50	4.22	1.08	0.19	72	0.85
I felt like I was a welcome part of the group participating in the activities.	24	4.21	0.93	50	4.38	1.09	0.67	72	0.51
The majority of students participating in the activities were girls.	24	2.38	1.64	50	2.14	1.60	−0.59	72	0.56
Participating in the activities increased my interest in computers.	24	4.46	0.83	50	4.24	0.96	−0.96	72	0.34

Table V. Gender Differences Among Perceptions of Computing Activities by Non-Computing Majors

	Male			Female			*t*-Test		
	N	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*p*
The majority of students participating in the activities were boys.	151	4.38	1.01	168	3.89	1.4	3.61	303	0.00
I enjoyed many of the activities.	151	4.16	0.89	168	3.77	1.06	3.56	317	0.00
I enjoyed learning about computers.	150	4.27	0.88	166	3.78	1.03	4.58	314	0.00
I was interested in computers before I participated in the activities.	151	4.16	0.99	167	3.53	1.25	4.88	311	0.00
I felt like I was a welcome part of the group participating in the activities.	151	4.19	0.99	168	3.83	1.07	3.09	317	0.00
The majority of students participating in the activities were girls.	151	2.17	1.47	168	2.30	1.39	−0.82	317	0.41
Participating in the activities increased my interest in computers.	150	3.85	0.94	167	3.37	1.07	4.21	315	0.00

Table VI. Comparison of Perceptions Among Males Majoring in Computing and Males Who Are Not

	Male Computing			Male Non-Computing			*t*-Test		
	N	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*p*
The majority of students participating in the activities were boys.	39	4.62	0.78	127	4.30	1.03	1.76	164	.08
I enjoyed many of the activities.	39	4.28	1.05	127	4.17	0.81	0.73	164	.47
I enjoyed learning about computers.	39	4.49	0.97	127	4.25	0.86	1.44	163	.15
I was interested in computers before I participated in the activities.	39	4.31	1.13	127	4.08	0.99	1.22	164	.22
I felt like I was a welcome part of the group participating in the activities.	39	4.31	1.17	127	4.14	0.93	0.92	164	.36
The majority of students participating in the activities were girls.	39	1.72	1.30	127	2.27	1.44	−2.13	164	.03
Participating in the activities increased my interest in computers.	39	4.18	1.00	126	3.81	0.92	2.15	163	.03

Table VII. Relationship Between Participation and Perception That Activity Influenced Choice in Major (Males)

	Required Participation		Voluntary Participation	
Affected my decision to choose a computer science or related major	10	20%	40	38.5%
Affected my decision to choose a major that does not require me to study computers or programming	4	8%	6	5.8%
Did not affect my decision when choosing my major	32	64%	44	42.3%
I am unsure what affect, if any, the activity had on me choosing my major.	4	8%	14	13.5%

that this participation affected their decision to major in a computing field. A significant relationship was found ($\Phi = 0.23, p = 0.048, N = 154$). Table VII shows the frequency of responses of those who indicated that they were affected, along with those who stated that they were not.

A second chi-square test (Phi) was conducted to assess the strength of the relationship between males who participated in an activity voluntarily, males who were required to participate, and males who did not participate. No significant relationship was found between respondents in these groups ($\Phi = 0.10$, $p = .49$, $N = 319$). Table VIII shows frequency of responses and demonstrates the positive relationship between males who

Table VIII. Relationship Between Participation and Major (Males)

	Required Participation		Voluntary Participation		No Participation		Don't Recall		Unsure	
Computing Major	14	20%	25	36%	27	39%	3	4%	0	0%
Non-Computing Major	43	12%	70	19%	222	61%	21	6%	6	2%

Table IX. Comparison of Perceptions Among Female Computing Majors and Female Non-Computing Majors

