Contributor Catalyst: A Pilot Program to Support HBCU Undergraduates Contributing to Open Source

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***Abstract*—This Innovative Practice Work in Progress paper reports on a pilot program to support HBCU undergraduates in learning about open source software contribution. Offered in the Summer of 2023, this program was called *Contributor Catalyst*. This program was designed to support students who had completed foundational computing coursework (i.e. introductory programming, data structures), but were still evaluating future education and career pathways. We served four HBCU undergraduates from the same institution in our pilot year.**

The program offered mentorship, instruction, and community-building through a hybrid-modality cohort model, in which students spent one week learning remotely, four weeks together in-person on an R1 residential campus, and then three more weeks collaborating remotely. Roughly the first half of the program was spent learning about open source tools, practices, and norms; the second half was spent contributing to *p5.js*, a real world project which the students chose from a vetted list of options. Community-building events were highlighted during the in-person portion of the program, for example: welcome and departure dinners, regional excursions, and participating in a Black Lives Matter garden workday. Students also participated in professional development such as attending an academic research conference and visiting a tech company.

Student learning was scaffolded by workshop-style instruction and was further supported by a layered community of practice. This community of practice included peer support from within the cohort, program support from their instructor, and project support from *p5.js* community members. Students also had many opportunities to engage with guests including project maintainers, faculty members, and industry professionals, all working in the realm of open source.

This paper offers an early report on our experiences and suggests how the program might evolve and grow in future years. In particular, we hope to build partnerships with additional HBCUs, document and share our program resources, and evaluate programmatic goals.

***Index Terms*—open source, undergraduate, HBCU, mentorship, active learning**

I. Introduction

Open source software is that which can be used, studied, modified, or distributed by anyone, as governed by the terms of an associated open source license. This model encourages collaborative and distributed development, where projects benefit from the voluntary participation of contributors around the world. Most software systems today, whether proprietary or not, rely on one or more open source software dependencies. Consequently, the future of innovation and cybersecurity depends on maintenance and advancement in this realm [1]. Recent years have seen increased investment from both the private and public sectors in supporting the creation of academic Open Source Program Offices (OSPOs), cultivation of academic open source ecosystems, and cross-sector collaborations with industry and nonprofit [2]–[4]. In parallel – and motivated also by a historical lack of diversity [5] – open source has become a hot area for internship/mentorship programs, and university coursework [6]–[12].

This paper documents the experience of piloting a program to support Historically Black College and University (HBCU) students in exploring open source contribution[1], with the ultimate goal of strengthening and diversifying the open source pipeline. Known as *Contributor Catalyst*[2], this program builds upon open source mentorship efforts predating ours, aiming to serve additional students marginalized in computing; namely, those enrolled at HBCUs. Participants learn about open source software research and career pathways by actually *contributing* to a real world open source project aligned with their interests and/or values.

In designing the program, we hoped that high-touch mentoring relationships would help participants envision themselves pursuing research and industry opportunities in open source. Through close mentorship, students would be encouraged to pursue ambitious opportunities and to persist when encountering obstacles, in addition to offering students tangible resources like time, advising, and opportunities of their own. Open source also lends itself to continued engagement beyond a summer program, allowing the participants to nurture technical skills and grow professional relationships while advancing towards graduation.

II. Related Work

The fundamental issue at hand is outlined in the Vision 2030 report as the "Missing Millions"; there exists a significant talent gap which disproportionately affects Black/African

[1]In this context, "contribution" refers primarily to improving the documentation, code, or other assets of existing open source projects.

[2]The program was previously known as the *OSRE (Open Source Research Experience) Catalyst*. Following the pilot offering, this was revised to the present and permanent name of *Contributor Catalyst*.

American representation in the science and engineering workforce [13]. Our efforts aim to move the needle in a positive direction within one computing subfield: open source software.

Identity-inclusive computing seeks to embed understanding of identity, intersectionality, discrimination, and bias into the discipline – with the goal of supporting more diverse populations, giving way to more socially and ethically responsible innovation [14], [15]. This includes focused professional development such as the Cultural Competence in Computing (3C) fellowship, which the first author is participating in [16]. Our pilot efforts leverage this research in service of inclusive and affirming experiential learning for HBCU student identities.

