Evaluating and comparing in-person and virtual experiential learning programs for improving STEM career readiness of students from underrepresented communities

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1 Executive Summary

The demand for science, technology, engineering, and mathematics (STEM) workers in the U.S. has grown 24% in the last decade (Noonan, 2017; U.S. Congress Joint Economic Committee, 2012). However, only 16% of STEM workers come from Hispanic and African American populations (Funk & Parker, 2018), even though diverse teams outperform their less diverse counterparts (Sommers, 2006). Because of this disparity, there is a need to direct underrepresented students to STEM careers. Pathway programs, like Duke University's HackBio outreach event, aim to address this discrepancy by directing students to certain careers. The HackBio outreach program in Durham, NC introduces underrepresented high school students to STEM careers and human-environment interactions through experiential learning. The program also engages Duke University undergraduate students as mentors to high school program participants.

HackBio is a multi-day program consisting of a tour of a Duke University research lab, an undergraduate "Questions and Answer" panel, a presentation from a Duke Admissions Officer, and two interactive environmental themed activities. The program culminates in a "hack" event where high school participants develop a solution to an environmental problem of their choosing and present their solution to the group at the end of the program. Historically, this outreach program has been an in-person event, but, in 2020, a virtual program was developed due to pandemic-related shutdowns.

The goals of this project were to 1) engage high school students in experiential learning in STEM fields, 2) use an evaluation model to assess the impact of HackBio in improving high school participants' understanding of environmental health challenges and pathways to STEM careers, 3) evaluate the impact of the program on undergraduate mentors to increase leadership, problem-solving, and mentoring skills, 4) determine if a virtual program can provide participants with a similar experience as an in-person event, and 5) identify programmatic areas for improvement.

I used pre- and post-program surveys with open-ended and Likert style questions to analyze the impact of the program on high school participants. I analyzed the open-ended questions using thematic

coding, and Likert style questions were analyzed using one-sided t-tests. In order to analyze the impact of the program on undergraduate volunteers, I used semi-structured interviews and analyzed these data with iterative thematic coding.

Both the in-person and virtual outreach events significantly increased high school student participants' understanding of environmental hazards in their community (p-values: in-person=0.017; virtual=0.003). High school students' confidence in their knowledge of environmental hazards in their community also increased for both events (p-values: in-person=0.0006; virtual=0.0002). Both events also significantly increased participants' preparedness for the college application process (p-values: in-person=0.012; virtual=0.0007) and understanding of STEM research (p-values: in-person=0.0003; virtual=0.002). This meets the expected outcomes of HackBio by increasing participants' understanding of environmental hazards and pathways to STEM careers. The in-person and virtual events had similar achievement of outcomes, which suggests that virtual experiential programming can be as effective as an in-person event.

Through thematic coding of interviews with undergraduate mentors, I found that undergraduates' main motivation for volunteering was for education or community outreach purposes. Undergraduates also indicated that they gained leadership, public speaking, problem-solving, and facilitation skills. Some undergraduates indicated they felt they acted as mentors during the program, but some felt they did not participate for long enough and did not have enough one-on-one interaction with the participants to be considered mentors.

While the results we gathered demonstrate that HackBio helps introduce underrepresented students to STEM careers and provides benefits to undergraduate participants, there are still areas in which HackBio can be improved. Based on the feedback from the survey responses and interviews, I would recommend that the program provide more college preparation modules, add more time for participants to interact with the undergraduate mentors, and reformat the expert speaker modules to be more student-driven. This approach would help students prepare more for college applications and give participants the ability to tailor the program to their interests, which would give them a more immersive and personalized experience. This personalization of the program can be used to help students envision themselves in STEM roles, sparking further interest and providing insight into potential future opportunities.

2 Introduction

2.1 Shortage of STEM workers and the “leaky” STEM Pipeline

Over the last decade, the demand for workers in science, technology, engineering, and mathematics (STEM) fields has grown rapidly with a 24.4% increase in STEM jobs, compared with a 4% increase in non-STEM jobs in the United States, and is expected to continue to grow into the future (Noonan, 2017; U.S. Congress Joint Economic Committee, 2012). Because of the shortage of STEM workers, there is an increased need for students educated in STEM fields. However, the education system cannot currently meet the demand for STEM education due to several barriers, including a shortage of qualified STEM educators due to systematic issues within the education system (Ejiwale, 2013; Hutchison, 2012). This is caused by high job turnover due to low pay compared to industry careers, a lack of strenuous training in STEM fields at the secondary education level, and a lack of professional development once within a school system (Ejiwale, 2013; Hutchison, 2012). Other barriers include poor preparation of students due to lack of proficiency in teaching in STEM fields at the K-12 level and a failure to develop students’ interest to enter STEM fields that leads to students leaving the pathway (Ejiwale, 2013). Improvements in STEM education opportunities are needed in schools at all levels to sufficiently meet this demand and address the systemic gaps in our educational systems (Honey et al., 2014; U.S. Congress Joint Economic Committee, 2012).

In order to combat issues with preparing students for STEM fields, extensive research has been conducted to focus on the STEM “pipeline” or “pathway,” which is the path that students take through the education system into STEM careers. The idea of the “leaky” pipeline describes when students leave a STEM career trajectory for other job markets (Alper & Gibbons, 1993). According to Allen-Ramdial and

Campbell (2014), students are most likely to leave the STEM pathway in two places: 1) before or during the early years of college and 2) between undergraduate and graduate programs. The reason for leaving the pathway is often due to insufficient mentor relationships which results in a lack of preparedness in STEM subjects (Allen-Ramdial & Campbell, 2014). In order to address these gaps, Estrada et al. recommends increasing institutional accountability to support underrepresented students by creating programming for students, addressing resource disparities, and finding creative ways to connect to students (2016). Many pathway programs have been developed at the K-12 level to guide students into STEM undergraduate majors to help address the problem in different ways (Caldwell et al., 2018).

2.2 Underrepresented students face institutional barriers to STEM careers

Underrepresented groups face complex systemic barriers to entry which inhibit their ability to exist and thrive in STEM fields. For underrepresented students, access to STEM pathway programs can be restricted due lack of support and resource disparity, which can then affect the STEM field as a whole. For example, research has shown that diverse teams outperform their less diverse counterparts (Sommers, 2006). However, African American and Hispanic populations are underrepresented in STEM fields, with a 9% and 7% presence as active STEM workers, respectively (Funk & Parker, 2018). Students in underrepresented and low-wealth populations tend to receive poorer academic training and receive less educational support from their families (Wang & Degol, 2013). Furthermore, because local school districts are often funded by the use of property taxes, lower income areas tend to have fewer resources available for schools (McGuire et al., 2008). According to the National Center for Educational Statistics (NCES) report by Aud et al. (2010), African American and Hispanic students end up underprepared for STEM careers, with fewer students reaching proficient levels in mathematics than White and Asian students. Underrepresented students are also less likely to complete higher level coursework in high school (Tyson et al., 2007). According to NCES, teachers in predominantly black schools were more likely to lack certification for the subject in which they taught (Aud et al., 2010).

2.3 Pathway programs for underrepresented students into STEM

In general, pathway programs can help address gaps in the STEM pathway (Caldway et al, 2018). Pathway programs are typically extracurricular events or camps that aim to direct students to certain professions. Most programs tend to target K-12 age groups or target only high school students, and those programs use active learning, experiential, and inquiry-based techniques (Caldwell et al., 2018). Inquiry-based learning has been shown to increase science literacy and positive attitudes toward science (Gormally et al., 2009; Gibson & Chase, 2002; Sesen & Tarhan, 2013). Additionally, research has shown that experiential learning can improve student motivation, increase knowledge retention, and build problem-solving and decision-making skills (Millenbah & Millspaugh, 2003).

When these types of programs are made accessible to underrepresented populations, they can be used to target underrepresented minority students to increase diversity in the STEM workforce and help students overcome barriers that they face in bridging the gap from high school to college. Ghee et al. (2016) found that a mentored summer research program for underrepresented students in college increased student confidence and improved student retention in STEM majors.

The area local to Duke University, Durham, North Carolina, has a large underrepresented population. Durham Public Schools (DPS) have 31 schools in the district with school-wide Title I programs − Title I is a funding program that provides financial assistance to schools with low-income families. The student population in the district is made up of 37% African Americans and 13% Hispanic students, respectively (CCD, 2018-19). Programs developed for experiential STEM learning are sorely needed in the Durham area to increase diversity in the STEM workforce and help these students bridge the gap from high school to college.

2.4 Description of HackBio

To address the need for experiential STEM educational content in Durham, we developed HackBio. HackBio is a multi-day program created to engage DPS high school students from traditionally underrepresented populations in experiential learning and team-based activities. The program introduces high school students to global human health challenges related to environmental exposures. It also includes professional development modules to demonstrate possible pathways to STEM careers. High school student participants in the program are expected to gain problem-solving skills, public speaking skills, knowledge in environmental issues, and an understanding of pathways to STEM careers.

A team of Duke University undergraduate students with experience in environmental science and human health research volunteer as mentors for the high school students and work with them to develop solutions to environmental exposures. This creates a tiered-mentoring program where high school students are mentored by undergraduates, and undergraduates are mentored by Duke University graduate students, staff, and faculty. Undergraduate mentors may derive benefits from participating in the program, including improved decision-making skills and problem-solving skills, as well as developed or enhanced leadership skills as a result of mentoring younger students.

Like many other STEM pathway programs, Hack Bio relies on volunteers to assist the program staff in providing programming. In general, volunteers choose to donate their time for a variety of reasons that can be categorized into personal and communal factors. In four different studies of college age students, work experience, resume building, personal satisfaction, and community building were major reasons students chose to participate in a volunteer program (Dean, 2014; Holdsworth, 2010; Moore et al., 2014; Qian & Yarnal, 2010). Understanding why students choose to volunteer in a particular program will help program coordinators recruit volunteers and help program coordinators modify the responsibilities of volunteers to provide them with an ideal experience. This information can help HackBio retain and increase the number of undergraduates that volunteer as mentors in the program.

2.5 Virtual programming:

Due to the global COVID-19 pandemic, HackBio in-person programming was eliminated from March to December of 2020 and HackBio was adapted to a virtual format. Little research has been completed on comparing the outcomes of virtual and in-person programs with the same or similar content, and the research that does exist has conflicting results. Some comparisons of students experiencing in-person and online formal education have found that students tend to perform better in-person than online (Fitzpatrick et al., 2020; Hurlbut, 2018). However, Hurlbut (2018) found that students who were comfortable with the online environment perform better than in-person students. Another study found that online students perform better in science courses than their in-person peers because teachers were more likely to initiate interactions with students in an online setting (Schoenfeld-Tacher et al., 2001). Merritt et al. (2020) suggested that increasing participant engagement and making sure students' needs are fully met can enhance student learning in online informal education programs. The pandemic-related transition to a virtual format provided an opportunity to compare how different elements of the HackBio program impacted students when performed in person and virtually.

2.6 Objectives of the project

The goals of this project were to 1) engage high school students in experiential learning in STEM fields, 2) use an evaluation model to assess the impact of HackBio in improving participants' understanding of environmental health challenges and pathways to STEM careers, 3) evaluate the impact of the program on undergraduate mentors to increase leadership, problem-solving, and mentoring skills, 4) determine if a virtual program can provide participants with a similar experience as an in-person event, and 5) identify programmatic areas for improvement.