	Female Computing			Female Non-Computing			*t*-Test		
	N	*M*	*SD*	*N*	*M*	*SD*	*t*	*df*	*p*
The majority of students participating in the activities were boys.	22	4.23	1.07	150	3.86	1.43	1.16	170	.25
I enjoyed many of the activities.	22	4.50	1.10	150	3.68	1.00	3.53	170	.00
I enjoyed learning about computers.	22	4.73	0.70	148	3.66	1.00	6.23	35	.00
I was interested in computers before I participated in the activities.	22	4.27	1.24	149	3.44	1.21	3.01	169	.00
I felt like I was a welcome part of the group participating in the activities.	22	4.00	1.11	150	3.79	1.06	0.85	170	.40
The majority of students participating in the activities were girls.	22	1.95	1.33	150	2.33	1.39	−1.18	170	.24
Participating in the activities increased my interest in computers.	22	4.27	1.20	149	3.28	1.00	4.26	169	.00

reported participating in an activity and those who are currently computing majors, and vice versa.

4.5. Comparison of Females Majoring in Computing Versus Females Who Are Not

Similar to the comparison among males, we compared women who are currently studying computing and those who are not. We evaluated and compared the responses of the perspectives of females who participated in computing activities prior to college (Table IX). Significant differences were found for four of the items, and these items were related to enjoyment of activities and levels of interest in computers.

A chi-square test (Phi) was conducted to assess the strength of the relationship between voluntary and required females who participated in an activity before college and the type of influence this participation had on their choice of major. A significant relationship was found ($\Phi = 0.340$, $p = .00$, $N = 162$), showing a stronger relationship between voluntary participation and choice of major than required participation. Table X shows the frequency of responses of those who indicated that they were affected, along with those who stated that they were not.

A chi-square test (Phi) was conducted to determine the strength of the relationship between females who participated in an activity voluntarily, females who were required

Table X. Relationship Between Participation and Perception That Activity Influenced Choice in Major (Females)

	Required Participation		Voluntary Participation	
Affected my decision to choose a computer science or related major	6	6.9%	18	24.0%
Affected my decision to choose a major that does not require me to study computers or programming	8	9.2%	10	13.3%
Did not affect my decision when choosing my major	66	75.9%	33	44.0%
I am unsure what affect, if any, the activity had on me choosing my major.	7	8.0%	14	18.7%

Table XI. Relationship Between Participation and Major (Females)

	Required Participation		Voluntary Participation		No Participation		Don't Recall		Unsure	
Computing Major	8	24%	14	42%	10	30%	1	3%	0	0%
Non-Computing Major	80	20%	70	18%	222	56%	21	5%	6	2%

to participate, and females who did not participate. We discovered that there is a very strong positive relationship between respondents in these groups ($\Phi = 0.183$, $p = .006$, $N = 432$). Table XI shows the frequency of responses. Similar to the results found for males, there is a stronger positive relationship between female undergraduate students who participated in a computing outreach activity and those who are currently majoring in computing. Likewise, there is a stronger positive relationship between female undergraduate students who are currently majoring in a field other than computing and those who did not participate in a pre-college learning activity.

4.6. Comparison of Males and Females

Using the percentages from earlier, we compared the perceptions among respondents of whether or not required or voluntary activities affected the respondents' choice of major with gender (Figure 10). We found several discrepancies among the four groups, which are discussed in detail in the next section.

We then compared the relationship between the choice of major with gender and the type of activity participation, if any. Figure 11 shows the results.

4.7. Activity Timing and Computing Major

An *rxc* contingency table produced several rows with fewer than five respondents each. Therefore, Fisher's exact test was used to determine whether or not there was a correlation between the timing of the activity and the choice of computing major [Wessa 2014]. Participation periods considered were No activity ($N = 473$), Elementary ($N = 14$), Junior High School ($N = 30$), High School ($N = 162$), both Junior High and High School ($N = 83$) and all three (Elementary, Junior High, and High School ($N = 38$). Since there were only three respondents who participated in both elementary and high school and seven for elementary and junior high, these were removed from the calculation. Results indicate a significant relationship, with $p = .02$, indicating that there was a significant relationship. However, with two categories being dropped due to insufficient responses, we could not gain any indication of which categories produced a stronger relationship.

