BJC in Action: Comparison of Student Perceptions of a Computer Science Principles Course

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***Abstract*—The Beauty and Joy of Computing (BJC) is a curriculum for the new AP Computer Science Principles course. Over the past 2 years, we have collected post-course surveys from 399 students participating in the BJC course. This paper investigates how the responses of females and students from underrepresented racial minority groups (URMs) differed from those of their counterparts. We found that female students had taken fewer CS courses prior to BJC but that students from URMs had taken more prior CS courses. Both groups were nearly equally likely to recommend the course to a friend, with about 80% recommending. We found no evidence to suggest that female students showed more or less interest in specific CS topics, such as learning how computing has changed the world or making mobile apps/games. Despite having taken more CS courses prior to BJC, we found that students from URMs were overall less likely to intend to take additional CS courses. Overall, our findings are fairly consistent with the literature, and suggest that BJC makes some progress towards broadening participation in computing.**

I. Introduction

Interest in increasing diversity in computing has grown over the past decade. Women and racial minorities are underrepresented in technology jobs, as well as computing majors in higher education [1]. Nationwide organizations such as NCWIT (National Center for Women and Information Technology) work with educational institutions and industry to help close this gap. Broadening participation projects such as Georgia Computes! [2] have become highly successful statewide initiatives. Now there is a focus on developing a curriculum to help high school students from diverse backgrounds to become interested in and prepared to succeed in CS.

The participation gap in computing applies to K12 schools as well. In 2014, only 37,278 students took the AP Computer Science A (APCS) exam. This was a 26% increase from the previous year but does not even come close to the 294,072 students taking the AP Calculus AB exam. Further, there is was a distinct lack of minority students taking the APCS with just under 20% female and 22% identifying as an underrepresented racial minority (defined below). To address this issue, the Exploring Computer Science and Computer Science Principles courses were developed.

The Beauty and Joy of Computing[1] (BJC) is a CS Principles course that combines pair-programming labs with lectures, ranging from artificial intelligence to the social implications of computing and technology, and readings on the relevance and impact of computing. Half of the BJC course is dedicated to programming, with students working in pairs on weekly labs and a project of their own choice. Optional modules use technologies such as GameMaker and AppInventor to apply computing concepts to new and interesting contexts. Course readings are drawn from Blown to Bits [3] and supplemented with articles, videos, and current events.

UC Berkeley and NC State partnered to offer BJC professional development to high school teachers from 2012-2015. In this paper, we investigate the differences in course perception of diverse students taking the BJC course. Our goal is to determine how well the curriculum meets the needs of students from underrepresented groups by investigating how they responded differently to questions about their backgrounds, experiences in the course, and future plans.

II. Background

According to Hill [4], "fewer women pursue STEM careers than would be expected based on the number of girls who earn high math scores." Companies such as Google [5], Twitter [6] and Microsoft [7] have reported demographics for their US employees in 2014 and 2015 as 83-90% male and 92-94% White or Asian-American. Industry is attempting to address these problems with programs like TEALS[2] and code.org. TEALS sends professionals into high school classrooms to help teach computer science, while code.org has created Hour of Code activities and provides professional development for K-5 teachers in large districts. The National Science Foundation funds the CS10K effort which seeks to have 10,000 teachers teaching computing in high schools. While these are important efforts, more work is necessary to prepare K-12 students and encourage them to pursue computing degrees.

Recognizing the need to create new solutions for engaging diverse students, the National Science Foundation supported new alliances for Broadening Participation in 2005, funding initiatives like the STARS Computing Corps to develop student leaders and Georgia Computes to improve statewide adoption of CS. Georgia Computes provided support for Computer Science from middle school through college [2], emphasizing increasing AP Computer Science A participation. Initially, less than 10% of high schools in Georgia offered APCS. Through hands-on teacher training and infusion of multimedia technologies to encourage a diverse student population, the number of those teaching the APCS exam rose by 78%.

With the higher entrance barrier to taking APCS, Margolis [1] designed a new 9th-10th grade, Exploring Computer Science (ECS) course, which focuses on equitable pedagogical practices and content designed specifically to appeal to students from URMs. NSF CS10K also supports CS Principles, a

[1] bjc.berkeley.edu

[2] http://www.tealsk12.org/

new AP (11th-12th grade) course designed to appeal to diverse students while showing the breadth of computer science.