3 Methods

3.1 Design of the project

The in-person HackBio event used in this analysis took place in February 2020 over the course of three days for five-and-a-half hours each day. Seventeen high school students attended the event and were present for all three days. Seven undergraduate students volunteered between one-and-a-half and seven hours during the event. We began the in-person HackBio event with a team-building experience of climbing the Duke Chapel tower, followed by a tour of a research lab on campus. We engaged participants in a "Question and Answer" panel where undergraduates answered questions about their experiences in STEM majors. This was followed by a presentation from a Duke Admissions Officer on the college application process. The following day, high school participants attended expert lectures on pathways to STEM careers and current research projects at Duke. We also engaged participants in two hands-on activities: 1) the Toxic Release Inventory (TRI) activity, where participants learned to use the EPA's TRI website to discover environmental hazards in their environment, and 2) a quantitative polymerase chain reaction (qPCR) lab activity where participants learned about cell biology and laboratory methods. The three-day event culminated in a "hack" event where high school participants identified an environmental exposure that they would like to mediate and created a solution to the problem they selected. For example, participants could try to determine the causes of high levels of lung cancer in an area and create a campaign to reduce smoking. Undergraduates mentored high school participants during the brainstorming period to help them develop their solution and craft a presentation. Finally, the high schoolers presented their solution to the group and expert judges, and then, answered questions from the audience.

The virtual program took place in December 2020 over the course of five days for one-and-a-half hours each day. Forty-three high school students attended the virtual event, but we did not require participants to attend all days of the event; therefore, some participants were not present for every day of the program. Four undergraduates attended the event as volunteers. All program elements took place over the Zoom video conferencing platform. The virtual event started with an ice breaker game and introductions to the Duke team on the first day. Next, participants engaged in a tutorial about using the TRI website. Whereas high schoolers would typically participate in a hands-on lab activity (e.g., qPCR lab activity) for an in-person HackBio program, the virtual program included a scavenger hunt to examine their connection to the outdoors and possible toxins in their environment away from the Zoom call. Then, participants attended a presentation with a Duke Admissions Officer and a "Question and Answer" panel with Duke undergraduates. Finally, participants participated in the "hack" event and worked with one Duke staff member as their mentor. We did not include expert lectures in the virtual HackBio event due to limitations on time. Key events for each program are outlined below (Table 1).

Table 1: Comparison of key events for the HackBio program across the in-person and virtual platforms

In-person event	**Virtual event**
Duke research lab tour	Virtual Duke research lab tour
Undergraduate question and answer panel	Undergraduate question and answer panel
Admissions presentation	Admissions presentation
Toxic Release Inventory interactive activity	Toxic Release Inventory interactive activity
qPCR lab activity	Environmental scavenger hunt
“Hack”	“Hack”
Expert lectures on career paths and STEM research	

3.2 Evaluation model

To determine whether the program provided benefits to the participants, I used a formative and summative evaluation model. This means that while the evaluation was done at the end of the program, the information collected can be used to provide constructive feedback to improve the program in the future. To determine the main goals of the program, I developed a logic model that outlines the relationship between the program’s activities and outcomes (see Appendix). The logic model shows that if high school students and undergraduate volunteers participate in HackBio, high school students should learn about pathways to STEM careers and gain knowledge pertaining to human-environment interactions. Undergraduate volunteers should experience leadership, problem-solving, and public speaking skills from participating in the program.

3.3 Data collection: high school student surveys

In order to assess the impact of HackBio on high school students participating in the in-person program, I created pre- and post-event surveys. The surveys consisted of open-ended and closed-ended questions that tested participants’ attitudes toward and understanding of environmental health exposures, their interest in pursuing an education or career in STEM after high school, and their opinions of the HackBio program.

I asked high school students before each event to provide their gender, grade level, ethnicity/race, which science courses they had taken, and if they knew anyone who worked in a STEM or environmental field. Before and after each event, I used four Likert style questions and two open-ended questions to analyze the environmental attitudes of the participants and four Likert style questions and three open ended questions to assess high school students' interest in college and knowledge of STEM research (see Appendix). To analyze participants' overall event experience, I used two Likert style questions and four open-ended questions in the post-event surveys (see Appendix). In the pre-survey for the virtual program, I used two Likert style questions and three open-ended questions to assess the affect the pandemic has had on participants and their education (see Appendix). After the virtual program, I also asked participants which parts of the event they attended, because attendance was not mandatory for all days and activities (see Appendix).

I collected the pre-event surveys for the in-person event on paper during a visit to the class at the high school one week prior to the in-person event, and I collected post-event surveys in-person at the end of the last day of the event. All 17 high school students from the in-person event completed both pre- and post-event surveys. I collected pre-event surveys for the virtual event via a Qualtrics form on the first day of the program and post-event surveys on the last day of the program. For the virtual program, some participants were not present on the first and last days of the event, so I administered those surveys on the next day the participants were available. I collected 29 pre-event surveys and 32 post-event surveys from the virtual event.

3.4 Data analysis: high school student surveys

The paper surveys were transcribed into a spreadsheet and the Qualtrics results were downloaded as a spreadsheet. I formatted the closed-ended questions using a Likert scale from 1-5. For each participant, I summarized paired questions pre- and post-event as a change in the response. Then, I conducted a one-sided t-test with a null hypothesis of no change ($\mu=0$), and an alternate hypothesis of positive change ($\mu>0$). Next, I uploaded both transcripts into NVivo, a qualitative analysis software. I used NVivo to code the open-ended survey responses for themes for each question. Initial themes included "environmental hazards," "not affected," "don't know," "increased knowledge," "suggestions," "program elements," and "pandemic effects." I added additional themes as they emerged from the data. I defined new themes, including specific environmental hazards (e.g., pollution) and specific pandemic effects (e.g., less social interaction), and then organized subthemes under the main sections. When the initial coding process was complete, I compared the themes discovered from each question between pre- and post-event responses (a complete codebook with theme definitions is available in the Appendix).

3.5 Data collection: undergraduate student interviews

After the in-person HackBio program was complete, I interviewed six out of the seven undergraduate mentors to assess whether they developed leadership skills as a result of participating in HackBio. I conducted interviews using a semi-structured interview format via the Zoom video conferencing platform. Each interview took approximately 20 minutes. Questions assessed why undergraduate mentors participated in HackBio, what benefits the undergraduate mentors may have gained during the program, what aspects of the program could be improved, and what relationship dynamics the undergraduate mentors had with the high school students with whom they interacted. I transcribed the audio recording after each interview.

3.6 Data analysis: undergraduate student interviews

After I completed the interviews, I used NVivo to code the transcripts for themes. Initial themes included "positive connotations," "negative connotations," "skills learned," "environment," "education," "mentoring," "outcomes," and "elements of the program." I added additional themes as they emerged from the data. I defined new themes (e.g., "preparedness" and "community outreach") and organized subthemes under main sections.

4 Results

4.1 Pre- and post- survey results

4.1.1 In-person event

4.1.1.1 Demographics

At our in-person event, 17 high school students attended, and there was a 100% response rate to the surveys. Three percent of the survey questions were left blank. Eighty-two percent of participants were female, a majority of participants (59%) were in the 10th grade, and most participants were African American (41%) or Hispanic or Latino (35%) (Figure 1). All participants had taken Physical Science and participants were all in a Biology class at the time of the event (Figure 2). Some students did not list Biology as a class they had taken, likely because they had not completed it yet. More than half the participants (53%) did not know anyone who worked in a STEM or environmental field, while 41% had a relative in a STEM or environmental field (Figure 3).

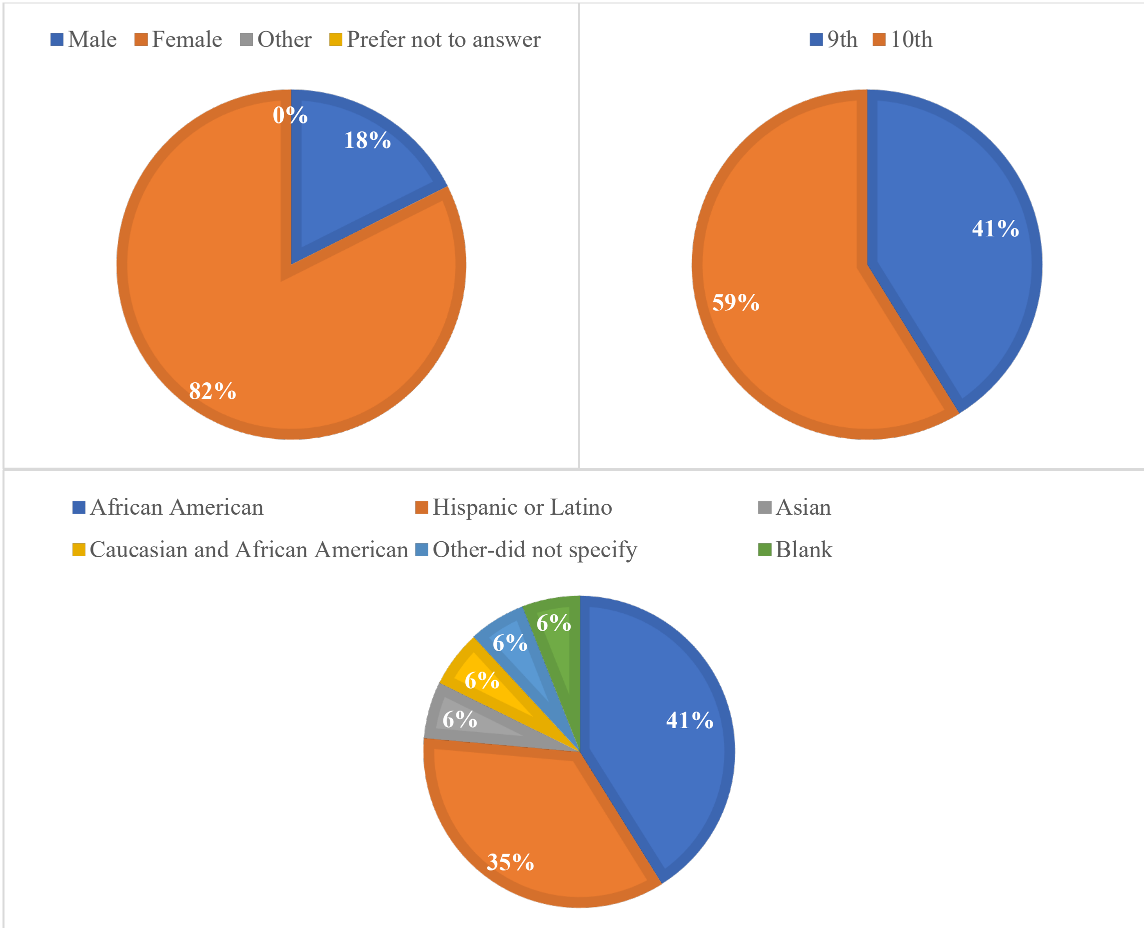

Figure 1: Percent of participants who identified with each gender, grade level, and ethnicity/race at the in-person event (n=17).

