Broadening Participation in Computing through a Biology Summer Research Experience for Undergraduates

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***Abstract*—Representation of Hispanics, and in particular Hispanic women, is notoriously low in computer science programs in higher education and in the tech industry. The engagement of undergraduate students in research, often and early in their path towards degree completion, has been championed as one of the principal reforms necessary to increase the number of capable professionals in Science, Technology, Engineering, and Mathematics (STEM). The benefits attributed to undergraduate research experiences have been reported to disproportionately benefit individuals from groups that have been historically underrepresented in STEM. The Interdisciplinary and Quantitative Biology Research Experience for Undergraduates (IQ-Bio-REU) summer program was created to engage ten (10) underrepresented undergraduate students in authentic research experiences in emerging fields of biology which integrate quantitative and computational approaches to projects ranging from molecular biosciences to bioinformatics to ecology to bridge the digital and data divide for underrepresented Hispanics and women in computing. Our poster speaks to our observations of our students, faculty, and trainers after participating in our NSF funded summer REU at a Hispanic Serving Institution in a predominantly Hispanic, low socio-economic neighborhood in Puerto Rico.**

Keywords—interdisciplinary, data science, broadening participation in computing, computational biology

I. Introduction

To increase the participation of underrepresented minority (URM) students in computational sciences, we created a summer research experience for undergraduates (REU) at a Hispanic-Serving Institution (HSI) for students from STEM disciplines to participate in projects that involve the application of computational analysis to biological research. Herein we describe the program and the computational and professional skill development workshops and other training activities that provided support for participants to successfully navigate their incursion into computational research.

According to the National Center for Women in Technology 2019 Scorecard of the women working in the United States in technology in 2017, 12.9% were African American, 19.7% were Asian/Pacific Islanders, and only 5.4% of them were Latina. Seeing as women occupied 26% of the occupations in Computer and Mathematical Occupations, we estimate Latinas occupy about 1% of them [1]. In the high-tech sector, numbers for URMs are even more disproportionate [2].

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The University of Puerto Rico Río Piedras (UPRRP) is a top research institution, categorized as a doctoral university with high research activity by The Carnegie Classification of Higher Institutions [3]. It is also one of the top producers of Hispanic PhDs in Science and Engineering in the US [4], yet it lags behind in computational science. In the College of Natural Sciences at UPRRP, over 60% of the undergraduate students in Biology are women and in Computer Science it hovers around 15%. The college's population is 98% Hispanic.

Undergraduate research experiences (UREs) have long been considered one of the principal reforms that are necessary to meet the workforce demands of the 21st century [5,6]. UREs have been reported to disproportionately benefit URMs in science, a growing segment of the population whose enrollment in STEM programs is increasing, but that abandons STEM degrees at a high rate [7,8].

II. Program Description

The IQ-Bio-REU was created to engage 10 undergraduate URMs (see Table 1) in authentic research experiences in emerging fields of biology integrating quantitative and computational approaches to projects ranging from molecular biosciences to ecology. Throughout the course of a nine-week period students were immersed in a mentored research project including a wide array of high-impact practices such as experimental design, data collection, troubleshooting, data analysis, working group discussions and the communication of their results to peers.

Participants also received training and practice for fluency in computational skills and data analysis and opportunities for professional development. Ultimately, our program aims to channel more students into careers at the vanguard of science and achieve the goal of promoting participation by URMs in computing within scientific disciplines, thus enhancing diversity in STEM.

One workshop presented by members of a Harvard BD2K center focused on the development of statistical tools that helped students better interpret their data. In the Replicathon, students were presented with two different conclusions from one dataset and they replicated several statistical analyses to present and defend their conclusions to the judges. Another

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workshop was offered by the Center for Brain, Minds and Machines at MIT. Postdoctoral and graduate students prepared two days of workshops to expose participants to the fields of neuroscience, statistical modeling, and machine learning in computational neuroscience.

TABLE I. PARTICIPANT CHARACTERISTICS

Demographic Characteristics of 2019 Cohort		
Total =10	***Participant Characteristics***	***Number***
	Non-CS Major	8
	Hispanic/Latinx	7
	African American	1
	Native American	1
	Female	6
	Rising Junior or earlier	5
	No prior research experience	4
	Non-traditional returning students	2

At the end of the summer we organized a mini-hackathon to help REU students solidify their understanding of the research carried out throughout the summer. REU members lead interdisciplinary teams, received feedback from the local community of mentors and our collaborators of the REU and presented their research to other scientists in the community.

III. PROGRAM OUTCOMES

The Software Carpentry workshop included a pre- and post-workshop surveys to see participants attitudes and self-reported skill levels. The surveys indicated that participants gained confidence in their data analysis skills. In response to "I can write a small program/script/macro to solve a problem in my own work" the pre-workshop survey results showed 46% of learners strongly disagreed with that statement, 23% agreed, and 0% strongly agreed. Post-workshop numbers changed to 14% strongly disagree, 43% agree, and 29% strongly agree.

The Undergraduate Research Student Self-Assessment (URSSA) is a self-report survey instrument that is widely used for the evaluation of research experiences [10]. It is intended as a retrospective self-report of perceived gains in understanding, skills and shifts in attitudes of students after participating in a research experience. The survey instrument was administered to participants on the final day of the REU experience. Participants perceived that they had significant gains in computational research skills after the program. Notably when asked to gauge their skills in "analysing data from patterns" on a 5 point scale, where 1=no gain and 5=great gain, the median score (M) was 4 (Standard Deviation [SD]=1.12). For "Understanding the connections among scientific disciplines", M=4.9 (SD=0.32) with 90% of participants reporting "great gain". With regards to gaining skills "working with computers", M=4.4 (SD=0.84, 60% great gain). Taken together, these results suggest that students embraced the interdisciplinary nature of the program and perceived that the program had been useful for the development of computational research skills in an interdisciplinary setting.

The experiences of IQ-Bio-REU triggered changes in attitudes beyond skill acquisition. In an unsolicited email months after the REU had concluded, one of our participants from the US stated that "Puerto Rico was honestly such a transformative experience, I left so prideful of being Latino. Really really proud! ...I may not be Puerto Rican, but we share so much in common! I think that's what's getting my through the hard times here is that I'm not just pursuing my goals for myself, but for my family and wider community."

The most unexpected outcome was the bond that the trainers that came from our collaborators on the mainland made with our students and program. Several were moved to return for the Hackathon and others were determined to help the university after seeing the lack of computational science on campus to the point of writing a proposal to develop curriculum for the university. It was clear that it had been an eye-opening experience for them to witnessing the digital and data divide that exists between our university and their own.

IV. CONCLUSIONS

The project demonstrated the importance of bringing URMs from different disciplines together at an HSI to build their confidence, and their computational and research skills. We expect that computer scientists from the program will persevere in their field and others will integrate computation into their future careers in STEM. By opening up our activities to the local community in future iterations, we strive to engage more URMs in computational science.

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