A recent study by Stanford University [8] concluded that it is important for diverse students to start taking CS classes early, that it is important that educators are aware of diversity issues, and that curriculum changes can have a large impact. With this understanding in mind, we analyzed BJC student post-course surveys to determine the course's success with diverse students.

III. Methods

Our goal was to determine whether females or students from URMs had different backgrounds before, experiences in, or outcomes from the BJC class. We collected post-course survey data from Fall 2013-Fall 2014 BJC courses whose teachers attended BJC PD from 2012-2014, resulting in 382 high school students at 18 high schools and 17 undergraduate students at a university[3] [9]. We defined students from URMs as those who reported their race/ethnicity to include: American Indian/Native Alaskan, Black/African American, Hispanic/Latino or Pacific Islander.

Survey questions asked participants about their background in CS and STEM fields, their access to technology, their interest in certain activities in the BJC curriculum, their perceptions about the treatment of diversity in the BJC classroom, and their intention to pursue CS and STEM in the future. While participants could skip questions, almost all questions had at least an 85% response rate. One question, asking about interest in making mobile apps/games, had only a 70% response rate, but this rate was generally constant across demographics.

A. Analysis

To ensure that we had as accurate demographic information as possible, we manually inspected responses to the race/ethnicity question. We adjusted one student who had reported race/ethnicity as "Other: Native American" to the American Indian category, but we did not adjust any students who reported country-specific races/ethnicities (e.g. Indian, Russian). Students were permitted to select multiple answers, and three students selected all options. We adjusted these students to only the Other category. Students were defined as URM if they selected any of the corresponding races/ethnicities, even if they also selected another category. Students who reported only Other (5.8%) were excluded from the URM comparisons, and students who did not report a gender (3.8%) were excluded from gender comparisons.

We analyzed two types of questions: true/false questions, and 5-point Likert-style questions. In both cases, we were interested in determining if females or students from URMs reported significantly different responses than their counterparts. For true/false questions we used a χ^2 test to determine significance, and for the Likert-style questions we used a Mann-Whitney U Test. In each test we compared either female and male students or students from and not from URMs.

Each classroom had a different teacher, with a different style and possibly altered curriculum. To control for any effects that the classroom itself may have had on the results we observed, we performed an analysis of covariance (ANCOVA) for each question with significant or near-significant differences in responses for females or students from URMs. In the ANCOVA, we used question response as the dependent variable, with either gender or URM status as the independent variable, while controlling for classroom as a covariate. This allowed us to test for differences between populations while controlling for the effect of individual classrooms.

[3]This sample does not include students from the BJC course at UC Berkeley

	Current Sample	AP CS 2014	US 2010
White	45.1%	49.7%	75.1%
African American	9.5%	3.7%	12.6%
Asian	12.8%	28.2%	4.8%
Hispanic	12.5%	8.3%	16.3%
American Indian	1.5%	<0.01%	0.9%
Multi-racial/Other/Not Stated	18.5%	10.0%	2.9%
Total URM	32.1%	22.0%	–
Total non-URM	62.2%	77.9%	–
Male	72.9%	80.0%	49.1%
Female	23.3%	20.0%	51.9%
Respondents	*n = 399*	*n = 39,278*	

TABLE I. Demographic breakdown of students in our dataset. For comparison, the same breakdown is provided for students who took the 2014 APCS Exam and the 2010 US population. Some race/ethnicity categories are included in Other, so URM totals cannot be directly computed.

IV. Results

We computed the demographic distribution of the students in our dataset, and compared it to the distribution of students taking the APCS Exam in 2014, as shown in Table I. The distributions are similar, though BJC classes saw higher participation from African American and Hispanic students and lower participation from Asian students. Note that our survey allowed students to select multiple race/ethnicity categories, while the AP exam did not, and that not all students who take the APCS course go on to take the exam. We also observed that female students in our dataset were more likely to be students from URMs (40.8%) than male students (30.2%).

A. Preparation

We investigated students' previous experience in STEM and CS, as well as their access to technology. Significantly fewer students from URMs had daily access to a computer (87.5% vs 96.8%; $p = 0.001$). This difference was significant when controlling for classroom in the ANCOVA ($F = 6.57$; $p = 0.011$). Female students were significantly more likely to have access to a tablet (60.2% vs 44.7%; $p = 0.013$), which was also significant in the ANCOVA ($F = 4.57$; $p = 0.033$). There were no other significant differences in computer, tablet or smartphone access.