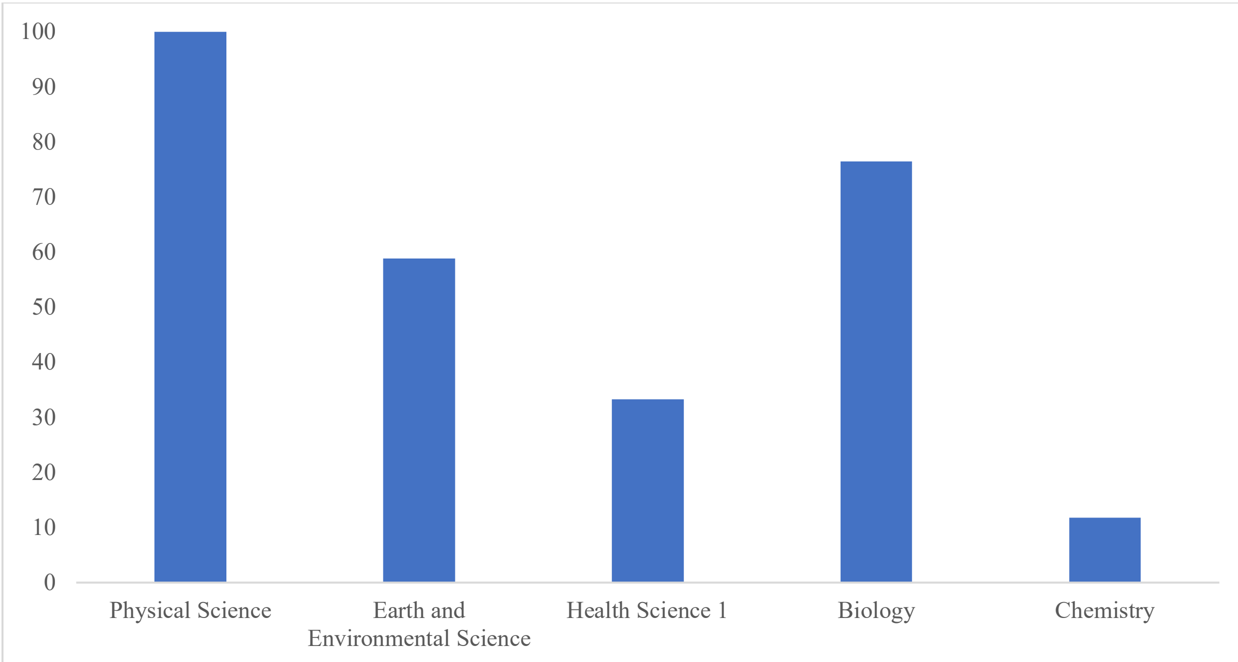

Figure 2: Percentages of participants at the in-person event who reported taking each science course (n=17).

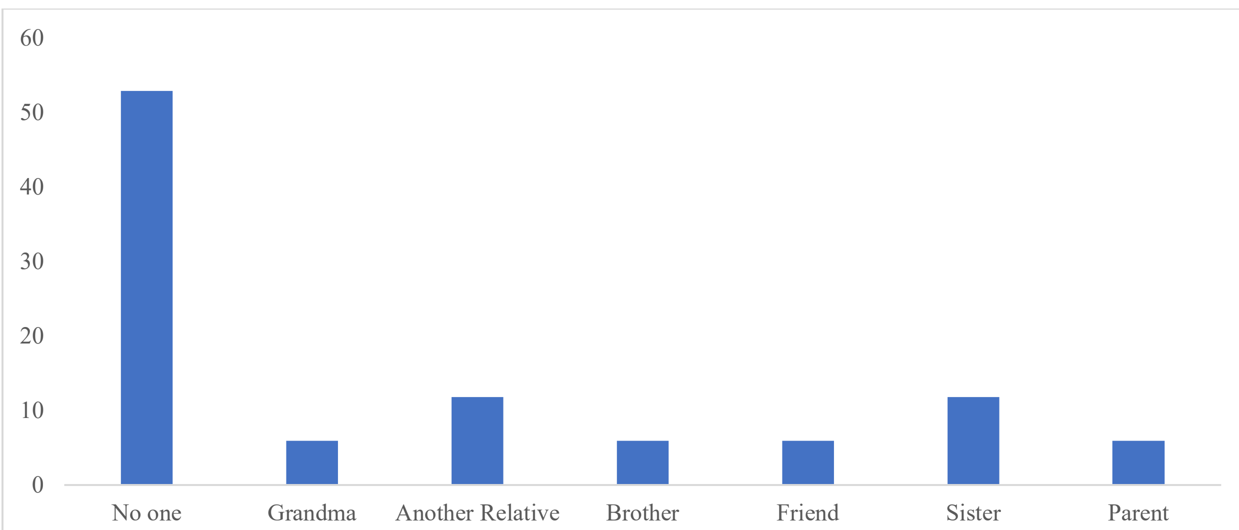

Figure 3: Percentage breakdown of participants' relation to someone in a STEM or environmental field (in-person event) (n=17).

4.1.1.2 Environmental health and human risk questions

Pre-survey responses showed that participants thought that humans do damage the environment (47% “great extent”, 53% “very great extent”), but most did not believe their community was affected to a “great extent” (29%) or a “very great extent” (6%) by environmental hazards (Figure 4). After the program, the number of participants that felt humans damage the environment to a “very great extent” increased by 6% (Figure 4) but the trend was not significant (p-value=0.334) (Table 3). However, significantly more participants felt their community was affected by environmental hazards to a “great extent” (6% increase) or “very great extent” (23% increase) after the event (p-value=0.017) (Figure 4, Table 3). No participants were “confident” or “very confident” in their knowledge of environmental hazards before the event (Figure 4). Nine participants had a significant increase in their confidence in their knowledge of environmental hazards (p-value= 0.0006) (Figure 4, Table 3). After the event, there appeared to be a trend with fewer participants claiming that human health was “not affected” (6% decrease) or only affected to “a small extent” (12% decrease) by the environment, however this was not significant (p-value=0.105) (Figure 4, Table 3).

Before the event, six participants said they did not know how their community was affected by environmental hazards and three said their community was not affected (Figure 5). Two major themes participants mentioned as ways their community was affected by environmental hazards were pollution (five counts) and air quality (three counts) (Figure 5). After the event, no participants said they did not know how their community was affected by environmental hazards, but four said their community was not affected (Figure 5). The top themes that participants mentioned as ways their community was affected by environmental hazards after the event were air quality (five counts) and toxins or chemicals (five counts) (Figure 5). Before the event, four participants stated they did not know how human health was affected by the environment and two participants said human health is not affected by their environment (Figure 5). The top themes that students mentioned relating human health and the environment after the event included human illness (seven counts) and air quality (five counts) (Figure 5). After the event, no participants said they did not know how human health is affected by the environment, but three participants said human health is not affected (Figure 5). The top themes that students mentioned included human illness (seven counts), toxins or chemicals (five counts), and air quality (four counts) (Figure 5).

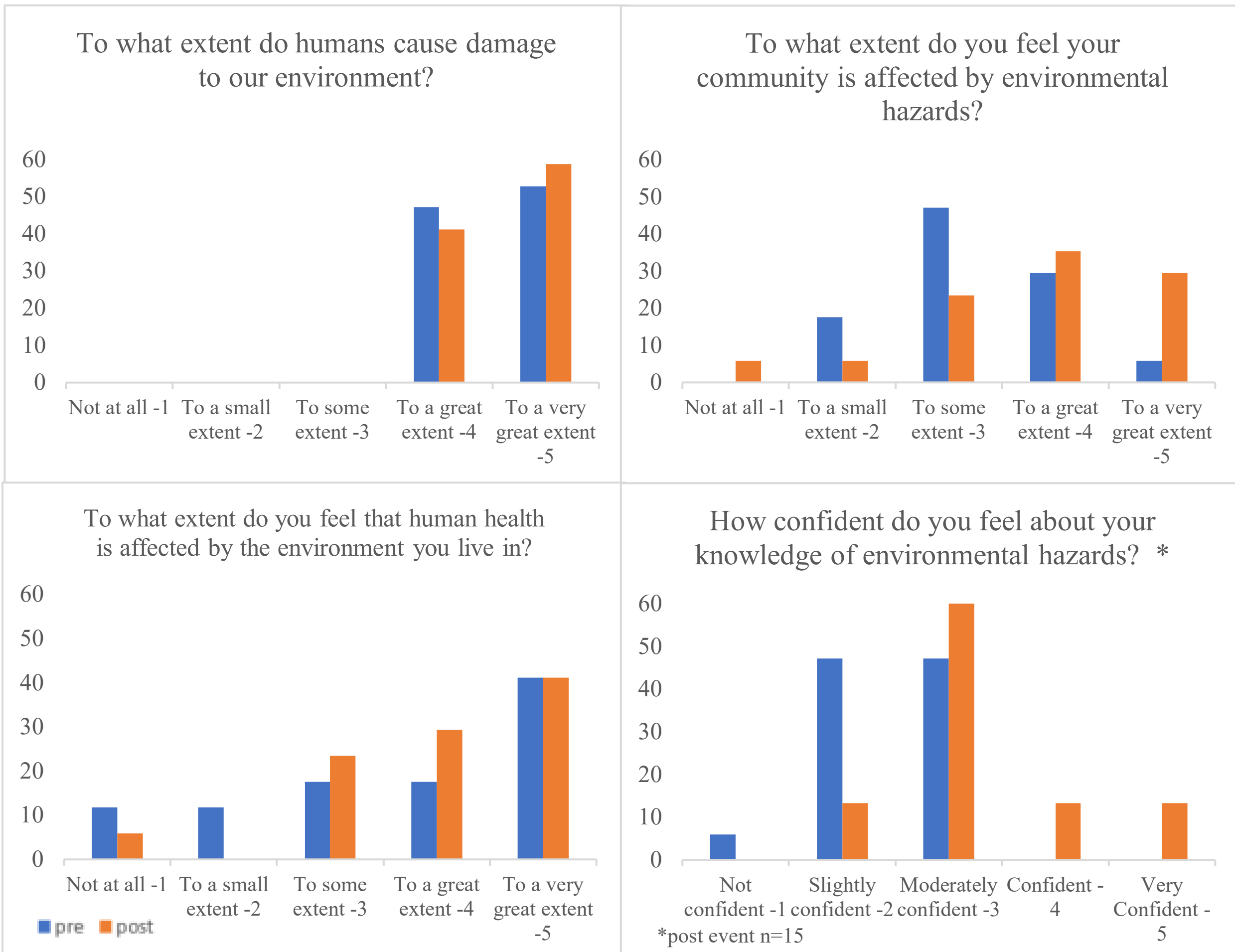

Figure 4: Percentage of participants for each scaled response option for the environmental Likert style questions from the in-person event (n=17).