5. DISCUSSION

In this section, we discuss the results of the survey, including the demographics of respondents, their reported levels of participation in computing activities prior to

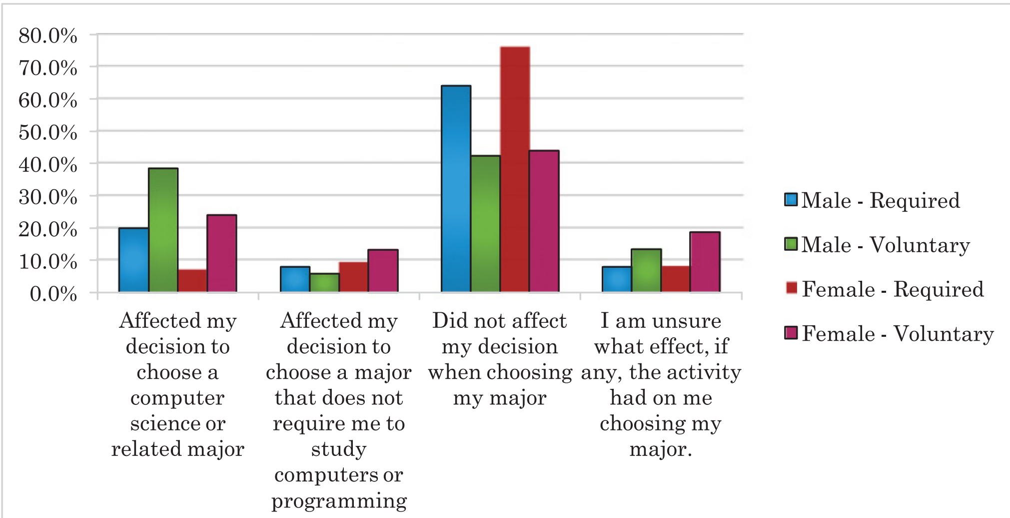

Fig. 10. Comparison of gender and participation type with perceptions of how participation affected the respondent.

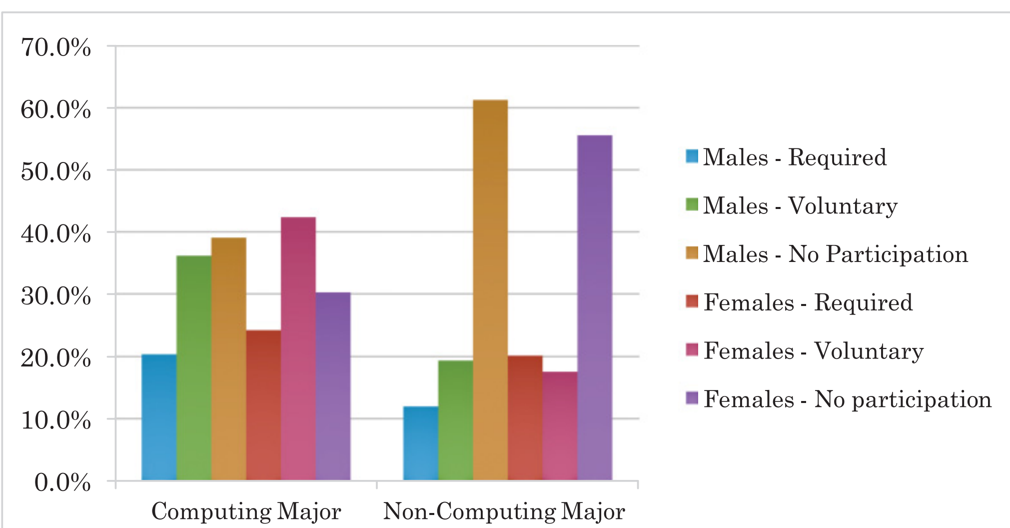

Fig. 11. Comparison of gender and participation type with current major.

college, significant differences in perception between male and female respondents, and limitations of the study.

5.1. Demographics and Reported Participation

Several key demographic results stood out as interesting and worthy of discussion. We found that there were more female (56.1%) than male (41.4%) responses to the survey. This may be explained by previous research confirming that women typically respond to online surveys at significantly higher rates than men [Sax et al. 2003] and that women currently outpace men in college enrollment within the United States [Lopez and Gonzalez-Barrera 2014].

