Implementation and Evaluation of a Virtual Hackathon in an Urban HSI Community College During COVID-19*

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Abstract

This paper shares the analysis of our quantitative findings regarding the impact of a virtual informal collaborative experiential learning activity on diverse students' computational thinking, critical thinking, and self-efficacy in STEM activities. Designed as part of an ongoing National Science Foundation sponsored project to provide underrepresented minority (URM) students from underserved economic backgrounds with real-world career preparation and technical education across disciplines through collaborative project activities using cutting-edge technologies, the Hackathon for Social Good was implemented during the COVID-19 shutdowns in a New York City community college in lower Manhattan. Students worked in teams to innovate practical solutions to global problems with mentor support from both academia and the tech industry. This intervention drew 36 students from Computer Science, Business, and Sociology classes, who worked with volunteers and alumni during a full-day event in the Fall of 2021, using AI and data science to design culturally sensitive data-driven solutions for real-world problems. The tracks covered the following topics: Zero Hunger, Clean Water, and Sanitation, Green Consumption, Racial Justice, Quality Education, Good Health, and Well Being. The two main objectives of this project are as follows: (1) Design a remote interdisciplinary one-day experiential collaborative learning environment to engage URM teams of students from a community college in applying computational thinking to develop solutions for social good. (2) Conduct research on our intervention to study its effect on students' self-efficacy, as well as their knowledge of, and comfort with, computational thinking, critical thinking, problem-solving, and STEM. The evidence gathered from qualitative and quantitative data indicates that using these mechanisms to infuse CT into student learning across disciplines has several positive outcomes. Students reported increased leadership skills, comfort with teamwork, problem-solving, and critical thinking. A quantitative study specifically showed a positive impact on student confidence in their ability to do CT and improved their sense of efficacy in impacting the world outside of the hackathon.

1 Introduction

Hackathons have been studied as a site for collaborative problem solving using technology to create solutions to real-world problems in one- to two-day challenges [10]. Incorporating project-based learning activities to engage students in STEM in an informal environment has been demonstrated to increase STEM engagement and positively expose students to a variety of STEM career options [14, 12]. Hackathons are also increasingly understood as a valuable educational tool [16]. A gap remains in the extant research on designing virtual experiential learning environments, such as virtual hackathons, for community college students. To address these issues, we designed, implemented, and evaluated our virtual hackathon during Fall 2021 at an urban Hispanic Serving Institution (HSI) community college for URM students. We included students from Computer Science, Business, and Sociology courses to cultivate interdisciplinary participation. Thirty-six students joined volunteers, business leaders, and alumni in a full-day event, including speeches, question-and-answer sessions with industry leaders, hack time, judging, and awards. The virtual hackathon activities had a discernible impact on URM students' computational thinking, critical thinking, creativity, and self-efficacy.

2 Related Work

Hackathons share common traits of collaborative problem-solving and technological innovation. Virtual hackathons have a unique position in contrast to a physical hackathon, in their ability to facilitate collaboration from individuals from a variety of locations, across gender and racial diversity. Flexible participation in virtual hackathons generates innovative ideas from a wide range of participants using free, widely distributed digital resources [16]. For example, the online collaboration provided by the "COVID-19 Flatten The Curve Hack #flattenthecurvehack," during the COVID-19 pandemic, incorporated international participation from 2000 individuals who worked collaboratively online to innovate solutions to the challenges of COVID-19 [20]. University-sponsored hackathons provide students with hands-on opportunities to develop new technical skills, connect with industry mentors, and work in a team with peers to solve real-world problems [8, 10, 13, 16, 23]. Virtual university-sponsored hackathons, similar to our intervention, facilitate university-industry collaboration, particularly during times such as the COVID-19 pandemic when colocation was not possible [8] and are increasingly understood as valuable collaborative instruments for problem-solving [4, 18].

Hackathons, by their design, are a hotbed for informal project-based learning (PBL) [9]. The effectiveness of PBL has been documented in studies on its effect on the choice of major, career aspirations, and overall student attitudes, particularly for URM students [3], and offers a site for culturally responsive pedagogy to thrive [5]. Prior research suggests that inquiry-based hands-on scaffolded learning, such as the kind we implemented in our project, can serve as a critical component in combating inequalities in computing for URM students, connecting computing to society, and using scaffolding to train students to apply abstractions and models in collaborative projects [9].