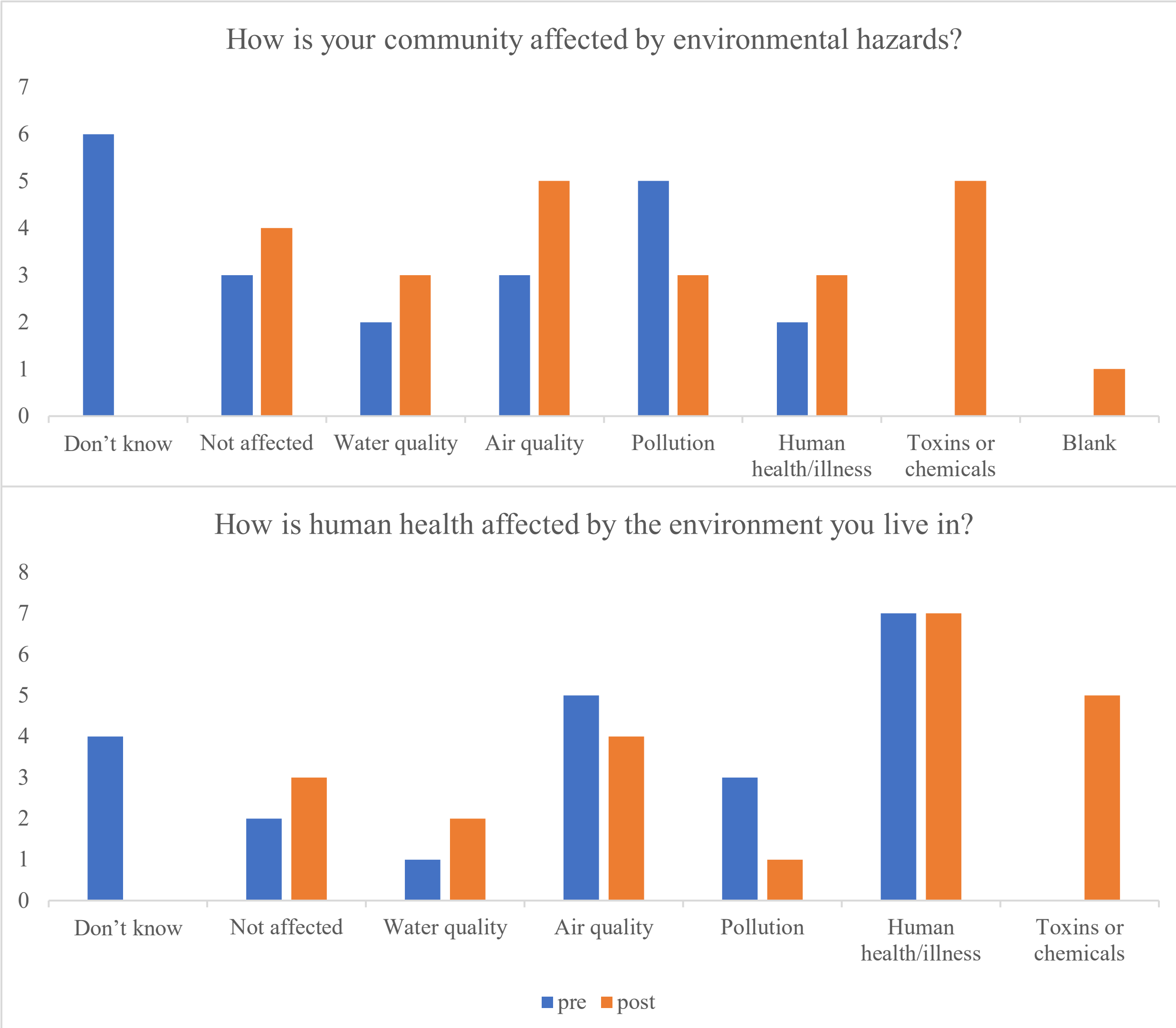

Figure 5: Count of how many times themes were coded at each open-ended environmental question from the in-person event (n=17).

4.1.1.3 College preparedness questions

Before the event, most participants said they were not prepared (31%) or only slightly prepared (31%) for the college application process (Figure 6). After the program, participants felt more prepared (p-value=0.012) with 18% of students saying they were "very prepared" for the college application process (Table 3). After the event, participants indicated that they understood more about STEM research in college than before (p-value=0.0003) (Table 3). Furthermore, 47% of participants said they understood the process of STEM research in college to a "great" or "very great" extent (Figure 6). There appeared to be an increase in students very interested in pursuing an education beyond high school, but the trend was not significant (p-value=0.135) (Table 3). There was not a significant increase in participants' interest in going into a STEM career (p-value=0.265) (Table 3).

Before the program, three participants said they did not know if they wanted to enter a STEM career, and seven participants left the question blank (Table 2). After the event, four more participants indicated that they were interested in science and research-based careers (Table 2). After the event, participants listed fewer colleges they were interested in attending and had similar interest in in-state schools relative to before the event (Table 2). Before the program, 12 participants said they did not know anything about STEM research in college. Participants also mentioned that STEM research involved mathematics (one count), requires focus (one count), and can involve scholarships for college (one count) before the program. After the event, only five participants said they didn't know anything about STEM research in college, and participants mentioned that STEM research included fun (two count), involved volunteering (one count), and gave the student freedom to choose their field of study (two count). Other participants said STEM research involved science, technology, engineering, and math (three count).

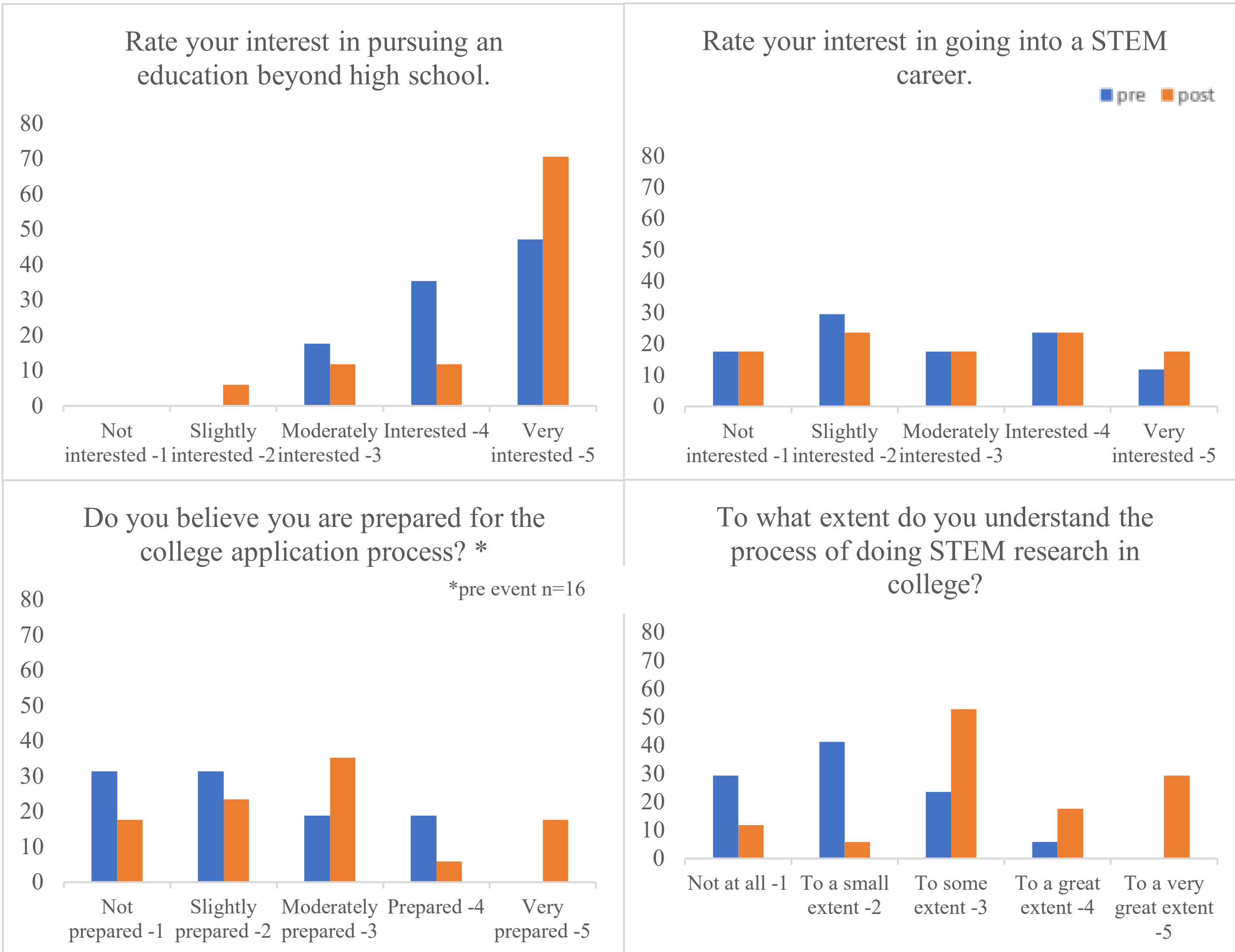

Figure 6: Percentage of participants for each scaled response option for the closed-ended college preparedness questions from the in-person event (n=17).

Table 2: Count of how many times themes were coded at open-ended college preparedness questions from the in-person event (n=17).

If you are interested in a STEM career, which one and why do you want to enter that field?		
Themes	**Pre-event**	**Post-event**
Don't know	3	1
Blank	7	6
Not interested	3	0
Science	1	3
Marine biology	2	3
Medicine	2	1
Biology	1	1
Microbiology	1	0
Chemistry	1	0
Research	0	2

What colleges are you interested in attending?		
Themes	**Pre-event**	**Post-event**
Don't know	2	5
Duke	6	5
UNC Chapel Hill	6	6
Other in-state	17	10
Out of state	10	6

Table 3: One-sided t-test for changes in Likert style questions for the in-person event (alpha=0.05).

Question	**t**	**df**	**p-value**
To what extent do humans cause damage to our environment?	0.43644	16	0.3342
To what extent do you feel your community is affected by environmental hazards?	2.3142	16	0.01714
To what extent do you feel that human health is affected by the environment you live in?	1.3054	16	0.1051
On a scale of 1-5, how confident do you feel about your knowledge of environmental hazards?	4.0256	14	0.00063
Rate your interest in pursuing an education beyond high school.	1.1442	16	0.1347
Rate your interest in going into a STEM career.	0.64327	16	0.2646
Do you believe you are prepared for the college application process?	2.5222	15	0.01173
To what extent do you understand the process of doing STEM research in college?	4.2426	16	0.00031

4.1.1.4 Ways to improve

After the program, 70% of participants said they learned at least "a moderate amount" from the event (Figure 7), and 69% of participants said at least "a moderate amount" of the information presented in the program was new (Figure 7). The main themes that participants mentioned as highlights of the program were the Duke Chapel climb (six count) and the undergraduate Q&A panel (five count) (Table 4). The themes participants mentioned as their least favorite parts of the program were the guest speaker talks (four count) and hack presentation (four count) (Table 4). Participants suggested more hands-on activities (five count), fewer speakers (three count), more diverse speakers (three count), better guest speakers (three count) (Table 4). One participant said that they "didn't understand what the guest speakers were saying half of the time." Two participants also suggested more undergraduate interactions (two count) (Table 4).

