The Effect of Gender on Student Self-Assessment in Introductory Computer Science Classes*

Ian Finlayson
Computer Science Department
The University of Mary Washington
ifinlay@umw.edu

Abstract

This paper will discuss the way that male and female students rate their abilities in introductory computer science courses. For the past two semesters, students in an introductory computer science course were given a survey at the end of the semester, asking about their experiences in the course. The survey asked students their gender, and also to rate themselves in the course as being either below-average, average, or above-average. The first semester used a traditional lecture-based course delivery. The second semester used team-based learning, in an effort to have students get a better sense of their own and their fellow student's abilities. In both courses however, female students rated themselves significantly lower than male students did, despite the fact that female students actually did better on average (though not statistically significantly better). This paper discusses these results in some detail, and talks about some future work which aims to ameliorate this issue.

1 Introduction

The gender gap in computer science refers to the fact that substantially more male students major in computer science than female students. According to the National Center for Education Statistics [5], only 18% of computer science degrees awarded in 2015 went to women. The gender divide is probably the most widely researched issue in computer science education. Several papers have identified this as a serious problem, including [16], [15], [4], and [13]. We have known about the gender gap for a long time and it has not improved in recent years.

There are multiple reasons behind the gender gap. The one that will be examined in this paper is that female students just do not view themselves as being as good at computer science as their fellow students who are male. When students feel like they are below average in a discipline, it is natural that they will not choose to major in said discipline. The problem is that, as this study shows, those feelings are often not accurate – because female students *are* as capable in computer science as male ones.

For the past two semesters, a survey was given to students in an introductory computer science class. This class is taken primarily by students who do not intend to major in computer science and it fulfills a general education requirement. The first semester, we found that female students did indeed rate themselves lower than did the male students, despite the fact that women actually did *better* in the course on average.

After these disappointing results, significant changes to the structure of the course were made in an effort to ameliorate this issue for the next semester. Specifically, team-based learning was employed in place of a traditional lecture format.

The reasoning behind this decision was that, in a traditional lecture class, students don't necessarily get a feel for how they are doing relative to their peers. In an introductory class there are always a couple students who have some programming experience. These students then answer questions and seem to be naturals at computer science. A student lacking confidence might assume most of the class is like that and that they're behind when they really are not.

In team-based learning, students work together in teams to complete quizzes on material, and also work in their team during in-class activities. It was hoped that by doing this, students would get a more accurate picture of how well their classmates are doing in the class, and be more confident in their own abilities.

The same survey was then given to this second group of students. Unfortunately, while the results of the survey were slightly better, there was still a large difference in the way male and female students rated themselves.

This paper will discuss this disappointing result, and offer some commentary on why we believe this approach did not successfully close the gap between

how male and female students rated their abilities. This paper presents a "negative result" of an approach that did not work, along with reasons why we believe this to be the case.

The rest of this paper is organized as follows: Section 2 will discuss related work, Section 3 will talk about the methodology of this study, including the course design of the two classes, and the survey given. Section 4 will give the results and analysis of the surveys. Section 5 will provide a discussion on why we believe this approach was not successful. Finally, Section 6 will draw conclusions and also discuss our future ideas for working towards a solution to this important and challenging problem.

2 Related Work

This section will discuss other works that have looked into the way that male and female students assess their abilities in computer science and related disciplines. It will also discuss some related work on team-based learning.

In [6], Jones identifies eight reasons leading to a decreased number of women in STEM fields generally, including belief about intelligence and self-assessment. She presents a number of possible solutions to these issues, such as teaching the growth mindset to counteract students feeling that they are inherently worse at mathematics and engineering.

Correll [3] performed a study on the way male and female high school students assess their own mathematics abilities. She found that male students were more likely to rate their abilities in a favorable light than female students. She also found that male students have a lower bar for what constitutes success in mathematics than their female peers.

Margolis has written extensively on the barriers to entry in computer science. In [10], she explores several reasons for the lower number of women in the field. She cites the feeling that other students (usually males) are ahead of them as a primary reason that female students become discouraged in their computer science courses.

In [14], Rubio et. al. discuss gender differences in introductory programming classes. They had found that male students had higher learning outcomes than female students, and used physical computing (using Arduino boards) to close that gap. In our work, we did not find that women performed worse in introductory courses, but rated themselves lower anyway.

