Self-Efficacy Study in Computing Among College Freshmen

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Abstract

Computer Science (CS) is not introduced equitably across K-12 schools, yet it is increasingly a necessary skill regardless of vocational pathway. Co-curricular activities such as summer camps have become a popular way to introduce CS to K-12 students. Researchers at our institution, through partnerships with other educational institutions and practitioners, developed a transdisciplinary approach of teaching CS in K-12 informal learning environments. Building on positive results in the K-12 informal learning environment, researchers are exploring the applicability of the transdisciplinary modules in formal instruction for early college learners in CS0 and CS1 courses.

This paper explores self-efficacy data collected from multiple CS0 and CS1 courses. Learners include freshmen in computing majors and in non-computing majors. We compare their self-efficacy growth in computing across race and gender, considering their formal or informal CS education experiences prior to entering college. This work is a part of a larger effort to redesign CS0 and CS1 courses to introduce more complex concepts and important design concepts such as parallel and distributed computing earlier in the curriculum. The authors' longer-term goal is to investigate active learning strategies that will introduce higher level computer science topics early in the curriculum to enable students to recognize content applicability earlier in their college pathway.

1. Introduction

Students who enter college with prior exposure to computer programming are shown to have a self-efficacy advantage [1]. While computer science initiatives have increased formal education opportunities throughout 47% of public schools in the state [2], students in poorer districts, and those in the most rural areas, have less access to that formal education in CS or informal activities that encourage computing and provide CS role models. Students with little or no access to CS in K-12 are less likely to identify with and pursue pathways to computer science education [3,4].

Experiences in early CS courses can influence the development of self-efficacy in computing among learners, and particularly for women as noted by Quade [5]. Bandura described self-efficacy as "the belief in one's capabilities to organize and execute courses of action required to produce given attainments," emphasizing that personal beliefs and actions contribute to self-efficacy attainment [6]. Quade's study found that women "consistently showed lower problem solving and computer confidence than their male counterparts" [5].

M. Chemers et.al. found that academic self-efficacy and optimism are strongly related to performance and adjustment in school for a first-year college student [7]. Zeldin and F. Pajares also emphasize that this feeling of self-efficacy is more critical to the educational and vocational pathway choice for women than men [8].

Since 2011, researchers at our institution have been studying the impact of gender-specific interventions in computing and cybersecurity on the self-efficacy of girls and women in computing. Mississippi State University's (MSU) Bulldog Bytes K-12 computing and cybersecurity outreach program has engaged over 1000 informal computer science learners since

2013 [4,9,10,11]. With increasing gaps between the number of computer science graduates and the number of unfilled jobs in computing, it is imperative that we discover opportunities for increasing entry and retention of persons traditionally underrepresented on computing pathways.

For this project, the authors considered best practices from Bulldog Bytes' transdisciplinary approach to engaging learners with computer science content in K-12 informal learning environments [11]. Ertas et. al. summarizes that "Boundaries for transdisciplinary courses are the boundaries of the problem being addressed, not the artificial boundaries of disciplines" [12]. In a transdisciplinary classroom, concepts are presented from several perspectives and the integration of content is "more fully appreciated by the students" [12]. They further note that for success, transdisciplinary modules must be designed by the faculty delivering the material and subject matter experts in the content areas [12]. Canter and Brumar concluded that a transdisciplinary approach "fosters lifelong learning through emphasis on teamwork; it creates new stimulating ideas, develops concepts and tools in order to solve real world issues" [13]. Results from a multi-semester application of this approach in CS0 and CS1 courses is presented.

2. The Study

The authors developed a survey to collect data on self-efficacy of students in CS0 and CS1 courses [5]. The survey collected data on the following items: gender, classification, race, previous programming experience. Questions asked about perceptions of their ability to perform computational thinking activities and their perceptions of others' abilities were presented and are shown in the results tables in the next section. In fall 2018, the survey was given at the end of the semester. During spring and fall 2019, the survey was given at the beginning of the semester, and then again towards the end of the semester. Overall, 256 students participated in the study.

Only students aged 18 years or older were included in this study. The courses studied by semester are listed in Table 1. Racial demographics for the students that participated in the study each semester is shown in Figure 1.