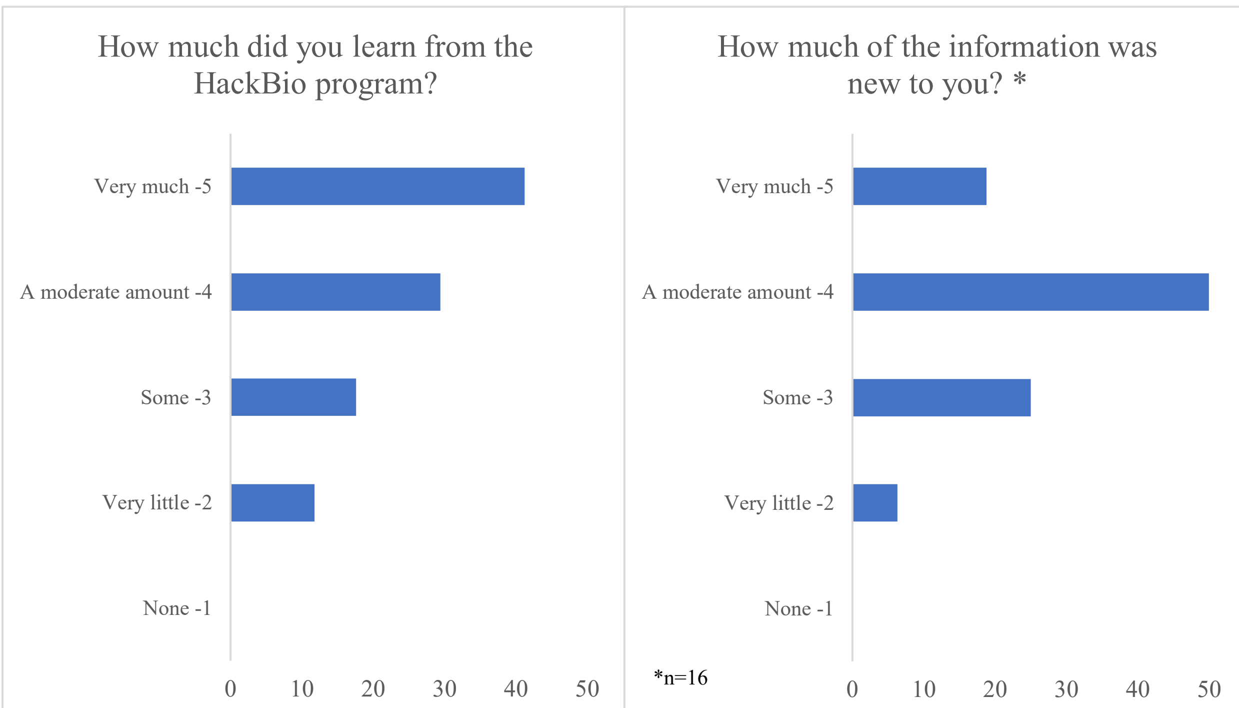

Figure 7: Percentage of participants for each scaled response option for post-event closed-ended questions from the in-person event (n=17).

Table 4: Count of how many times themes were coded to open-ended post-program questions from the in-person event (n=17).

What do you consider the highlights of HackBio?	
Themes	**Count**
Chapel Climb	6
Admissions talk	1
Guest speaker	1
Hack	2
Lab tour	1
Lunch	2
Presentation	2
Undergrad Q&A	5

In what ways could HackBio be improved?	
Themes	**Count**
Fewer speakers	3
More diverse speakers	3
Better speakers	3
More interactive	5
More undergrads	2

What was your least favorite part of HackBio?	
Themes	**Count**
Guest speakers	4
Presentation	4
Lab tour	1
Walking	2

4.1.2 Virtual event

4.1.2.1 Demographics

Forty-three high school students were invited to attend the virtual event. We received 29 responses to the pre-event survey and 32 responses to the post-event survey. All participants who responded to the pre-event survey also responded to the post-event survey. Three percent of questions were left blank in the pre-event survey, and seven percent of questions were left blank in the post-event survey for the 29 participants who responded to both surveys. The three participants who responded only to the post-event survey could not be included in the quantitative analysis but were included in the qualitative analysis. Those three participants left 18% of questions blank. Seventy-nine percent of participants were female, and 41% of participants were Hispanic or Latino (Figure 8). A majority (62%) of participants were in the 9th grade (Figure 8) and participants did not have a common background of science courses (Figure 9). However, all participants were enrolled in a biology class at the time of the event. Sixty-six percent of participants did not know anyone who works in a STEM field (Figure 10).

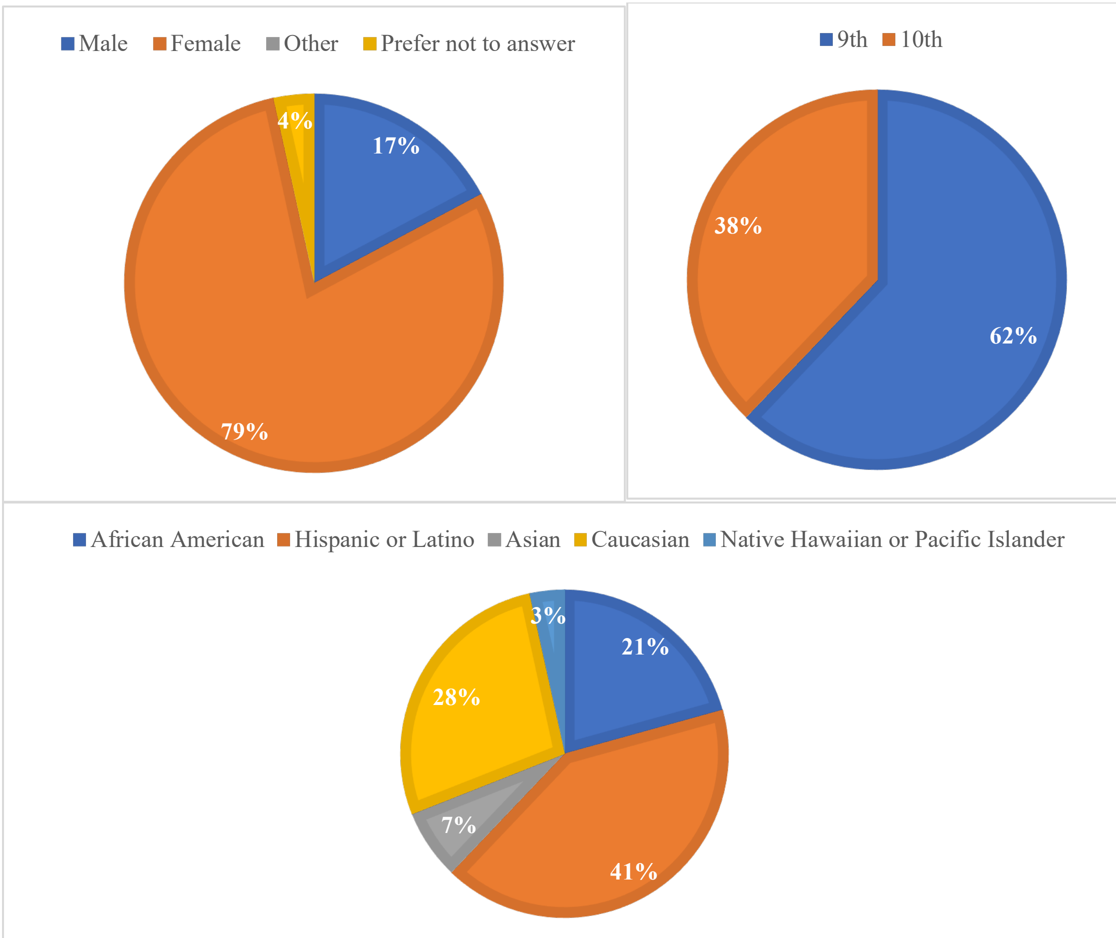

Figure 8: Percent of participants who identified with each gender, grade level, and ethnicity/race at the virtual event (n=29).

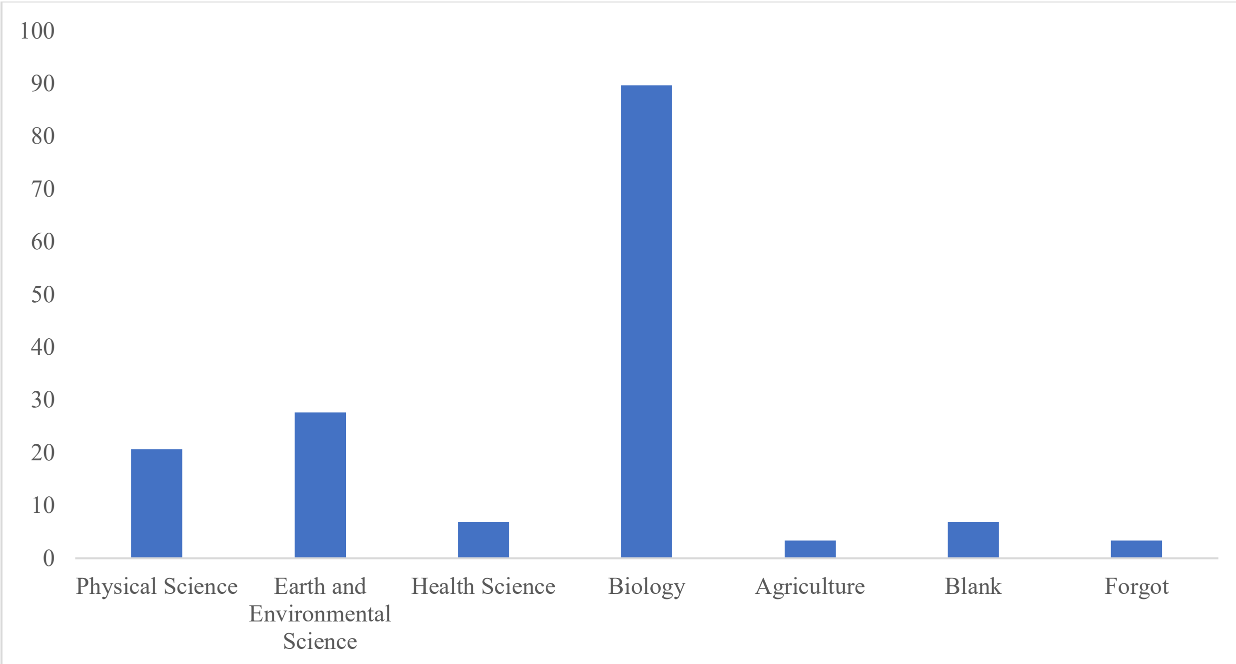

Figure 9: Percentages of participants at the virtual event who reported taking each science course (n=29).

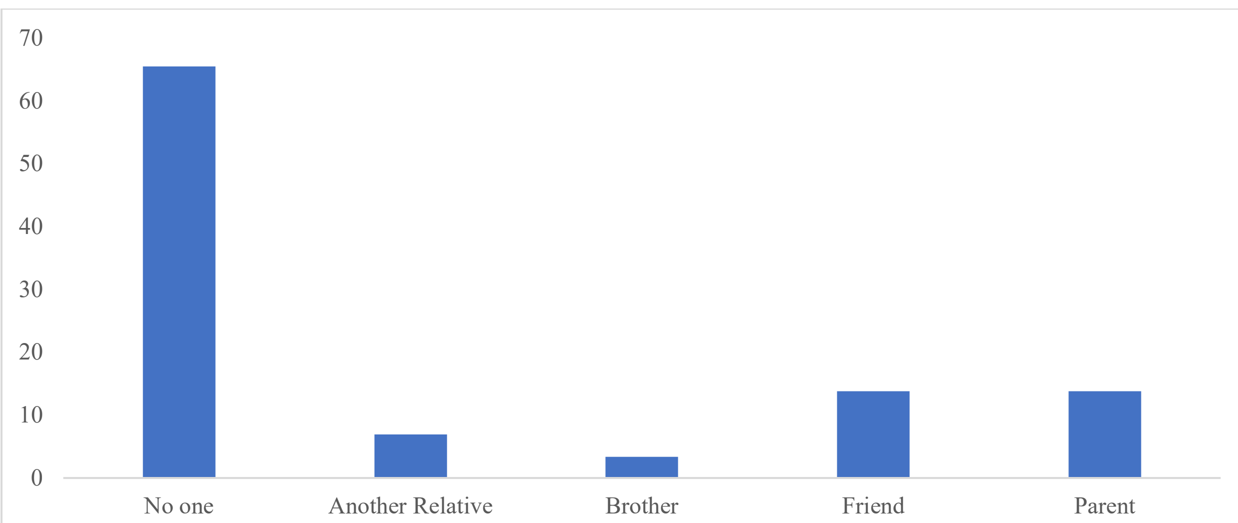

Figure 10: Percentage breakdown of participants' relation to someone in a STEM or environmental field (virtual event) (n=29).