Nine respondents (1.1%) identified as transgender, which is higher than the estimated 0.3% of people in the United States [Gates 2011]. The percentage of transgender people in the United States is difficult to measure, as there are so few national population surveys that include gender identity as a question and people may be hesitant to identify as transgender. Although it is difficult to speculate why the number of transgender respondents to our survey is higher than the estimates for the general population, it is worth noting.

A large percentage of respondents (39.1%) indicated that they had participated in a computing activity, with a larger percentage of men (47%) than women (30.6%) reporting participation. The largest number of activities was reported to have taken place during high school (39.1%), followed by junior high or middle school (21.7%), and then by elementary school (9.3%). The higher number of reported activities during secondary school may be an artifact of a larger number of outreach programs, or it may be a result of better respondent recall for activities occurring in the more recent past. The literature review supports the hypothesis that participants may have better recall for more recent activities, as the outreach programs appear to be evenly split between high school and middle school. A larger number of women (53.7%) indicated that they had not participated in any computing activities prior to college compared to men (43.3%).

In another U.S. study in the state of Georgia [Guzdial et al. 2012], results of a survey administered to undergraduate students enrolled in an introductory computer science class found that 31% of the participants were female and 69% were male. Although not strictly longitudinal in nature, the results of this recollective study found that 28% of the respondents ($N = 1{,}434$) had participated in computing activities in middle school (with 14% indicating that they participated in out-of-school activities during the middle school time frame), and 32% indicated participation in high school (with 16% indicating that they had participated in out-of-school activities during the high school time frame). If there are no duplicates in the reported in-school and out-of-school activity participation, then a maximum of 42% of the participants engaged in computing activities in middle school and 48% of the participants engaged in computing activities in high school, which is slightly higher than our reported figures of 39.1% and 21.7%. However, this could be due to the fact that the Georgia study was only given to students enrolled in a computing course and that efforts have been under way in Georgia for many years to increase the access to and number of computing activities at these levels.

When participants in our study were asked whether the activities they participated in were required or optional, 20.4% indicated that they were required and 26.7% indicated that they chose to participate. Male respondents were twice as likely to indicate that their participation in the activities was voluntary than required. The split was more even with female respondents: 20.4% of female respondents indicated that their participation in the activities was required, and 19.4% reported voluntarily participation. This result may suggest that required computing activities remains important for engaging women, as they are less likely to have participated in voluntary activities than men. This provides some evidence that the approach taken by programs (e.g., Georgia Computes!) in which teacher professional development is as important as summer outreach programs may be an effective approach for engaging female students. It also supports the CSTA's call for requiring students to learn computing in K-12 education to attract more interest in computing as a career choice by exposing computing to a more diverse group of students [Simard et al. 2010].

5.2. Impact on the College Major

Approximately half of our study participants indicated that participation in pre-college computing activities had no impact on their choice of college major, with slightly more women indicating so (29.3%) than men (22.5%). More than a fifth of respondents (21.9%) indicated that the computing activities had impacted their choice of major, with twice as many men (14.8%) indicating an impact than women (7.1%).

The results of our chi-square test indicate a strong relationship between participation in pre-college computing activities and the choice of a computing major. However, the relationship between having participated in a computing activity and choosing to major in computing existed only for the male respondents. It is plausible that participation in computing activities indicated an early interest on the part of male respondents, thus explaining their higher likelihood of choosing a computing major. This is bolstered by the higher percentage of males who reported participating in voluntary activities.

What is most interesting for both male and females, and one of the most significant findings of this study, is that required participation had more impact on males who later chose computer science or a related major (20%) than it did it on their female counterparts (6.9%). One possible conclusion is that the types of activities matter when it comes to increasing diversity, even among required activities.

Our findings differ slightly from a recent study conducted by Google [Wang et al. 2015]. In this survey of more than 1,700 men and women, they found that women indicated their previous exposure as one of the four main factors in their choice of computing as a career/major. In their study, it accounted for 22.4% of the explainable factors that influenced this choice. The study also concluded that the type of activity does not change the impact, but that simply the exposure is the key.