Alvarado and Dodd [1] discuss the gender gap at Harvey Mudd College, which has had success involving more female students into computer science. They have done this in part by introducing computer science with breadth-first topics, sending students to the Grace Hopper conference, and involving freshman students in research projects.

In [17], Werner et. al. propose the use of pair programming to help female computer science students. They posit that pair programming erodes the idea that computer science is a solitary endeavor, and that requiring team work is beneficial to female students especially. They found that all students in their study had improved confidence with pair programming, but women especially did.

Khan and Luxton-Reilly [7] also suggest that a primary reason for the gender gap is that female students view computing as only involving technology and not involving social interaction. They propose incorporating examples and exercises that relate to social science into computing courses. They suggest that this will interest female students in computer science more than typical examples and exercises.

There have been many studies on team-based learning, mostly which explore its efficacy in improving student learning outcomes. The definitive source on team-based learning is [11]. Two studies that look at team-based learning specifically for computer science courses are [8] and [9]. These papers find benefits in the team-based learning approach, but do not specifically look at how male and female students rate themselves.

3 Methodology

This study concerns two introductory computer science courses, taught in successive semesters. The first used a traditional, lecture-based delivery. In this course, the class met three days per week. The first two days, material was given to the students via lecture. The third day was used for in-class lab exercises. Students were allowed to work together in the lab, but most did not.

Team-based learning was used in the following semester. In this format, students were given readings on each week's material to complete outside of class. Then, on the first day of each week, students completed a Readiness Assessment Test, or RAT. These are short multiple choice quizzes that test a student's comprehension of the reading they completed.

In team-based learning, students complete the RAT *twice*, the first time individually and the second time with their team. When completing the RAT with their team, students used a scratch-off card to give their answers. This gives students immediate feedback on their answers. If they get a question wrong, they are able to guess again for a reduced number of points. Students working in a team need to come to a consensus on what to guess. In doing things this way, it was hoped that students would sometimes see that they got a question right individually that others in their team did not, even if they might assume that team member was further ahead then them. After the RAT, the instructor addressed any questions students had, and clarified any difficult

material.

On the second weekly class meeting, the teams would work together on in-class activities. These included answering questions, solving small programming challenges, or finding problems in code. Sometimes the class would work on a larger program, with parts of the program assigned to each group to work on in their teams, then combined together as a class.

The third class meeting of the week was again a lab session. Unlike the previous semester, students were more likely to work together on the labs, because they had gotten to know their team members and became comfortable working with them.

In both semesters a survey, was given out to students. The survey asked several questions about students experiences in the course. One of the questions asked students "How do you feel you are doing in the course relative to your classmates?". The options given were "I feel that most others are doing better than me.", "I feel I am somewhere near the average.", and "I feel that I am doing better than most others.". Students were also asked to provide their gender. There were other questions about various other parts of the class, but these were not relevant for this paper. The survey was given anonymously, and was not graded.

4 Results

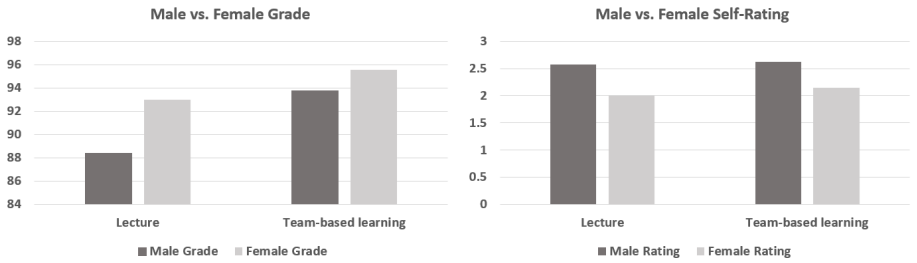
In the first semester, 23 of the 28 students enrolled completed the survey (82% response rate). There was a strong correlation between gender and how students rated themselves. If we assign a 1, 2, and 3 to each of the three ratings, then female students had an average of 2 while male students had an average of 2.57. Additionally, none of the male students chose the lowest category while four of the female students did.