4.1.2.2 Pandemic questions

Sixty-nine percent of all participants said the pandemic had made them think more about science and those participants commented that they thought about science in relation to viruses and vaccines. Ninety percent of participants said the way their classes are run has changed since the start of the pandemic (Table 5). Eleven participants mentioned that they had switched to virtual learning and four participants said that learning was more independent (Table 5). Twenty participants said they had more time outside of classes, but six participants also mentioned they had limited social interaction (Table 5). Fourteen participants said they had better organization or better grades (Table 5). Others said classes were less hands-on and they were less focused on schoolwork (Table 5). Participants also mentioned physical issues as effects of learning online, such as eye strain from Zoom calls, stress, and tiredness (Table 5). In the closed-ended questions, 46% of participants said they had the same amount of work as before the pandemic, and 45% said they study the same amount as before the pandemic (Figure 5).

Table 5: Count of how many themes were coded to open-ended pandemic related questions from the virtual event (n=29).

Has the way that your classes are run changed since the pandemic arrived in March, what changes occurred?	
Themes	**Count**
Not affected	2
Better grades	1
Better organization	1
More independent	4
Less focused	1
Less hand on	1
Limited social interaction	4
More time outside class	9
Eye strain	1
Stress	1
Virtual learning	11

Name 3 ways you feel attending classes online has affected your education, either for the better or for the worse.	
Themes	**Count**
Not affected	1
Accomplish more	1
Better grades	7
Better organization	7
Bored	2
Distractions	1
Ease of communication	1
Instability	1
Less competition	3
Less focused	2
Less hands on	2
Less incentive	3
Less understanding	3
Limited social interaction	6
More focused	2
More motivated	1
Work harder	1
More resources	1
More time outside class	20
More work	4

Themes	Count
Eye strain	2
Stress	5
Tired	2
Less work	3
Blank	4

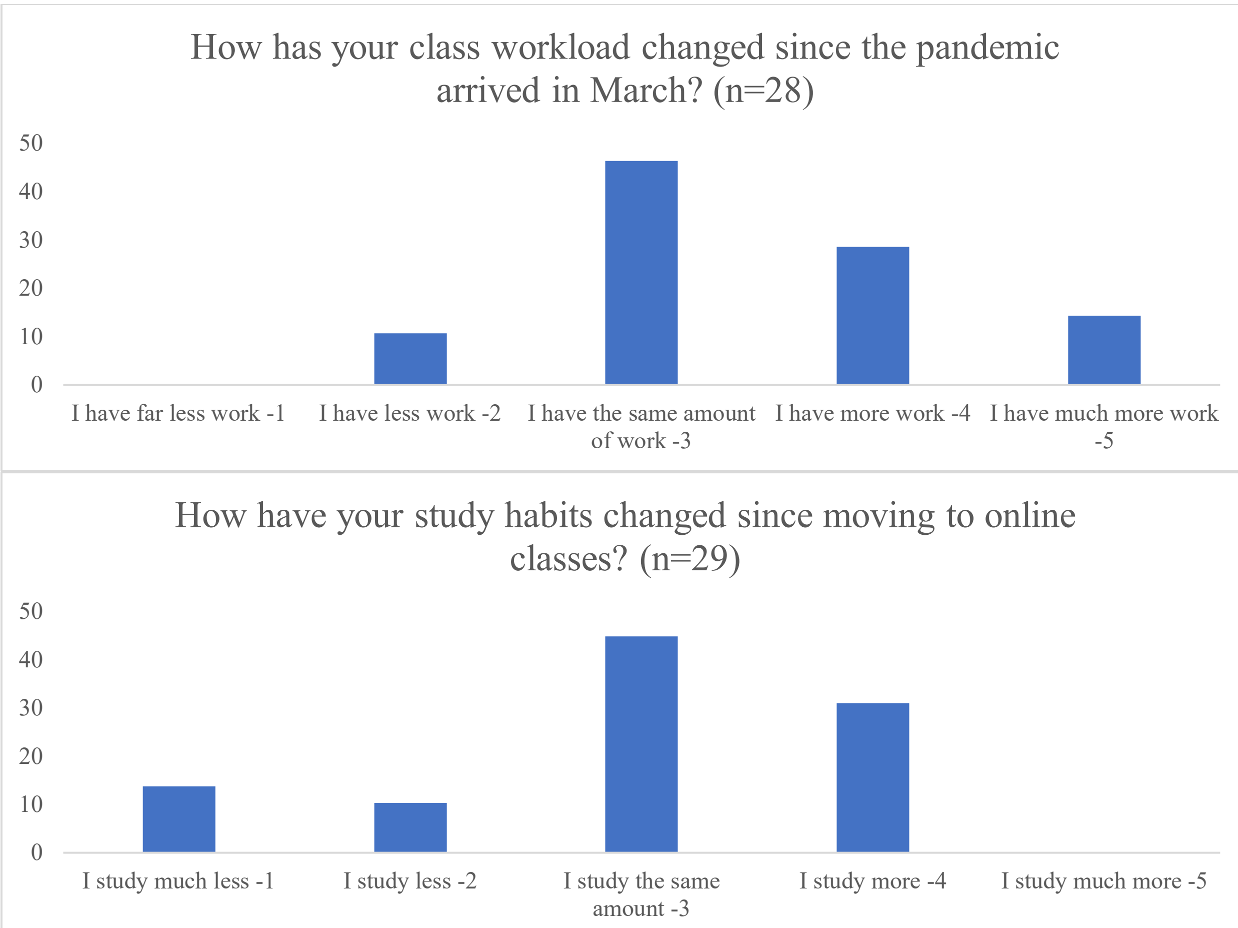

Figure 11: Percent of respondents for each scaled response option for the closed-ended pandemic questions from the virtual event.

4.1.2.3 Environmental health and human risk questions

Before the virtual program, 90% of participants claimed humans damage the environment to a “great extent” or a “very great extent” (Figure 12) and this measure did not significantly increase (p-value=0.177) (Table 7). Despite this, 55% of participants only felt their community was affected to “some extent” (Figure 12). More participants felt their community was more severely affected by environmental hazards (p-value=0.003) (Table 7), with 20% more participants saying their community was affected to a "great extent" (Figure 12). Participants also felt human health was more severely affected by the environment (p-value=0.007) (Table 7), and the number of participants that felt human health is affected by the environment to a "very great extent" increased by 17% (Figure 12). After the program, participants were significantly more confident in their knowledge of environmental hazards (p-value=0.0002) (Table 7), with 90% of participants at least "moderately confident in their knowledge of environmental hazards (Figure 12).

In the open-ended responses before the event, eight participants said they did not know what hazards were present in their community, and two participants said their community was not affected by any environmental hazards (Figure 13). After the program, only three individuals said they did not know what hazards are present in their community (Figure 13). The four primary themes participants mentioned as ways their community was affected by environmental hazards after the program were toxins or chemicals (nine count), air quality (seven count), water quality (five count), and pollution (five count) (Figure 13). Before the program, five participants did not know how human health was affected by the environment, and four participants said human health was not affected by the environment (Figure 13). After the event, only three participants said they did not know how human health was affected by the environment, and two fewer participants said human health was not affected (Figure 13). After the event, participants said air quality (seven count), toxins or chemicals (five count), and pollution (four count) could have adverse effects on human health (Figure 13). Some also mentioned that environmental hazards could cause human illness (14 count) (Figure 13).

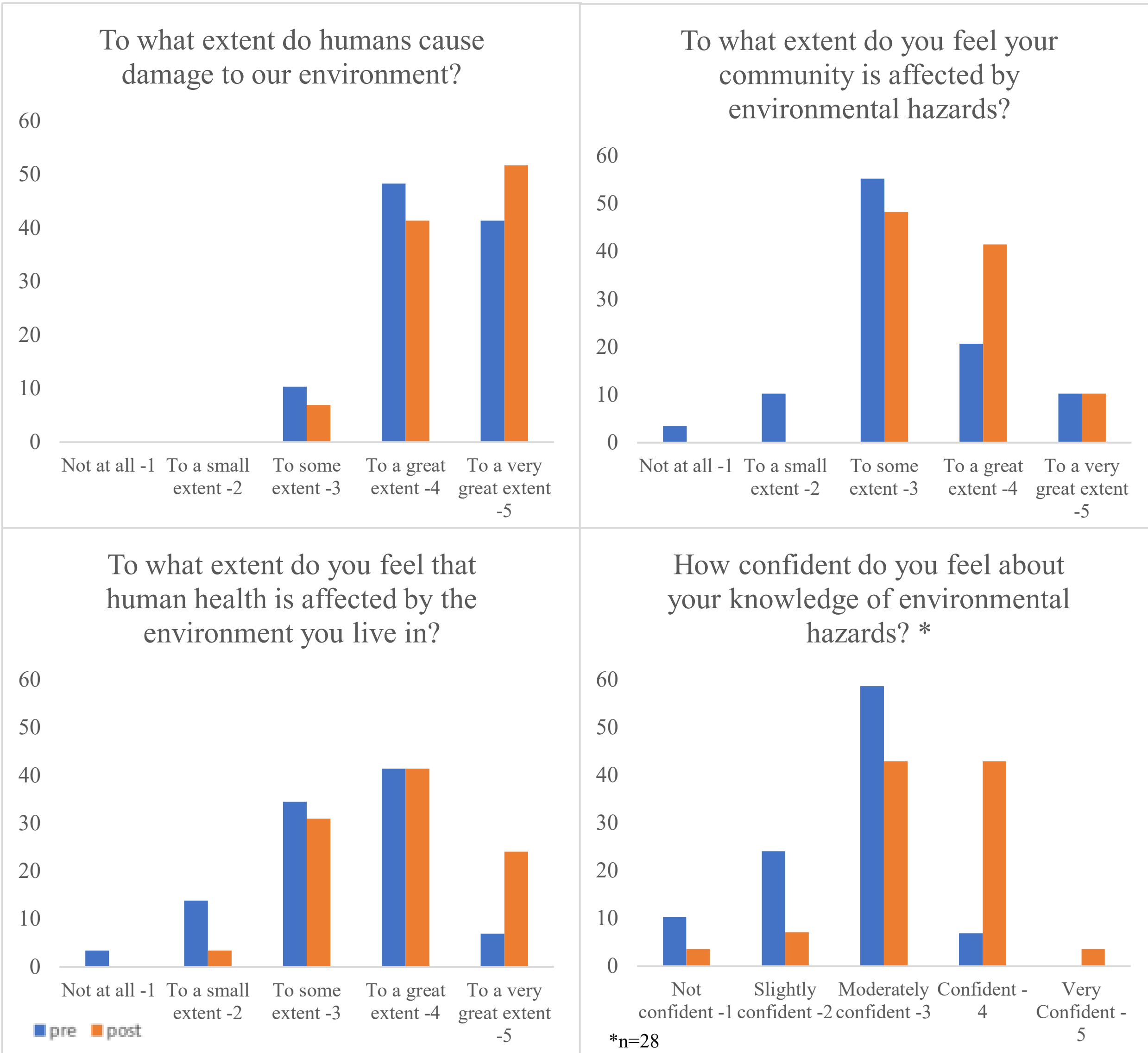

Figure 12: Percent of participants for each scaled response option for the environmental closed-ended Likert scale questions from the virtual event (n=29).