Table 1. Courses studied by semester

COURSE	SEMESTER	NUMBER OF STUDENTS ENROLLED
CSE 1002 (CS0)	Fall 2018	153
CSE 1233 (CS1)	Spring 2019	62
CSE 1002 (CS0)	Spring 2019	37
CSE 1284 (CS1)	Fall 2019	226
CSE 1001 (CS0)	Fall 2019	13

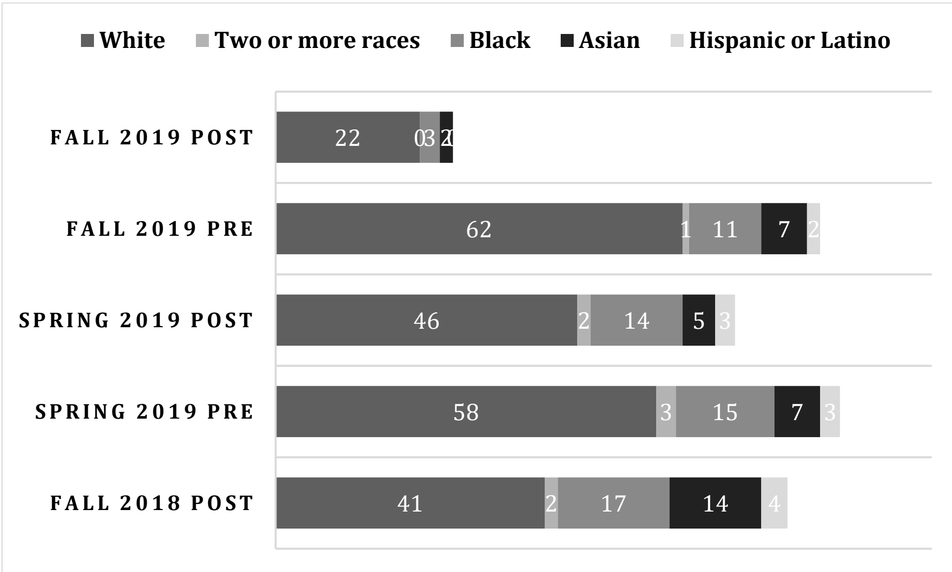

Figure 1. Racial characteristics of participants (Column label are in numbers)

3. Results

Table 1 and Figure 1 illustrate that the majority of participants in the data collection are white males. Pre-survey results across semesters indicate more male exposure to pre-college formal and informal learning in computing. Similarly, the perception of being good at computer programming at the beginning of the semester is significantly greater for males than females as shown in Figure 2.

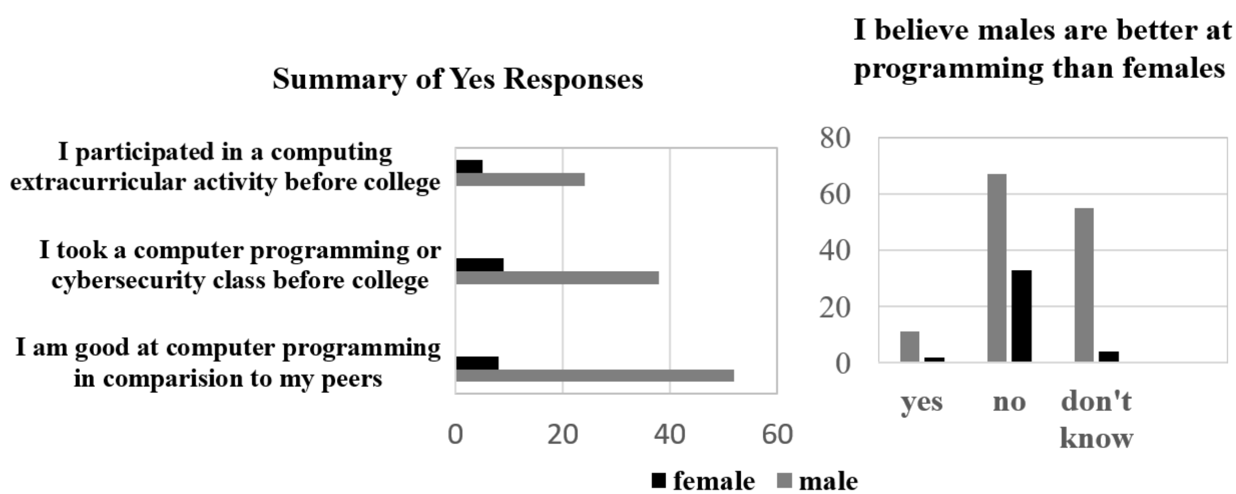

Figure 2. Male vs Female Experience & perceptions (Column label are in numbers)