PBL provides hands-on opportunities for students to exercise their unique strengths, assets, and agency, in contrast to the deficits-based approach which is often found in interventions targeting URM in STEM [11]. Incorporating scaffolding into project-based learning allows students to build familiarity with concepts in complex domains and reduces the cognitive load in the learning process [7]. We followed this scaffolding model by incorporating skill-building preparatory materials and team building. Professional skills are one of the strongest sites of positive change for students who participate in hackathons [18]. Hackathons replicate the problem-solving and collaboration required in the business world and often produce portfolio projects by participants upon completion, which can be used to demonstrate students' capabilities to future employers. Digital badging has been studied to show real-world benefits in career development, by providing third-party credentials, to display on a website, Linked-In, or resume, demonstrating competence and skill in a technical area [6]. We incorporated these findings in our project design, by including professional skill development; providing students with industry mentorship and networking; and the opportunity to create portfolio projects, along with digital badging.

Community-engaged engineering helps students develop a design for justice lens which embeds socio-technical thinking skills into the learning process [10]. The subject matter of our challenge engaged students in solving global problems to incorporate these benefits into the student experience [12, 17]. The ideation and design of this project carefully build on the successes outlined in the literature by incorporating these concepts in an intervention developed for the unique urban URM community college context.

3 Designing a Virtual Hackathon Co-Curricular Learning Environment

Our virtual hackathon engaged interdisciplinary student teams remotely using Zoom for one full Saturday. The collaborative, synchronous activity was supported by faculty and student peer mentors and judged by industry professionals. Hackathon projects for social good were designed to be scaffolded, and culturally responsive, to encourage student engagement in solving real-world problems [19]. Student teams collaboratively used cutting-edge technology to develop innovative solutions to challenging problems which incorporated a global Call for Code challenge [1] and the UN's sustainable development goals (SDGs) [2]. Call for Code is a global initiative led by IBM to apply crowdsourced coding solutions to societal issues, requiring students to collaborate virtually to design a new or speculative product to solve real-world problems. Teams designed projects for six tracks of UN SDGs: Zero Hunger, Clean Water, and Sanitation, Green Consumption, Racial Justice, Quality Education, Good Health, and well-being. Solutions incorporated AI/data science and were communicated by a website and video.

Faculty in Computer Science, Sociology, and Business departments collaborated in the lead-up to Fall 2021 to facilitate the participation of an interdisciplinary cohort of students. Students were encouraged to participate through announcements made in all classes including a video featuring student testimonials from previous hackathons at our institution. In the weeks leading up to the hackathon, students had the opportunity to meet across disciplines on Zoom in the Success and Innovation Lab, an ongoing virtual site active during the semester for student education and innovation. In addition to becoming familiar with technical topics and onboarding, facilitated by the Computer Science Faculty and the BMCC Computer Programming Club, students self-selected their teammates in these meetings. Some teams expanded to include members who registered on the day of the event, which was added by hackathon administrators. Peer mentors led morning workshops on three tracks of technical skills that students could self-select to join.

Throughout the hack period, student teams were separated into Zoom rooms with their teams to collaborate, and receive mentoring and insight from industry experts and peer mentors. At the end of the day, team presentations were judged by industry experts who chose six winning teams. While judges deliberated, students participated in a focus group about their experiences. Student projects became portfolio pieces for student career development, housed on the DevPost "Home for Hackathons" site.

4 Research Methods

Our research employed quantitative survey research and qualitative focus groups. The survey research was conducted at the end of the Hackathon day using Qualtrics software. We administered a single survey developed by the research team to gather demographic data and ask questions about feelings and attitudes prior to the hackathon, and post-hackathon to capture shifts in student attitude attributable to engagement with the hackathon. This survey also provided the benefit of having pre and post-responses as matched pairs for almost all questions and students. The survey explored the impact of an informal, virtual, experiential learning activity, e.g. the hackathon, on students' knowledge of, and comfort with, computational thinking, critical thinking, problem-solving, and self-efficacy with regard to STEM activities.

4.1 Human Subjects

All human subjects' guidelines were followed in this study, including submission and approval as exempt research from the university's Institutional Review Board (IRB).

4.2 Survey

Survey questions were modified from surveys by [15]. Questions included demographic information. Students also completed 5-6 point Likert scale questions related to their STEM knowledge (5-point), comfort (5-point), and self-efficacy (6-point) prior to and post the hackathon. The term "computational thinking" [21, 22] was adapted from these sources and defined for students throughout the hackathon and in the survey as "thinking logically to solve problems and abstracting principles and applying them in other situations."

5 Quantitative Findings

Thirty-four students are included in the sample, as within the group of 36 students who completed the survey, 2 were under 18. The majority of the students were in a computer science-related major. Forty-four percent of participants selected that neither of their parents attended college. Twenty-five percent reported that one or both of their parents completed a university degree. Fifty-three percent of the students work on or off campus, with 26% working full-time off campus. Of the respondents, 62.5% received financial aid, and 37.5% did not receive financial aid. While 88% of the respondents selected that they chose their major because of interest in the subject matter, 56% of students chose their major because of potential pay. Another 47% of students selected the prospect of making a difference and an equal percentage selected work conditions and expected benefits as their rationale for choosing their major.