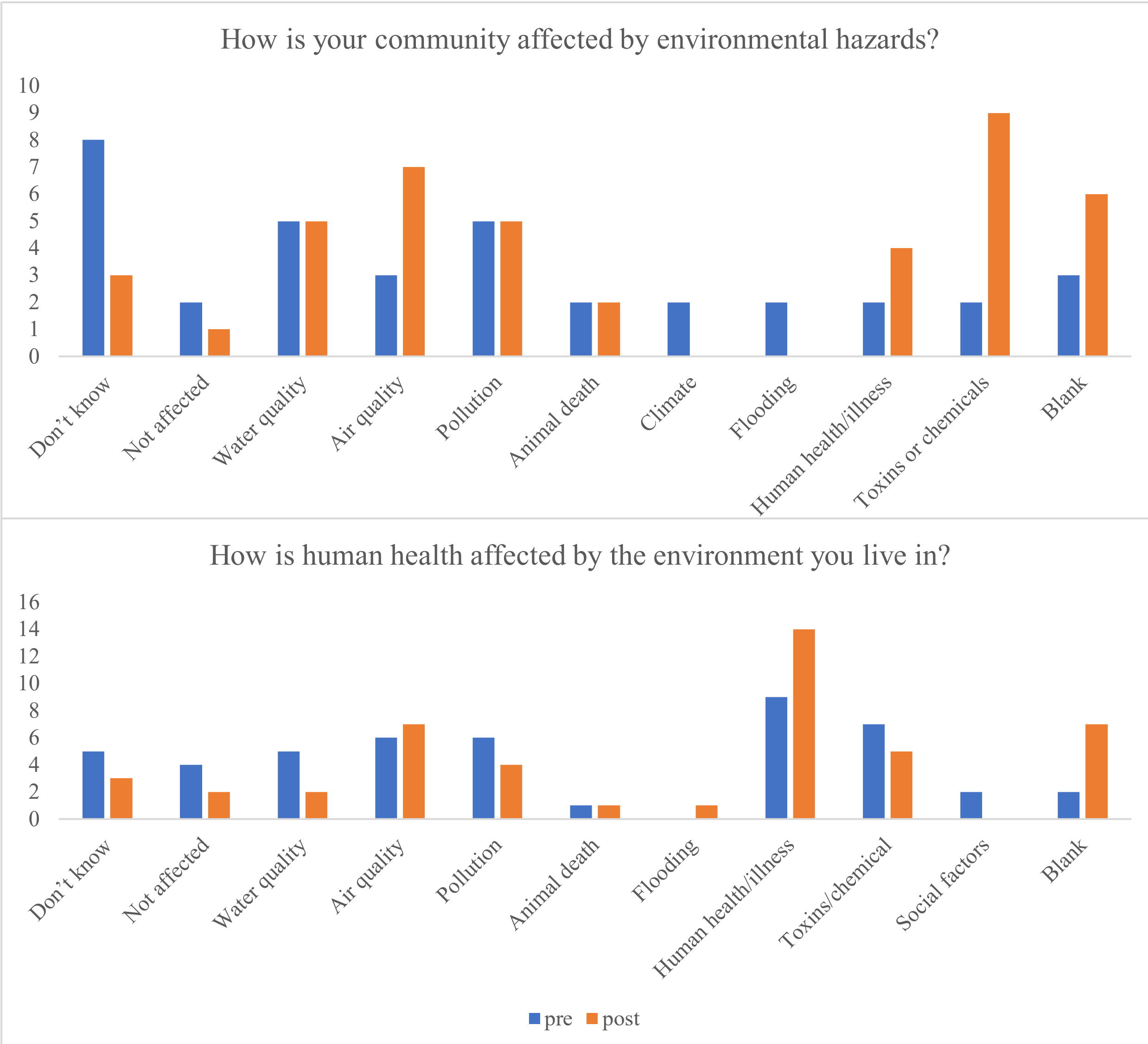

Figure 13: Count of how many times themes were coded at the open-ended environmental questions from the virtual event (pre-event n=29, post-event n=32).

4.1.2.4 College preparedness questions:

Before the event, 65% of the respondents said they were at least "moderately prepared" for the college application process (Figure 14). After the program, participants' felt more prepared for the college application process (p-value=0.0007) (Table 7) (Figure 14). Over half the participants (59%) said they only understood the process of doing STEM research in college to a "small extent" or "not at all" before the program (Figure 14), but their understanding of the process significantly increased afterwards (p-value=0.002) (Table 7). Most participants (61%) said they understood the process to some extent after the event (Figure 14). Participants were not significantly more interested in pursuing an education beyond high school (p-value=0.762) or pursuing a STEM career (p-value=0.435) after the event (Table 7).

Before the program, most of the participants who were interested in a STEM career chose medicine or biology as their career of choice (10 count), although 12 participants left the question blank (Table 6). After the event, many participants were interested in science-based careers (16 count), but 15 participants still left the question blank (Table 6). Before the program, 86% of participants chose at least one in-state school as a college they would like to attend. Participants' interests in colleges post-event were similar to what they reported before the event (Table 6). Before the event, participants mentioned that STEM research involved innovation (two count) and university funding (two count) and can be done in many fields of study (three count). Eight fewer participants said they did not know anything about doing STEM research after the program and participants also mentioned that STEM research involved freedom to choose a topic (two count), innovation (two count), focus and studying (four count), and making a positive difference in the world (two count).

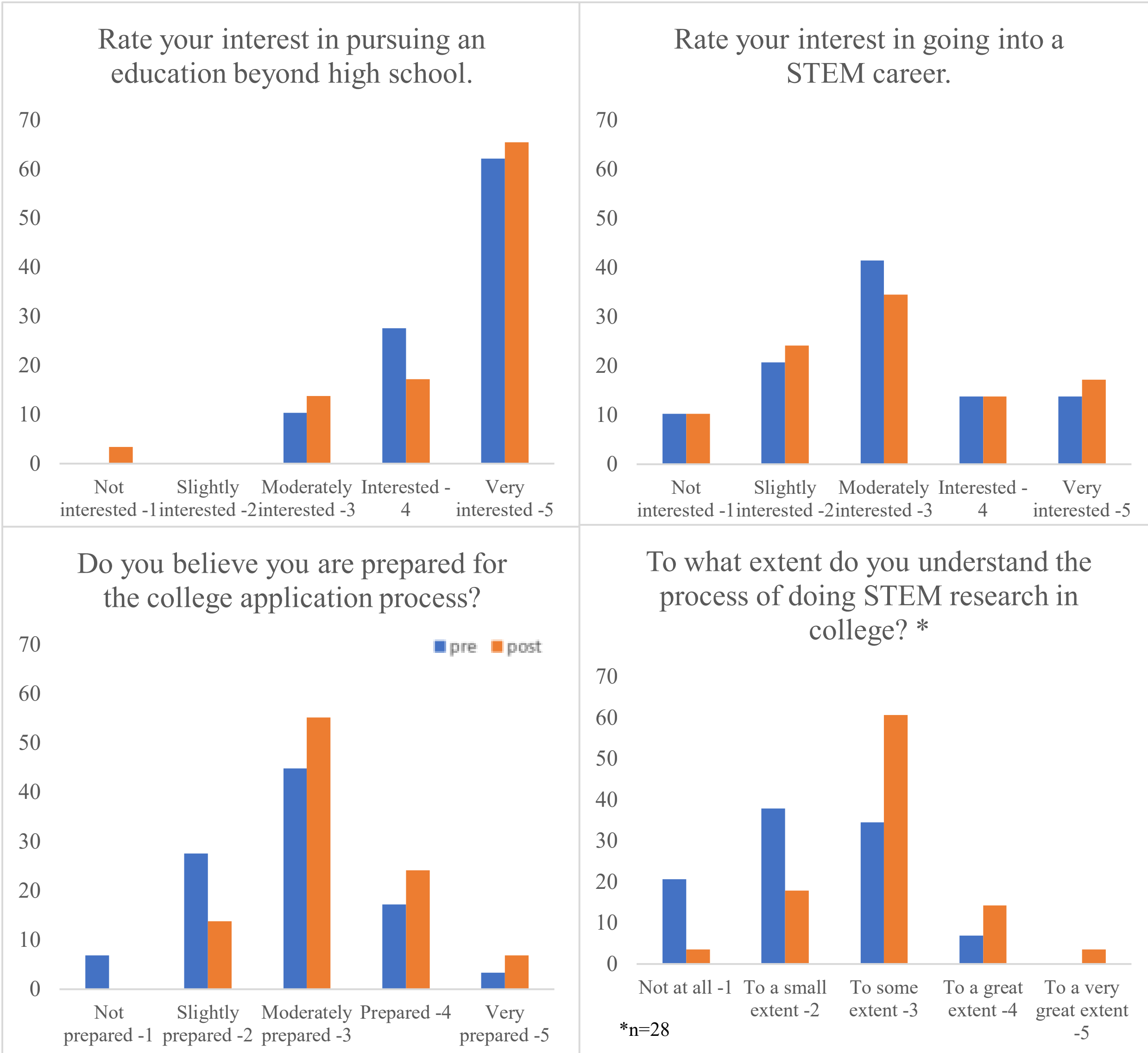

Figure 14: Percentage of participants for each scaled response option for the closed-ended Likert style college preparedness questions from the virtual event (n=29).

Table 6: Counts of how many times themes were coded at qualitative college preparedness questions from the virtual event.