Our program design is informed by accelerated cohort learning models such as the Computing Talent Initiative and CSin3, developed in partnership between CSU Monterey Bay and Hartnell Community College. These research efforts have shown the importance of cross-institutional partnership, learning amongst peers with shared lived experience, and building pathways to industry careers [17], [18]. Our work translates these findings into a short-term open source-focused program, leveraging R1-HBCU collaboration. Our program also exposes participants to technical opportunity and community beyond their home region, notable given that CSin3 alumni who relocated for work expressed greater job satisfaction [19].

Contributor Catalyst expands an existing pool of programs bridging underserved students with industry mentors and support, including a pilot Google-HBCU partnership, Mentors in Tech, and CodeDay Labs [11], [20]–[22]. The dearth of resources affecting racially minoritized students is especially significant and long-standing [23], motivating our decision to focus on HBCU students.

Additional open source internship/mentorship opportunities serve as inspiration for our work, including: Major League Hacking Fellowships, GitHub's All-In for Students, Linux Foundation Mentorship Programs, Outreachy, and Google Summer of Code [7], [10], [12], [24], [25]. Some of these programs offer a cohort model, some are competitively compensated, and some serve racially minoritized students. However, none of these programs meets all of the aforementioned criteria. We aim to fill this gap, further augmenting our offerings with a racial identity-affirming in-person cohort component.

Lastly, our curriculum and structured learning activities leverage extensive prior research on teaching open source, including professional development (which the first author has participated in), capstone courses, and multi-institutional collaborations [6], [9], [26]–[29]. This work substantiates the value of teaching open source not only for career development, but also for empowering students to have real world impact and potentially bolster their sense of belonging, self-efficacy, and growth mindset [20], [30]–[32]. Our experiential learning activities put this research into practice with HBCU students, especially relevant as we are unaware of any HBCU offering coursework on open source software development.

Broadly speaking, research has shown a sense of belonging, STEM identity, growth mindset, self-efficacy, and social impact to be influential in attracting and retaining diverse talent. Research has also established high-touch mentorship and learning cohorts as effective ways to help minoritized students thrive despite obstacles of systemic racism, gender bias, and/or economic disadvantage. Our efforts synthesize and put the above into practice, leveraging cross-sector and cross-institutional expertise to do so.

III. Pilot Program Offering

This pilot was conducted in partnership between the University of California at Santa Cruz (a West Coast R1 institution) and Norfolk State University (an East Coast HBCU). An HBCU faculty partner – the second author of this paper – assisted in the conceptual design of the program, determination of suitable prerequisites, and recruiting of students. We engaged four undergraduates from Norfolk State University (NSU) who had completed foundational computing coursework (i.e. introductory programming, data structures) and were evaluating STEM career and education prospects beyond graduation.

The pilot program ran for eight weeks: one week remotely, four weeks in-person on the UC Santa Cruz residential campus, and then three more weeks remotely. Roughly the first half of the program was spent learning about open source tools, practices, and norms; the second half was spent contributing to a real world project which the students chose from list of communities known to be supportive of new contributors. The program was facilitated by a lead mentor – a postdoctoral fellow and the first author on this paper – who has extensive teaching experience and has completed additional training on topics like equity-minded mentoring, inclusive feedback, allyship, and bystander intervention.

A. In-person Activities

Time spent in-person centered around topics like open source history, culture, tools, project evaluation, and technical skill-building. It featured frequent peer collaboration, supplemented by small group and one-on-one mentorship. Experiential learning activities targeted both the development of soft skills (e.g. communication, teamwork, leadership) and technical skills essential to open source contribution (e.g. version control, bug triage). Covered technical skills also included:

- Setting up a project-specific development environment
- Orienting oneself within a new codebase
- Parsing documentation, contributing to its improvement if/when necessary
- Testing and debugging unfamiliar code
- Determining next steps when feeling lost or discouraged (in open source culture, this is often termed "being productively lost")

Students spent half of each workday in the lab with their lead mentor, using the rest of each workday to complete assignments.