From the post-surveys across semesters illustrated in Figure 3, gaps between positive perceptions of programming ability among males versus females is apparent. Interestingly, the number of males indicating that they believed males are better than females at computer programming increased from 5.5% to 7.0 % in spring 2019, and that measure decreased from 7.1% to 3.6% in fall 2019. Males who indicated they are good in computer programming in comparison to their peers increased from 16.7% to 29.6% in spring 2019. Similar patterns can be seen in fall 2019 pre- to post- results where self-efficacy grew from 29.8% to 42.9% for male students, but remained flat for females.

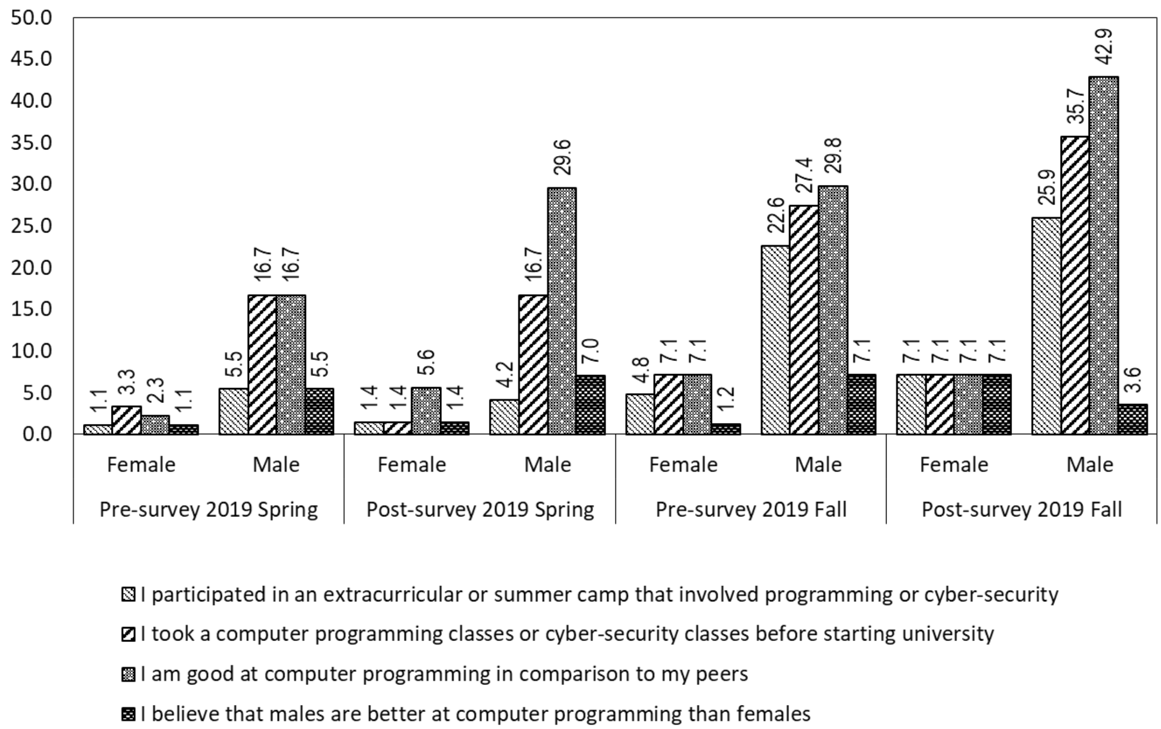

Figure 3. Perceptions of Male vs Female between pre-post survey in Spring 2019 and fall 2019 (Column labels are in percentage).

With the post-survey results across semesters presented in Figure 4, gaps between positive perceptions of programming ability among males versus females is evident. The perception of male students reporting to be better at computer programming than their peers in fall 2018 is higher at 49.4% than subsequent semesters. There is no substantial difference in perception of females cross the semesters. Male students largely do not express a perception that they are better at computer programming than females.