5.3. Perceptions of Outreach Activities

Part of the survey included questions asking respondents about their perception of the computing activities, including the percentage of male and female participants, their enjoyment and learning during the activities, and the impact the activities had on interest in computers. There were no significant differences in responses regarding perception of activities for male and female computing majors. This result is interesting because it suggests that perceptions of computing activities are similar among computing majors regardless of their gender.

There were, however, significant differences in perception between male and female respondents who chose a major outside of the computing field. Female respondents who did not major in computing in college were less likely to indicate that a majority of students participating in the pre-college computing activities were boys, less likely to indicate that they enjoyed many of the activities, less likely to indicate that they enjoyed learning about computers, less likely to say that they were interested in computers before participating in the activities, less likely to say that they were a welcome part of the groups participating in the activities, and less likely to indicate that participating in the activities increased their interest in computers.

Given that the women responding to these questions did not choose a major in computing, their relative lack of interest in computers and in the activities is perhaps not surprising. But what is notable is that the significant differences reported here were with respect to men who also chose not to major in computing, which is a group one would also expect to have not been particularly engaged by the activities. The results suggest that female participants who do not ultimately major in computing have a much stronger negative perception of the computing activities than male participants who choose a major outside of computing. Although many pre-college computing activities are designed to diversify computing, it may be that boys receive these activities more favorably than girls.

This result is also interesting when put in the context of the previously mentioned Google survey [Wang et al. 2015]. In this survey, the authors found that for college graduates who did not major in computer science, a larger percentage of women than men were not able to recall the availability of computer science classes, extracurricular computer science classes, extracurricular computer science clubs, and computer science camps. It would seem that for these students, the availability of such activities did not appeal to them or garner their interest or notice.

Since requiring participation in K-12 is becoming a major call for action within the United States, this supports the need for additional research into why these differences exist [National Science Foundation 2013]. If increasing the number of majors in the computing field is as urgent as it appears, then presenting pre-college computing activities effective for both women and men is equally important, and even required activities should engage both genders for maximum impact on expanding the technology job pool within the United States.

5.4. Differences Between Female Computing Majors and Other Female Majors

Our results suggest that the perceptions of the computing activities on the part of female computing majors and female participants choosing other majors are very different. We discovered four significant differences between these two groups. Women who chose a major in computing were more likely to indicate that they enjoyed the activities, that they enjoyed learning about computers, that they were interested in computers before participating in the activities, and that participating in the activities increased their interest in computers. There were no significant differences in perception regarding the number of boys versus girls participating in the programs and no significant differences regarding how welcome the women felt during the activities.

These results suggest that, like the boys who majored in computer science, female computing majors were more likely to have been interested in computing prior to their participation in pre-college computing activities. For those who majored in computing, they were much more likely to state that participating in the activities increased their interest in computing (M = 4.18, SD = 1.00, $N = 39$) compared to non-majors (M = 3.81, SD = 0.92, $N = 126$). For females, this relationship was more significant, with computing majors more likely to say that the activities increased their interest (M = 4.27, SD = 1.20, $N = 22$) than non-females (M = 3.28, SD = 1.00, $N = 149$). This discrepancy is noteworthy and shows that in general, outreach activities are not having the same long-term effect on females as they are on males.

Males were equally likely to say that they enjoyed the activities and learning about computers whether or not they were computing majors, whereas females showed a significant difference here. Females not majoring in computing did not enjoy the activities or learning about computers. Unlike their male counterparts, they also did not feel as if they were a welcome part of the group and were not interested in computing prior to the activity.

These findings support the findings of Guzdial et al. [2012] with regard to perceptions about majoring in computing for non-majors. In the survey of Georgia students, the results were not separated by gender, but they did ask non-majors why they did not want to pursue a degree in computing. The results showed that 30% of the respondents indicated that they did not want to do the kind of work to which a computing major leads, 25% indicated that they had little interest in the subject matter, 20% indicated that they did not enjoy computing courses, 16% indicated a lack of confidence in their ability to succeed in computing, and 13% indicated that they do not “fit in” in computing. These results also do not take into account whether or not these students ever participated in a computing outreach activity before college.