In the process of their learning, participants made unplanned contributions to the *Kits* project [33]; *Kits* is an instructional

project that simulates work on an existing open source product which has been frozen in time. This included attending a scrum call run by faculty doing open source contribution focused teaching and research, extensive review and testing of GitLab "merge requests", and suggesting improvements to project documentation. While they began engaging with the *Kits* project as users, they quickly became contributors – and their efforts helped prepare this project for fall semester classroom deployment. Their contributions were celebrated by the project's faculty maintainers.

Students also participated in identity-affirming events hosted by Diversity, Equity, and Inclusion (DEI) partners on the UC Santa Cruz campus, including a movie night with other visiting HBCU students and a workday in the campus Black Lives Matter garden. Supplemental community-building activities included a group hike, beach lunch, birthday celebrations, and off-campus welcome and departure dinners.

B. Remote Activities

The remote portion of the program centered around contributing to an active open source project from a location of participants' choosing, such as a family home. The pilot cohort chose to contribute to *p5.js*, a JavaScript library enabling interactive creative coding, which especially aims to support novice programmers. This choice complemented this particular cohort's pre-existing engagement in creative activities such as photography and painting.

During this period, students received project-specific guidance from developers/maintainers internal to their project, alongside continued support from the lead mentor. Contributions included many documentation improvements, as well as translation and internationalization support. Using technical knowledge gleaned from the *Kits* project, students were also able to address a six-year-old bug; they were able to garner community support for their proposed fix and saw it merged into the *p5.js* codebase.

During this portion of the program, the cohort and lead mentor met daily on Zoom for coworking sessions. This was supplemented by frequent asynchronous communication on Slack. We also discussed future opportunities like internships, jobs, and graduate programs – including how to evaluate opportunities and prepare to apply to them.

C. Distributed Activities

Throughout the program, pilot program participants also engaged with:

- Four open source industry professionals, via a combination of in-person visits and Zoom calls
- One open source postdoctoral fellow/researcher
- Two technical conferences, one in-person and one on Zoom
- A seminar on open source business practices hosted by an academic Open Source Program Office
- A tech company visit, where students met with a Black Senior Software Engineer Ph.D. and his diverse technical team

These experiences offered supplemental technical content, professional development, and a glimpse into "a day in the life" of both an open source researcher and practitioner.

IV. Pilot Outcomes

All four students participated fully in the program, made meaningful contributions to a real world open source project (*p5.js*), and evaluated the program favorably. In an end-of-program survey, all four students indicated that upon completion of the *Contributor Catalyst* program, they were "more likely" to pursue an industry career specifically in open source, as well as to continue contributing to open source on their own time. Most students also indicated that they were "more likely" to apply to graduate degree programs. Students also evaluated their lead mentor very positively on measures including *conveyed feelings of respect for students as individuals, conveyed empathy for concerns and feelings discussed by students*, and *serving as a role model* [34].

Since the program's conclusion, all four participants have kept in touch with the program's lead mentor. One student recommended a peer to apply for the program, while another will be returning as an alumni peer mentor himself. This student also assisted in recruiting applicants for a second/upcoming program offering.

A third student has applied to a master's degree program, crediting the *Contributor Catalyst* as a factor in his decision to apply. (This was informally communicated to the lead mentor when requesting a letter of recommendation.)

The fourth student has since spoken on an open source mentorship panel as part of an open source symposium, alongside a variety of mentorship program founders and organizers. This student also joined the lead mentor in attending the All Things Open conference, where he was able to build technical skills and grow his professional network, including in-person time with one of the faculty *Kits* maintainers and one of the symposium panelists. Following the conference, this student was also an invited guest on a podcast hosted by two experienced open source practitioners; a full episode was devoted to interviewing him about his personal experiences in open source.

V. Reflections

Reflections from pilot program participants highlight the value of experiential learning and the importance of a close-knit cohort:

> "I've improved my documentation skills enough to where I am able to get my point across, and others can understand the context of the information I have gathered. I believe this came about mostly from having to spend some number of hours looking at other issues, speaking in group meetings where we had to jot down notes, and creating pull-requests where I had to document my process to live on the site forever."
>
> "During the program I found myself in unfamiliar territory (a lot). Troubleshooting errors, finding

clever work-arounds, and reading (lots of reading) portrayed this. [...] my prior knowledge was less useful than my ability to learn new material and ask thought-provoking questions."