A t-test was run to determine if this difference was statistically significant. Before running the t-test, an f-test was first conducted to ensure that variance between the two groups was not equal. The independent sample, one-tailed t-test reveled that there was a strong statistically significant difference between the way that the male and female students rated themselves ($t=-2.1$, $p=.026$).

All of this is despite the fact that women actually performed *better* in the class on average with an average final grade of 92.97, as opposed to 88.39 for the male students, though this grade difference was not found to be statistically significant.

For the second semester, 15 of the 28 students completed the survey (54% response rate). This time the female student's self rating averaged 2.14 and the males averaged 2.62. So roughly the same gap as the previous semester existed, though both averages were slightly higher. Again, no male students

Figure 1: Summary of class performance vs. self-assessment between male and female students across the two sections



rated themselves as below average, while two female students did. And again women actually had a better final grade average at 95.56, compared to 93.77 for men (the course had a bit of grade inflation due to the team RATs and some extra credit opportunities).

We again verified that the variance between the groups was not equal with an f-test, and then conducted an independent sample, one-tailed t-test. The results of this test were a little less strong than the previous one (t=-1.5, p=0.079). Because the p-value is not less than 0.05, we did not quite find the statistically significant difference between the two groups that we had in the first semester. However, there is still a 92.1% chance that the variance in the groups was not caused by chance – i.e. that it's predicted by gender.

We then performed two additional t-tests to verify that the use of team-based learning had little to no effect on the way these groups of students rated themselves. First we compared the female students in the lecture-based course to the female students in the team-based learning course. The results showed no strong difference between the way these populations rated themselves (t=-0.449, p=0.331). We then compared the male students under the lecture-based course to the male students under the team-based learning course. Again, we found no significant difference (t=-0.197, p=0.424).

In conclusion, we found that under both classes gender *was* a strong predictor for how students rated themselves relative to their peers. We also found that the method of delivery (lecture vs. team-based learning) did *not* predict the students ratings.

5 Discussion

This section will provide some commentary on why we believe the use of team-based learning was not successful in closing the gap between the way that

women and men rate themselves. In reflecting on this, we believe we have more insight into this problem than we previously had.

The adoption of team-based learning was made primarily because it would give students a closer look at how their fellow students solve problems, and give them a clearer idea of how they are performing relative to their classmates.

However, if a less-confident student reads the material and studies hard, and then does better than another student on the RAT, she may not take that as a sign that she is as good, or better at computer science than the other student. She may instead just chalk it up to the fact that she read and the other student did not.

These false feelings of being behind others are related to imposter syndrome, which is the feeling many people have of being "faking it" and not actually deserving of success that they have achieved. Imposter syndrome is known to affect women more than it affects men [2]. Those with imposter syndrome often feel that their success comes from working harder than others have to, or just getting lucky, and isn't really deserved.

So we believe the primary problem with female students rating themselves lower is not really related to them actually not knowing how well they were doing in the class relative to their peers. It is instead due to them mistakenly believing that their success is not deserved. They believe there are "naturals" who are fit to be good computer scientists, and they don't see themselves as that regardless of how well they're currently doing.

6 Conclusions and Future Work

This insight has directed the future direction of this project. Rather than try to give students a more accurate view of their performance relative to their peers (which seems naïve in retrospect), we will instead focus on addressing the core of the problem, which is the underlying lack of belief in a student's own success and ability.

We propose to do that by addressing the issue head-on. In the next iteration of this project, we plan to explicitly talk about the issue of the gender gap in computer science, and imposter syndrome. Students will have readings on these topics and be asked to write reflective papers on them. We hope that talking about these issues openly will get students to think more deeply about how they view themselves.

Another idea we have is to talk about the idea of a fixed mindset vs. a growth mindset. Prior work [12] has shown that teaching a growth mindset in computer science classrooms can help students be more resilient and willing to take risks. We suspect it may also help students realize that there are no "naturals" at computer science and, conversely, anyone can work to become a

successful computer scientist.

This paper presented the negative result that team-based learning made little difference in the way that male and female students rated their performance in an introductory computer science course. In both the traditional lecture-based class, and in the team-based learning one, female students rated themselves significantly lower than their male counterparts. This is an important problem because the fact that many women incorrectly see themselves as worse at computer science is a major cause of the gender gap in this field.

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