The results from our survey are encouraging in that they suggest that outreach programs in general make female students feel welcome regardless of their previous interest in computing. But it also suggests that outreach programs may not be completely successful at encouraging females with a limited interest in computing to seriously consider it as a major. This may explain in part why nearly three out of four females who were required to participate in such activities did not feel that their participation affected their choice of major. The data suggests that girls who majored in computing were already interested in the field as a major, whereas those who were not interested were not as affected—at least not to the same extent as boys.

The relationship between students participating in computing activities and their ultimate choice of an undergraduate major was considered, with differences found between the male and female respondents. We found a statistically significant relationship between participation in a pre-college computing activity and the ultimate decision to major in computing. Female undergraduates who did not participate in a computing outreach activity were more likely to report that they had chosen to major in something other than computing, and female undergraduates who had participated in a computing outreach activity were more likely to have chosen computing as their major. Here it is difficult to distinguish whether interest in computing pre-existed their participation in the activity or whether the outreach activity changed their overall interest in computing. Follow-up work should focus on distinguishing between interest in computing before and after the activity, although this is certainly limited by the participants' recall ability.

5.5. Study Limitations

There are several limitations to this study, and the results should be evaluated within the context of these limitations [Campbell and Stanley 1963]. With respect to the participant pool, we surveyed students at both private and public institutions in geographically different locations across the United States. Participants from these institutions may not be representative of the entire population of postsecondary students in the United States. Additionally, nonresponse bias for the entire survey, as well as individual questions within the survey, may have influenced the results [Sax et al. 2003]. The entire study is based on self-reports provided by participants, which is prone to error. Only undergraduate students were surveyed, leaving out those who may have participated in computing outreach activities and later chose not to study at the university level. Additionally, although we carefully selected a diverse representation of schools, additional representation from universities with more diverse populations may have contributed to a more robust dataset.

We recognize that computing as a major does not equate with certain majors that apply computing in other fields, such as medicine, social science, or humanities. Although we only chose to evaluate the former, the former may also be a direct or indirect result of computing outreach efforts.

Many of the participants in the study might have only had one intervention in high school, whereas others had several interventions throughout their K-12 education. Certain computing outreach activities often may be pedagogically and culturally different than those offered in formal education settings in the classroom. Further study to tease out the differences between formal education computing purposes and experiences and the wide variety of outreach activities is desired to expand upon and clarify the results of this research.

Although no correlation could be found, this is further complicated by the fact that we do not capture in what type of activities the respondents participated—that is, attending a girl-focused summer program is treated the same as joining a majority boys' seasonal robotics club.

Several questions relied on respondent recall. Therefore, recall bias could skew the data, even with the prompts that were provided within the survey, particularly related to the questions regarding how the participant felt when engaged in the outreach activity. We took steps to control for recall bias, yet these limitations could affect the results of the study. Although care was taken in choosing survey questions and choices that are unambiguous, there is a risk that participants may have misinterpreted the questions or choices or that different participants interpreted a question in different ways.

Our survey asks participants to recall activities that may have occurred multiple years previously, and it queries the people who participated in the activities rather than the organizers of the programs. Thus, it is difficult to obtain highly detailed organizational information that the participants may not have known or been able to recall after a lengthy gap in time, such as the specific tools used or problems considered during the program, the gender composition of the participants, and the specific length of the program. However, the survey did gather crucial information that contributes to our understanding of the impact of pre-college computing programs.

Another variable that may impact this study is the possibility that respondents have had some other strong experiences that created a very negative or positive impression of computing. For example, female non-computing majors may be motivated to speak ill of their outreach experiences due to other variables. A qualitative follow-up of these women may provide more insight into reasons why, as well as interpret the results in context with other research.

6. CONCLUSION

Many, if not all, programs focused on improving the gender imbalance in computer science have an evaluative component to the projects, but the evaluation of the program is often limited in duration. Typically, the evaluation takes place immediately before the program; during the program; and, in some limited cases, during a short period after the program has concluded. But many gender outreach programs are aiming to change the trajectory of female participation in computing as a field, and measuring the impact of such programs requires longer tracking of participants for full evaluation.