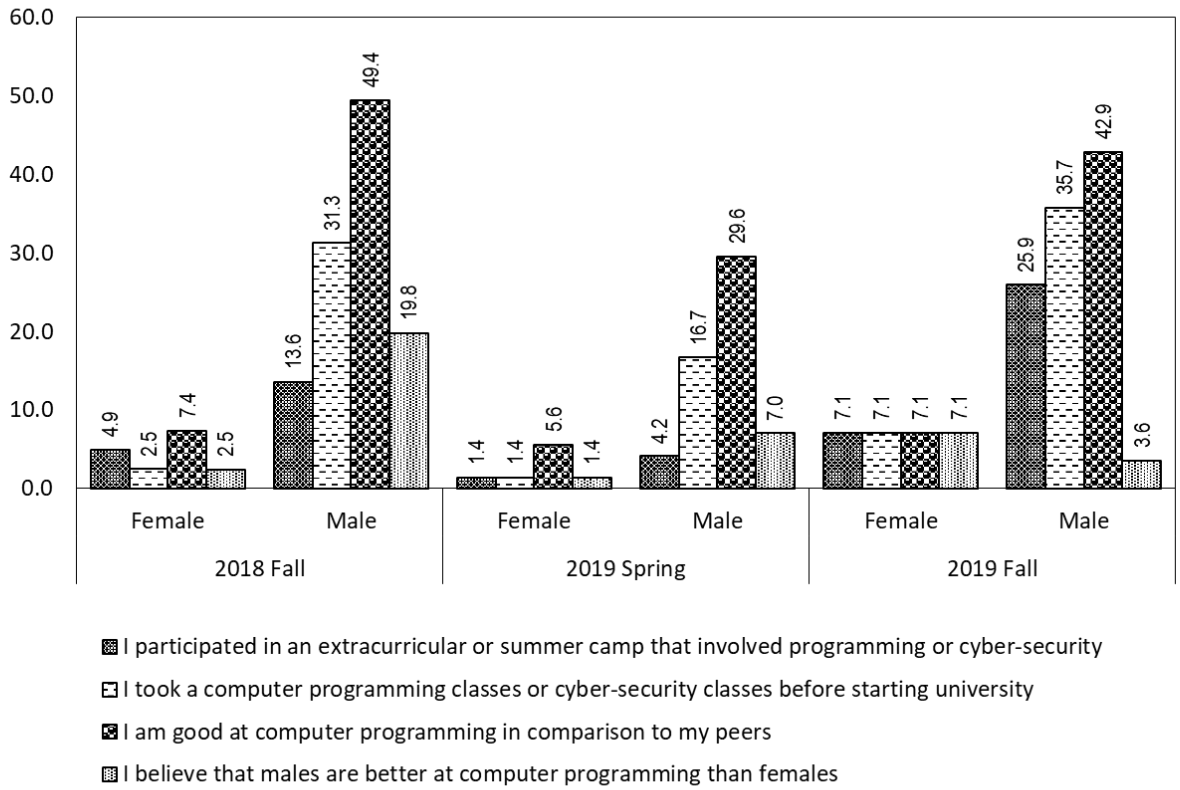

Figure 4. Perceptions of Males versus Females in Post- surveys Fall 2018 and Fall 2019(Column labels are in percentage).

The racial demographics of the classes studied reflect the underrepresentation of racial minorities in computer science education. All fall 2018 data is from CS0 students with a major in computer science or software engineering. Spring 2019 data represents CS1 students not in a computing major, while the fall 2019 data is from CS1 students in those computing majors. Observation of the data reveals varying results which may attribute to male and female self-efficacy in computer programming.

Comparing computing experiences of males and females before entering college, we found that males consistently reported engagement with formal and informal computing education before entering college than females. Further, students entering a computing major had more prior exposure to formal and informal computing education prior to entering college.

4. Summary

This work provides a baseline for our work to use transdisciplinary modules to introduce parallel and distributed computing modules into CS0 and CS1. Knowing the perceptions of students when they enter these classes, will enable us to tweak modules for introduction of more complex technical topics to freshmen level students. The increase in less positive perceptions of confidence in programming ability among female learners warrants further study and is particularly interesting since the instructors for the classes surveyed were both female.

Acknowledgement

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