"I feel very competent when it comes to contributing to open source now. I know how to judge whether a project would be good for me or not, and whether a specific issue is worth working on. I also know some concrete first steps to take before contributing to a project to make sure what I'm doing is procedurally correct for that project."

"Throughout all of my experience in the program, working with a team has opened me to new perspectives of solving a particular problem. Not only that, but it allowed me to explore ideas that were slightly outside of my skill set, and improve on my communication for the ideas that I did have."

The impact of diverse engagement from industry mentors was also highlighted in students' experiences. Feedback on the pilot program survey supports that this was, in fact, imperative to students envisioning themselves as open source developers. A few examples:

"For a long time, I assumed that professional coders were knowledgeable about every facet of their field. [...] Over the course of this summer, I have begun to realize that being a programmer means encountering problems that you haven't the faintest idea about where to start and slowly work towards finding [a] solution that works within your current situation."

"When I would first picture a software engineer, I would think it was someone who knew everything that everyone else didn't. I thought they knew how to solve every problem or create software efficiently for every scenario. [...] that perception changed for me. I started viewing a software engineer as someone who could figure out whatever they needed to figure out to create their desired software."

"The idea of these human encyclopedias has started to morph into a vision of people who just knew where to go for info or where to start when solving a problem which seems much more realistic and feasible to me now."

Lastly, *every single participant* spoke to the importance of their peer community, including the following:

"[...] group members are vital resources when solving projects. I learned it is okay to ask others for answers that you don't know."

"The most valuable thing I learned is how important a support system is. A good support system can help you feel comfortable wherever you go, and with whatever you're trying to do. I plan to build connections with more intention now than I used to."

We credit much of the apparent success of our pilot program to the involvement of key collaborative partners; these are relationships critical to the continued development, scaling, and effectiveness of our program. Our HBCU faculty partner was integral to conceptualizing the program format, emphasizing the importance of an in-person component – along with campus community support for Black students – especially given the demographic and cultural differences between the HBCU and R1 geographic home regions. To this end, we also worked with key DEI-focused campus collaborators who supported participants with social events, welcome swag bags, and ad hoc institutional support.

When asked in the pilot program survey how participants would like to see the program expand, if at all, three out of four students indicated that they would like the organizers to build partnerships with a limited additional number of HBCUs. Pilot participants also favored engaging program alumni as peer mentors, serving to support students' transition to the UC Santa Cruz residential campus as well as support their technical learning and identity. Alumni mentors would also be well-poised to contribute to the revision and evolution of the program over time.

VI. Future Work

Over the next three years, we plan to gradually grow the program to include additional HBCU partner schools each year – reaching a total of 24 participants across six partner institutions in the third year. Based on the lead mentor's classroom experience and student feedback, this is as large as a program like this can grow before sacrificing cohesion and quality relationships. These numbers also enable us to ground our community in micro-cohorts of four students per participating HBCU, with each micro-cohort entering the program with shared social and academic context. Students will also be supported by the addition of alumni peer mentors (from past cohorts) and graduate student mentors (from UC Santa Cruz) as the program scales.

Participants and peer mentors will live together during their time on the UC Santa Cruz campus, participating in additional community-building with their graduate student and lead mentors. We hope to cultivate a nested community of mentorship and support: a tight-knit participant cohort at the core, situated within broader communities of peer support, life experience, and technical knowledge. To this end, we will deepen our collaboration with DEI campus partners to include additional events and social support.

We will engage an evaluator to assess whether the program is effective in realizing our vision and reaching our goals. We are especially interested in understanding how open source experiential learning may impact measures like growth mindset, STEM identity, sense of belonging, self-efficacy, and perceptions of computing and social impact.

As the program grows, we will refine and document our model so that it may be of use to other researchers and practitioners. Such a model could, for example, translate to empowering students in open source who are underrepresented along other facets such as gender identity, caste, disability, or income.

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