We therefore undertook a study to evaluate the long-term impact recollectively. Although we took steps to control for recall bias, these results do not replace a full-scale longitudinal study. Despite this, some interesting findings are worth further investigation. For example, why do female participants who do not ultimately major in computing have a much stronger negative perception of the outreach activities than male participants who also choose non-computing majors?

We were unable to distinguish whether interest in computing pre-existed for females participating in the activity or whether the outreach activity changed their overall interest in computing. Another area for further research might help distinguish between interest in computing before and after the activity.

Given the range of possibilities in interpreting the results without more in-depth analysis, we recommend follow-up qualitative studies to explain the differences found. We also recommend that those conducting outreach activities consider collecting data to evaluate the long-term impact on participants. In particular, we recommend that outreach programs capture the following data to ensure that underlying factors can be identified:

- Collect demographic data of participants, including gender, ethnicity, age, and school year;

- Collect the level of interest in computing prior to and after the activities;
- Use a validated instrument to collect self-efficacy of participants prior to the activity, after the activity, and 1 year after the activity;
- Collect post-high school data, including college, trade school, certifications, and/or related employment, to identify tech-related courses and employment;
- Collect the type of activity, including whether it is required or voluntary, the number of contact hours, the number of hours participants spent outside of the activity on activity-related tasks (e.g., homework), and the most significant features of the activity; and
- Collect the mode of delivery, the amount of teacher-student engagement, and the qualifications and demographics of the instructors.

Although such collection of data requires communication and follow-up that can be time consuming, the data is needed to ultimately determine which activities are effective in the long term in increasing diversity in the computing field. At a minimum, ensuring that government-sponsored initiatives, such as those funded by the National Science Foundation or equivalents in other countries, are required to track such data can provide a centralized database to aid in the identification of those programs that are more successful in the long term.

APPENDIX A

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APPENDIX B. EFFECTIVENESS OF TECHNOLOGY OUTREACH SURVEY

1. Please specify your status as a student:
   - ◯ Undergraduate student (1)
   - ◯ Graduate student (2)
   - ◯ Not a graduate or undergraduate student (3)
2. Please specify your major area of study:
   - ◯ Art (e.g. animation, graphic design, digital cinema, studio art, art history, etc.) (4)
   - ◯ Business (e.g. accounting, finance, marketing, management, etc.) (5)
   - ◯ Computing or related field (e.g. computer science, interactive media, human-computer interaction, information systems, information technology, etc.) (1)
   - ◯ Education (6)
   - ◯ Engineering (7)
   - ◯ Game design or development (3)
   - ◯ Humanities (e.g. art, history, philosophy, literature, languages, religion, etc.) (8)
   - ◯ Mathematics (9)
   - ◯ Natural or life sciences (e.g. astronomy, biology, chemistry, environmental sciences, physics, etc.) (10)
   - ◯ Nursing (11)
   - ◯ Performing arts (e.g. acting, costume design, music, theater, etc.) (12)
   - ◯ Social sciences (e.g. anthropology, economics, political science, psychology, sociology, etc. (13)
   - ◯ Other (please specify) (14) ____________________

Answer 3 – If 2. "Computing or related field" Is Not Selected

3. Have you taken or do you plan to take any computing classes (programming, game development, robotics, etc.) in college:
   - ◯ Yes (1)
   - ◯ No (2)
   - ◯ Undecided (3)
   - ◯ Other (Please comment) (4) ____________________

Answer 4. – If Q4 Yes Is Selected

4. Please mark which best reflects the reason for you taking a computing class in college:
   - ◯ It is required, and I do not have a choice. (1)
   - ◯ Given a list of required courses to choose from, I am choosing to take a computing class. (2)
   - ◯ It is not required at all, and I am choosing to take the class. (3)
   - ◯ Other (4) ____________________
5. In many schools, camps, and organizations, there are clubs and activities for learning about computers, such as programming, games, hardware, robotics, and more.

Some of these clubs and activities may meet only once, while others meet over the course of an entire year or longer. Some are activities within other clubs, such as Girl Scouts or Boy Scouts. Some meet as part of a class in school and others meet after school or during the summer or winter breaks, and even during special camps. Some use special software to introduce students to computer programming using tools like Scratch or Alice.