Prior to the BJC course, female students had taken significantly fewer CS courses ($p = 0.003$), while students from URMs had taken significantly more previous CS courses ($p = 0.006$). However, when comparing *whether or not* students had taken at least one CS course, the differences were not significant for students from URMs (83.1% vs 75.2%; $p = 0.113$) or female students (74.73% vs 79.44%; $p = 0.42$). Further, this difference was not significant when controlling for classroom in the ANCOVA for females ($F = 2.69$; $p = 0.102$) or students from URMs ($F = 0.09$; $p = 0.770$). There were no significant difference in the number of previous math or science classes taken by either group.

B. The Course

Students were asked to report how interesting they found certain BJC activities on a 5-point scale, including pair programming, learning how computing has changed the world and learning to make mobile apps/games. There were no significant differences between female and male students' responses. Students from URMs reported higher interest in learning how computing has changed the world ($p = 0.072$) and in making mobile apps/games ($p = 0.082$), but these differences were not significant. The results were similar when controlling for classroom: ($F = 3.47$; $p = 0.063$) and ($F = 3.70$; $p = 0.055$), respectively. It is important to note that we expect there to be very different teacher adoption rates for making games and apps for BJC, since these are optional course modules.

We also compared students' experiences and preferences during the BJC course. When students were asked if they would recommend the BJC course to a friend, there were no significant differences for females or students from URMs. There were no significant differences in the number of hours students reported working on the BJC course outside of class, even though preparatory privilege often impacts the amount of work needed for students from underrepresented groups.

Finally, students were asked to report their agreement with statements about the course's success in embracing diversity on a 5-point scale. The statements we selected were, "the learning environment was free from discrimination," "in this class, I felt out of place," and "In this class, I felt comfortable interacting with students with different characteristics." There were no significant differences in responses for either group.

C. Students' Intentions

We asked students about their intentions to pursue CS and STEM in the future. Significantly fewer students from URMs reported an interest in taking more CS courses (53.1% vs 69.4%; $p = 0.002$), but there were no significant differences between female and male students. The difference for students from URMs was significant when controlling for classroom in the ANCOVA ($F = 10.18$; $p = 0.002$).

Students from URMs were significantly less likely to report an intention to major or minor in CS (39.8% vs 53.2%; $p = 0.019$), which was also significant when controlling for classroom ($F = 9.73$; $p = 0.002$). Female students were less likely to report an intention to major or minor in CS (40.9% vs 52.6%; $p = 0.082$), but the difference was not significant generally, nor when controlling for classroom ($F = 1.90$; $p = 0.169$). There were no significant differences in female and male students' intention to major or minor in STEM. Students from URMs were less likely to intend a STEM major or minor (43.0% vs 52.8%; $p = 0.088$), but the difference was not significant generally, nor when controlling for classroom ($F = 1.93$; $p = 0.165$).

D. Summary

We looked at 17 questions for URM and female students, for a total of 34 significance tests, as shown in Table II. While we choose to report significant findings at the 0.05% alpha level, we also used Benjamini-Hochberg correction [10] to control the False Discovery Rate at 5%. Afterwards, we found that three results remained significant: students from URMs are less likely than non-URM students to have daily access to a computer, they are less likely to intend to take additional CS courses, and female students are less likely than males to have taken previous CS courses. The former two differences were significant when controlling for classroom.

Question	Comp.	p	Statistic	UR%	NUR%
Access to computer	Female	0.485	χ^2 = 4.87E-01	91.4	94.2
	URM	0.001	χ^2 = 1.06E+01	87.5	96.8
Access to tablet	Female	0.013	χ^2 = 6.21E+00	60.2	44.7
	URM	0.134	χ^2 = 2.25E+00	53.9	45.2
Access to smartphone	Female	0.263	χ^2 = 1.25E+00	80.6	74.2
	URM	0.900	χ^2 = 1.58E-02	74.2	75.4
Previous math courses	Female	0.215	W = 1.21E+04		
	URM	0.999	W = 1.55E+04		
Previous science courses	Female	0.107	W = 1.17E+04		
	URM	0.957	W = 1.51E+04		
Previous CS courses	Female	0.003	W = 1.06E+04		
	URM	0.006	W = 1.77E+04		
Recommend BJC course	Female	0.980	χ^2 = 6.00E-04	80.6	80.4
	URM	0.845	χ^2 = 3.84E-02	78.9	80.6
Hours spent outside of class on BJC course	Female	0.340	W = 1.27E+04		
	URM	0.936	W = 1.59E+04		
Interest in pair programming	Female	0.164	W = 1.13E+04		
	URM	0.104	W = 1.60E+04		
Interest in how CS changed the world	Female	0.344	W = 1.22E+04		
	URM	0.072	W = 1.53E+04		
Interest in making mobile apps/games	Female	0.943	W = 6.78E+03		
	URM	0.082	W = 9.19E+03		
Classroom was free from discrimination	Female	0.598	W = 1.38E+04		
	URM	0.269	W = 1.47E+04		
Student felt out of place	Female	0.871	W = 1.35E+04		
	URM	0.051	W = 1.74E+04		
Comfort with students of different characteristics	Female	0.308	W = 1.44E+04		
	URM	0.822	W = 1.55E+04		
Intention to take more CS courses	Female	0.142	χ^2 = 2.16E+00	58.1	66.7
	URM	0.002	χ^2 = 9.61E+00	53.1	69.4
Intention to major/minor in CS	Female	0.065	χ^2 = 3.42E+00	40.9	52.6
	URM	0.019	χ^2 = 5.53E+00	39.8	53.2
Intention to major/minor in STEM	Female	0.593	χ^2 = 2.85E-01	52.7	48.8
	URM	0.089	χ^2 = 2.90E+00	43.0	52.8