The project did an excellent job of recruiting female students to the hackathon with almost half (41%) identifying as women, with the remaining 59% of the participants identifying as men. This number is much higher than the percentage of women students in computer science nationwide. Men were more likely than women to have 'always thought that they would study in this field' and indicated their interest in 'the social aspects of jobs.' Men's interests were more influenced by faculty members and other students, while women were more influenced by parents. There was a broad distribution of race and ethnicity among the participating students with 19% of the students self-classified as Latino(a), 3% preferred not to answer. Only 18% of students classified themselves as white.

5.1 Paired t-tests for Knowledge

Students rated their knowledge of computational thinking, problem-solving, critical thinking, and Science, Engineering, Technology, and Mathematics (STEM) on a five-point Likert Scale from "not knowledgeable at all" to "very knowledgeable" prior to and post the hackathon, compared using paired t-tests. On average, students' knowledge of computational thinking was lower prior to the hackathon than after the hackathon. This improvement was statistically significant as in Figure 1. Students' knowledge of problem-solving was significantly lower prior to than post the hackathon. Students' self-reported knowledge of critical thinking was significantly lower prior to the hackathon. Students reported knowledge of STEM was also significantly lower prior to the hackathon (Figure 1).

	Pre-survey		Post-Survey		
	Mean	SD	Mean	SD	t
Computational Thinking	3.31	1.03	3.63	1.008	-3.754**
Problem Solving	3.66	0.971	4.03	0.861	-4.313***
Critical Thinking	3.63	0.942	3.91	0.963	-3.483**
STEM	3.47	1.016	3.69	0.965	-2.521*
*p<.05 , **p<.01, ***p<.001					

Figure 1: Results of Paired t-tests for Knowledge

5.2 Paired t-tests for Comfort

Students rated their comfort level with computational thinking, problem-solving, critical thinking, and Science, Engineering, Technology, and Mathematics (STEM) on a five-point Likert Scale from "not comfortable at all" to "very comfortable" prior to and post hackathon. The mean level of comfort with each of these items prior to the hackathon was significantly lower than post participation (Figure 2).

	Pre-survey		Post-Survey		
	Mean	SD	Mean	SD	t
Computational Thinking	3.28	0.958	3.72	0.958	-3.999***
Problem Solving	3.53	0.915	4.03	0.897	-4.546***
Critical Thinking	3.68	0.945	4	0.894	-2.997**
STEM	3.47	1.016	3.75	0.916	-3.483**
*p<.05 , **p<.01, ***p<.001					

Figure 2: Results of Paired t-tests for Comfort

5.3 Paired t-tests for Computational Thinking

Students were asked a series of questions in regard to computational thinking based upon a 6-point Likert scale from strongly disagree to strongly agree. Students reported a significantly higher level of agreement that they could apply knowledge of computational thinking to solve problems after the hackathon than prior. Students' comfort level learning computational thinking concepts significantly increased. Students reported significant gains in their agreement that they could use computational thinking in their daily life. Students were significantly more likely to report that they found computational thinking not boring post the hackathon. The change in the statement "the challenge of solving problems using computational thinking appeals to me" was moderately significant with students reporting higher agreement post the hackathon than prior to the hackathon. Students reported that they would more likely choose to take computational thinking classes if given the opportunity after the hackathon than prior to the hackathon (Figure 3).

	Pre-survey		Post-Survey		
	Mean	SD	Mean	SD	t
Apply Computational Thinking to Solve Problems	4.53	1.107	4.94	0.759	-2.347*
Comfort Learning Computational Thinking Concepts	4.53	0.983	5.06	0.801	-3.947***
Use Computational Thinking in Daily Life	4.5	0.95	5.06	0.716	-3.788**
Computational Thinking Not Boring	4.65	1.199	5.13	0.763	-3.028**
Challenge of Solving Problems Using Computational Thinking Appeals to Me	4.74	1.032	5.06	0.68	-1.834
Choose to Take Computational Thinking Classes	4.69	0.93	5.03	0.778	-2.267*
*p<.05 , **p<.01, ***p<.001					

Figure 3: Results of Paired t-tests for Computational Thinking

5.4 Paired t-tests for STEM

While most of the students were interested in a STEM career prior to the hackathon, many still found STEM intimidating prior to the hackathon. Students significantly reported that they felt more confident in their ability to solve real-world problems related to STEM after the hackathon than prior to the hackathon. Students were asked to rate their level of agreement on a 6-point Likert scale from strongly disagree to strongly agree in their interest in STEM. Students did not have a significant increase in STEM as a possible career choice. Since the beginning average response was over 5 on a six-point scale, it is possible that there was a ceiling effect on this particular item with students participating in the hackathon already having a strong interest in a STEM career. Students did report a significant decrease in their intimidation in STEM. Confidence in their ability to do computational thinking significantly increased. Students also were statistically significantly more likely to report agreement with the statement that they felt that they could make meaningful changes in the world around them after the hackathon (Figure 4).