You may have participated in one or more of these activities in high school or even earlier. Think back for a moment and consider any of these types of activities that you may have participated in. This section asks you a few questions about these types of activities.

6. At some point in the past before starting college, did you participate in an activity or activities to learn about computers, like programming, game development, or robotics?
   ◯ Yes, as a required part of my classes in school or activities outside of school (clubs, scouts, churches, etc.) (1)
   ◯ Yes, as a voluntary activity in conjunction with classes in school or activities outside of school (clubs, scouts, churches, etc.) (2)
   ◯ No, I did not participate in such an activity (3)
   ◯ I don't recall (4)
   ◯ Unsure (please comment) (5) ____________________

Answer 7. – If 6. "Yes, as a required part of my classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected Or "Yes, as a voluntary activity in conjunction with classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected

7. To the best of your recollection, when did you participate in this activity or activities (mark all that apply):
   ☐ While in high school (1)
   ☐ While in middle or junior high school (2)
   ☐ While in elementary school (3)
   ☐ Others (please specify): (4) ____________________

Answer 8 – If 6. "Yes, as a required part of my classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected Or "Yes, as a voluntary activity in conjunction with classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected

8. How did participating in these activities affect your decision to choose your major? Participating in these activities:
   ◯ Affected my decision to choose a game design or development major (1)
   ◯ Affected my decision to choose a computer science or related major (2)
   ◯ Affected my decision to choose a major that does not require me to study computers or programming (3)
   ◯ Did not affect my decision when choosing my major (4)
   ◯ I am unsure what affect, if any, the activity had on me choosing my major. (5)

Answer 9. – If Q3 "Yes" Is Selected Or ("No" Is Selected And 6. "Yes, as a required part of my classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected Or "Yes, as a voluntary activity in conjunction with classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected

9. Participating in these activities:
   ◯ Affected my decision to choose to take a computer related class in college. (1)
   ◯ Affected my decision to choose NOT to take a computer related class in college. (2)
   ◯ Did not affect my decision to take or not take a computer related class in college. (3)

◯ I am unsure what affect, if any, the activity had on my decision to take or not take a computer related class in college. (4)

Answer 10 – If 6. "Yes, as a required part of my classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected Or "Yes, as a voluntary activity in conjunction with classes in school or activities outside of school (clubs, scouts, churches, etc.)" Is Selected

10. Please rate the following items using the scale provided:

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)	Not applicable (6)	Do not recall (7)
The majority of students participating in the activities were boys. (1)	◯	◯	◯	◯	◯	◯	◯
I enjoyed many of the activities. (2)	◯	◯	◯	◯	◯	◯	◯
I enjoyed learning about computers. (3)	◯	◯	◯	◯	◯	◯	◯
I was interested in computers before I participated in the activities. (4)	◯	◯	◯	◯	◯	◯	◯
I felt like I was a welcome part of the group participating in the activities. (5)	◯	◯	◯	◯	◯	◯	◯
The majority of students participating in the activities were girls. (6)	◯	◯	◯	◯	◯	◯	◯
Participating in the activities increased my interest in computers. (7)	◯	◯	◯	◯	◯	◯	◯

11. With which of the following groups do you most closely identify? Mark all that apply.
☐ American Indian or Alaska Native (1)
☐ Asian (2)
☐ Asian Indian (3)
☐ Black or African American (4)
☐ Chinese (5)
☐ Filipino (6)
☐ Guamanian or Chamorro (7)
☐ Hispanic/Latino/Latina (8)
☐ Japanese (9)
☐ Korean (10)
☐ Middle Eastern (11)
☐ Native American (12)
☐ Native Hawaiian (13)
☐ Samoan (14)
☐ Vietnamese (15)
☐ White (16)

☐ Other Asian (not previously mentioned) (17)
☐ Other Pacific Islander (18)
☐ Some other race (19)
☐ Multi-racial (20)
☐ Decline to answer (21)

12. Please specify your gender:
    ◯ Male (1)
    ◯ Female (2)
    ◯ Transgender (3)
    ◯ Decline to specify (4)

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