TABLE II. P-VALUE AND TEST STATISTIC FOR EACH TEST. FOR χ^2 TESTS, WE REPORT THE PERCENT OF EACH GROUP (UR% AND NON-UR%) THAT RESPONDED YES.

V. DISCUSSION

This survey of 399 students taking a BJC course suggests that the course likely addresses some barriers for female and URM students. While students from diverse backgrounds enjoyed the course enough to recommend it to a friend, much work is still needed. We need to address the lower number of CS courses taken by female students and the lack of interest among students from URMs in taking more CS courses.

We found that female students had taken fewer CS courses prior to BJC. This is consistent with a report by NCWIT [11] indicating that 60% of the students surveyed who had not taken a computer programming course in high school were female.

This trend follows into college where only 0.3% of female students intend to major in CS. Interestingly, in our sample, students from URMs had taken more CS courses than majority students prior to BJC. This may be due to the availability of various computing courses at their schools, or due to increased interest. Cohoon and colleagues [12] have been working on a formula to attract female and URM students to CS and encourage them into a CS major. They offer multiple gateway courses that would allow students to pursue the major. One option, CS1X, is specifically designed to help any student work at their own pace towards mastery of basic CS concepts. The course has been extremely successful and offers multiple suggestions for diversity-friendly pedagogy.

Students from all groups were nearly equally likely to recommend the course to a friend, with around 80% of students recommending the course. Further, there were no significant differences in workload outside of class, or their perceptions of how the course handled diversity. This speaks to a fairly positive attitude towards this CS course for most students. Schulte and Knobelsdorf note that students experiences in CS shape their conceptualization of CS and that courses "work as a starting point for some students, while they build a barrier for others" [13]. Positive experiences in and attitudes towards CS are vital in the effort to avoid or breakdown these barriers and increase diversity in computing.

We found no significant differences between male and female students' interest in learning how CS has changed the world or in making mobile apps/games. While the former is often cited as a motivation for females to learn CS [14], [15], [16], and the latter is often seen as having more appeal to males than females [17], we found no evidence to support these claims. Students in BJC seemed to equally enjoy the topics, suggesting that the material appeals comparably to a diverse audience. Since CS courses often leave these socially relevant topics out, females and students from URMs might find such CS courses less relevant. Including these topics may help all students realize their importance.

Perhaps the most troubling finding is that students from URMs are significantly less likely than non-URMs to intend to take additional CS courses after this course, regardless of how many CS courses they had previously taken. This could be a lack of options beyond the BJC course available to those students, or a lack of interest in courses seen as more programming-heavy. Female students, on the other hand, were not significantly less likely than males to intend to take additional courses, despite having taken fewer prior to BJC. Again, this could be an artifact of course availability at the students' schools. In the future, we will investigate the reasons for future intentions to continue in CS.

VI. Future Work

Our findings suggest that the BJC course is on track to addressing some of the barriers to diversity in CS. We plan to more thoroughly explore the lack of interest from URM students in taking more CS courses after BJC. We would also like to look more closely at different units within the curriculum to determine if their activities and pedagogies are consistent with those expressed in the literature. Finally, with over 80% of students willing to recommend the course to a friend we think it would be helpful to find out what about it appeals to students (e.g. easy, fun, interesting, challenging).

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