Almost 99% of the students enjoyed the experience, learned from the experience, liked being part of a team trying to solve problems, and learned

	Pre-survey		Post-Survey		
	Mean	SD	Mean	SD	t
Interest in STEM as Career Choice	5.25	0.762	5.31	0.644	-0.571
Not find STEM intimidating	3.48	1.387	4.03	1.516	-2.326*
Confident in Ability to Solve Real World Problems Related to STEM	4.16	1.194	4.63	1.264	-2.227*
Make Meaningful Change in the World	4.41	1.241	4.91	1.201	-2.490*
*p<.05 , **p<.01, ***p<.001					

Figure 4: Results of Paired t-tests for STEM

important problem-solving skills that they planned on using beyond the experience. All but one student completed the project. A slight majority of students had the opportunity to work with students outside of their major. Over half of the students responded that they definitely planned on participating next year. Twenty-two students responded to the open-ended question about what they gained from participating, their responses corroborate the survey results, including these notable statements:

- I gained experience in Google Sites, problem-solving, resolving conflicts, working in a team, collaborating, seeing how time management affects us, and creating something from scratch to fruition.
- I was able to do some practical programming. I have only done basic programs in classes.
- I gained comfort to work on tech projects.
- Learn to solve the problem by using technology.

Notably, 59% responded about gaining teamwork skills or making new friends. For example, one student responded that they "gained experience in working as a team as well as how to manage and coordinate tasks/roles." Another student responded that they had gained, "friendship, and I learned how to work as a team and help each other out to solve fun and challenging problems." Similarly, 32% of the respondents mentioned gaining problem-solving skills such as the student that responded that they had gained "the ability to work as a team to tackle a problem through programming." Likewise, 32% of the students reported that they had gained leadership skills from participating in the project. One student reported that they had gained "teamwork knowledge, group leading and learning from doing research on the topic" and another reported that they gained "how to organize the project, be an effective team leader."

6 Suggestions for Future Hackathons

Of the respondents, 21 students answered an open-ended question about what could be done to improve the Hackathon. These responses were coded into categories with 55% of the students wanting the Hackathon to last longer and 15% of the students suggesting that the Hackathon not be changed. Each of the next categories included 10% of the students: (1) increase publicity, emphasize no coding is needed (2) more topics, (3) in-person, and (4) allow more time for student preparation in advance. We have noted a need to diversify the hackathon to include more non-CIS students. The all-day Saturday format was difficult for most of the non-CIS students, particularly students who work on weekends. Assigning a grade to the activity may increase participation. The term *hackathon* had negative connotations for non-CIS and URM students. All student self-selected teams were not interdisciplinary. The project team is currently experimenting and evaluating replacing 'hackathon' with the term *ideathon*, including class projects for a grade, with paired interdisciplinary classes to ensure interdisciplinary student teams, and will publish the results in the future.

7 Conclusion and Future Work

Empowering students to solve real-world challenges reframes engaging URM in STEM from a deficits-based approach, to engaging students as active agents of positive change in the world. Our research was motivated by the idea that incorporating a hackathon for students at a two-year college connects their learning to professional application, and connections with industry mentors offer pathways for further career development. Our project bridges the gap between formal and informal learning and the application of knowledge by developing the virtual hackathon model for URM students across disciplines and collecting evaluation data in order to study the efficacy of the effort on student confidence. Results indicate that virtual hackathons can be valuable co-curricular pedagogies. The findings support previous research that found virtual hackathons can improve student skills in problem-solving and teamwork[8]. Our virtual hackathon produced positive impacts found in other project-based learning experiences such as building skills in problem-solving, and critical thinking. Students reported significant increases from this single-day virtual hackathon in comfort and self-efficacy in computational thinking, critical thinking, problem-solving, and STEM. Open-ended responses revealed the hackathon helped many of the students gain leadership skills. Further research, incorporating students with a wider range of interest in STEM, is necessary to understand the impact of hackathons on students' interest in STEM.

We are working to broaden participation in our hackathon and will publish these findings in the future. The future work will include analyses of qualitative data, retention data, and findings on the impact of redesigning the virtual hackathon to engage more students across disciplines.

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