If you are interested in a STEM career, which one and why do you want to enter that field? (n=29)		
Themes	**Pre-event**	**Post-event**
Don't know	5	4
Not interested/blank	12	15
Programmer	1	0
Biology	2	2
Marine biology	2	1
Medicine	9	7
Environment	0	1
Chemistry	0	1
Engineering	0	2
Science	0	2

What colleges are you interested in attending? (n=32)		
Category	**Pre-event**	**Post-event**
Don't know	3	2
Duke	14	17
UNC Chapel Hill	17	17
Other in-state	17	9
Out of state	21	17
Blank	0	4

Table 7: One-sided t-test for changes in Likert style questions for the virtual event (alpha=0.05).			
Question	**t**	**df**	**p-value**
To what extent do humans cause damage to our environment?	0.94094	28	0.1774
To what extent do you feel your community is affected by environmental hazards?	3.0179	28	0.00269
To what extent do you feel that human health is affected by the environment you live in?	2.637	28	0.00675
On a scale of 1-5, how confident do you feel about your knowledge of environmental hazards?	4.1038	27	0.00017
Rate your interest in pursuing an education beyond high school.	-0.72157	28	0.7617
Rate your interest in going into a STEM career.	0.16617	28	0.4346
Do you believe you are prepared for the college application process?	3.5496	28	0.00069
To what extent do you understand the process of doing STEM research in college?	3.1001	28	0.00219

4.1.2.5 Ways to improve

Out of the 29 participants that responded to both surveys, 100% of participants attended Monday, Tuesday, and Thursday, 90% of participants attended on Friday, and nearly 50% attended on Wednesday (which was an optional day). Three participants only participated in the post-event survey, and I only used data from their open-ended questions. Optional HackBio activities that occurred on Wednesday included the virtual lab tour (35% participant attendance), undergraduate Q&A panel (45% participant attendance), and admissions talk (45% participant attendance). Seventy-nine percent of participants said they learned at least "a moderate amount" from the event and 69% said at least "a moderate amount" of the information was new (Figure 15). When participants were asked to list the highlights of the event, 16 mentioned the student-led hack presentations, followed by the scavenger hunt (seven participants), and the undergraduate Q&A panel (six participants) (Table 8). When asked about their least favorite parts of the program, participants listed the scavenger hunt (14 participants), the hack presentations (six participants), and the Toxic Release Inventory activity (four participants) (Table 8). While most participants did not think any action was needed to improve the program, four participants suggested the event be shorter, four participants suggested the program be more interactive, and three participants said the program should occur during a different time of day instead of their lunch period (Table 8).

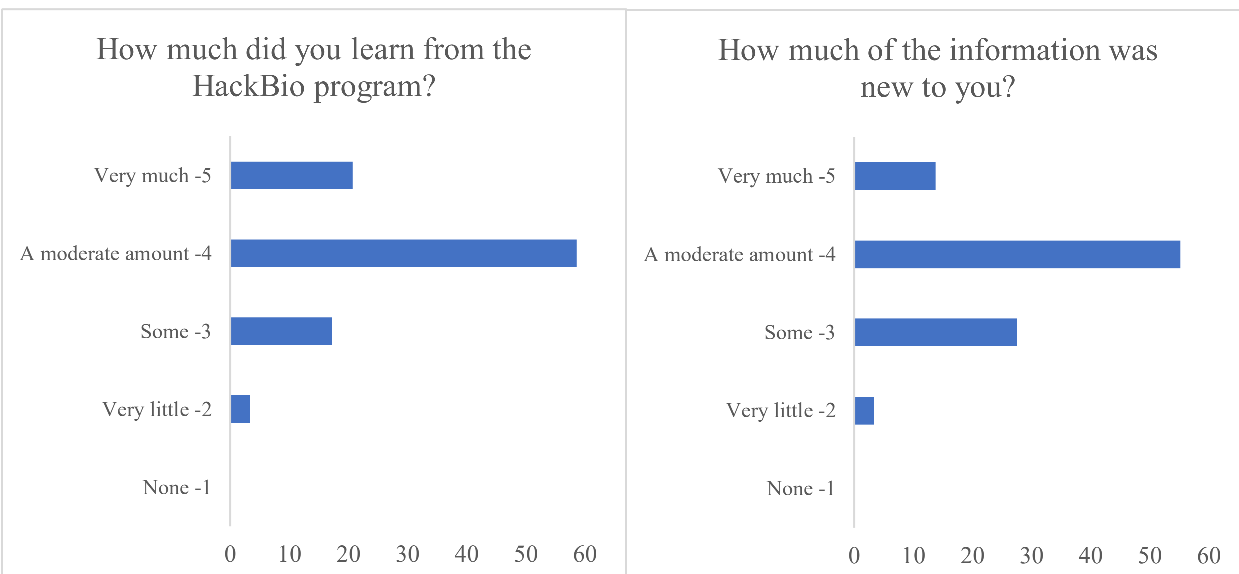

Figure 15: Percentage of participants for each scaled response options for the closed-ended Likert style post program questions from the virtual event (n=29).

Table 8: Counts of how many times themes were coded to open-ended post-program questions from the virtual event.

What do you consider the highlights of HackBio? (n=32)	
Themes	**Count**
Increased knowledge	1
Admissions talk	3
Hack	5
Scavenger hunt	7
Presentations	16
Undergrad Q&A	6

What was your least favorite part of HackBio? (n=31)	
Themes	**Count**
Admissions talk	1
Hack	1
Scavenger hunt	14
TRI	4
Presentations	6
Undergrad Q&A	1
Too long	1

In what ways could HackBio be improved? (n=28)	
Themes	**Count**
Nothing, already good	13
Scavenger hunt	1
In person	1
Not during lunch	3
More college prep	1
More interactive	4
Shorter	4

4.2 Undergraduate Interview results

I interviewed six out of the seven undergraduates who volunteered at the in person HackBio event during the spring and summer following the program. There were four seniors, one junior, and one sophomore who volunteered. Five of the interviewees majored in Biology, while two interviewees majored in environmental science. One interviewee double majored in both. Two of the interviewees had participated in a HackBio event at least twice before. Interviewees participated in different parts of the program and spoke to their experiences during those parts of the event.

The themes that emerged during the interviews included education, mentorship, community outreach, preparedness, negative and positive attitudes, skills gained, and suggestions for the program (see Appendix). I expected to find the environment as a major theme, but I did not code it to any interviews.

4.2.1 Motivation for engagement

All of the undergraduate interviewees mentioned education or community outreach as a reason for participating in the program. Some interviewees mentioned having previous experience in teaching children, and enjoying that experience was a motivator for joining this program. Two individuals mentioned having experiences with being mentored and exposed to science as a high schooler and wanted to mentor students as they were mentored. One interviewee noted, “I was fortunate enough growing up to have people kind of mentor me and expose me to science early on and I think that's really what led me to where I am now and I think it's important to give back” (C, personal communication, July 8, 2020). Others mentioned wanting to share information about their subject area, stating, “I thought it was a pretty interesting opportunity to talk to these kids and […] teach them about what I do every day” (B, personal communication, July 21, 2020).

4.2.2 Skills gained

I asked interviewees about different skills they may have gained while participating in the program. Initially, we expected undergraduates to gain leadership, mentorship, public speaking, and problem-solving skills, because the program targets these skills. The interviewees mentioned those skills, but interviewees also mentioned facilitation and teaching scientific communication as well (Figure 16). All interviewees mentioned leadership, problem-solving, public speaking, and facilitation (Figure 16).

All interviewees mentioned facilitation more than any other skill (Figure 16). Interviewees discussed balancing guiding participants to answers versus telling them an answer: “one thing I saw that was challenging was […] prompting students but not […] giving them an answer” (A, personal communication, June 22, 2020). Another interviewee mentioned that the program “has made me really practice and learn how to ask questions better […] and like provide guidance without giving them the answer to things I think that really was like my biggest take away” (E, personal communication, April 17, 2020).

Five of the interviewees (83%) mentioned leadership as a skill they used or improved upon during the program (Figure 16). One interviewee mentioned that they learned how to be “a role model to younger kids and you know just kind of like communicate well about like my experiences” (D, personal communication, April 17, 2020). Another interviewee suggested that being on the undergraduate panel made them feel like they were in charge instead of being a subordinate (F, personal communication, March 30, 2020).

All interviewees described the use of problem-solving skills during the program. One interviewee mentioned that they were “having to like think on your feet and like develop questions to ask [the high school students]” (D, personal communication, April 17, 2020). The other four interviewees also mentioned having to figure out how to facilitate interactions with the program participants. One interviewee said they did not improve their problem-solving skills, but they mentioned troubleshooting with participants which falls into problem-solving.

Five of the interviewees (83%) mentioned that they used or improved upon their public speaking skills during the program (Figure 16). One interviewee said that they “got more confidence talking around kids who are a little older” (A, personal communication, June 22, 2020). Another interviewee said that participating in the undergraduate panel “help[ed] me […] answer[…] questions kind of concisely but also […] direct it towards like a younger audience that may not know as much about the science” (B, personal communication, July 21, 2020). One interviewee also mentioned assisting participants in communicating during their presentations. They said that they help participants with “making sure you don't have a lot of words on your slide, [and] making sure you tell a story progressively” during their presentation (A, personal communication, June 22, 2020).

4.2.3 Mentorship

One goal of the program is to facilitate a mentor relationship between undergraduates and high school participants. I asked interviewees if they felt that they acted as mentors during the program, and respondents had mixed feelings. When asked directly if they felt they were a mentor, interviewee A said, “I don't, I think if I'd done the undergraduate panel I would have felt more like a mentor because I see mentors as like a word that characterizes like both like academics, but also like all elements of life” (A personal communication, June 22, 2020). However, earlier in the interview, the interviewees talked about their “ability to mentor students” and said, “I saw improvement in the students’ presentation who I had mentored” (A, personal communication, June 22, 2020). Interviewee F said they did not volunteer in the program for a long enough period to feel like they mentored the participants, but they also mentioned the program let them “give mentorship back if you can even if it’s in like a small way” (F, personal communication, March 30, 20200. Interviewee B did not feel they were a mentor either because “mentoring is better when it's like one-on-one you're really talking to someone and getting to know them” (B, personal communication, July 21, 2020). The remaining interviewees said they did feel like they were mentors during the program. Interviewee D said the program was “one of like the more impactful times I like served as a mentor to someone” (D, personal communication, April 17, 2020).

4.2.4 Challenges and suggestions for improvement

During the interview, I asked interviewees about challenges they faced and suggestions for improvement. The main themes interviewees mentioned for improvement included adding a training session for volunteers before the program, reformatting group sizes, and adding diversity to the program staff.

All interviewees mentioned that helping participants stay on track and facilitating discussion was one of the biggest challenges they faced. One interviewee mentioned that the biggest challenge interacting with participants was deciding when to “come up and like try to interact with them because I didn't want to come up too often because I thought that could be disruptive but I wanted to make sure that I was doing my part” (A, personal communication, June 22, 2020). Another interviewee said that, “it was like a little difficult to like make [the participants] ask questions like make them think deeply” (D, personal communication, April 17, 2020).

Four interviewees mentioned they would like to have a training session for volunteers before the program to improve preparedness. Interviewee A said, “it would have been helpful to kind of receive a little more information about what HackBio was and what my exact role was going to be and […] in what way I could be most beneficial” (A, personal communication, June 22, 2020). Others mentioned that having background information about the program participants and their level of knowledge would have been helpful to them, “I didn't exactly know where [the participants’] science knowledge was, […] so trying to like phrase some of my answers the correct way might have been a little difficult because I wasn't entirely sure what would be too confusing for them or what would be like way too easy for them” (B, personal communication, July 21, 2020).

Interviewees also suggested reorganizing how program participants were grouped. Some interviewees suggested that participants could be put into smaller groups in order to make more personal connections with the program participants. Interviewee F said, "[when] navigating a group of five or six people at once […] I think more shy people weren't able to like really build a connection even though sometimes I got the sense that they wanted to" (F, personal communication, March 30, 2020) and interviewee B mentioned that, "if you did the like smaller group discussions, it might be more of a mentoring experience" (B, personal communication, July 21, 2020).

Two interviewees also mentioned that adding diversity to the program staff would be helpful to the program participants to allow them to learn from individuals with different backgrounds. One interviewee mentioned that the program could include more program staff from different ethnicities and genders. Both interviewees suggested having staff from different programs of study speak to the participants. One interviewee mentioned, "the kids [could] learn a bit more about different types of biology research that you can do at Duke" (B, personal communication, July 21, 2020).

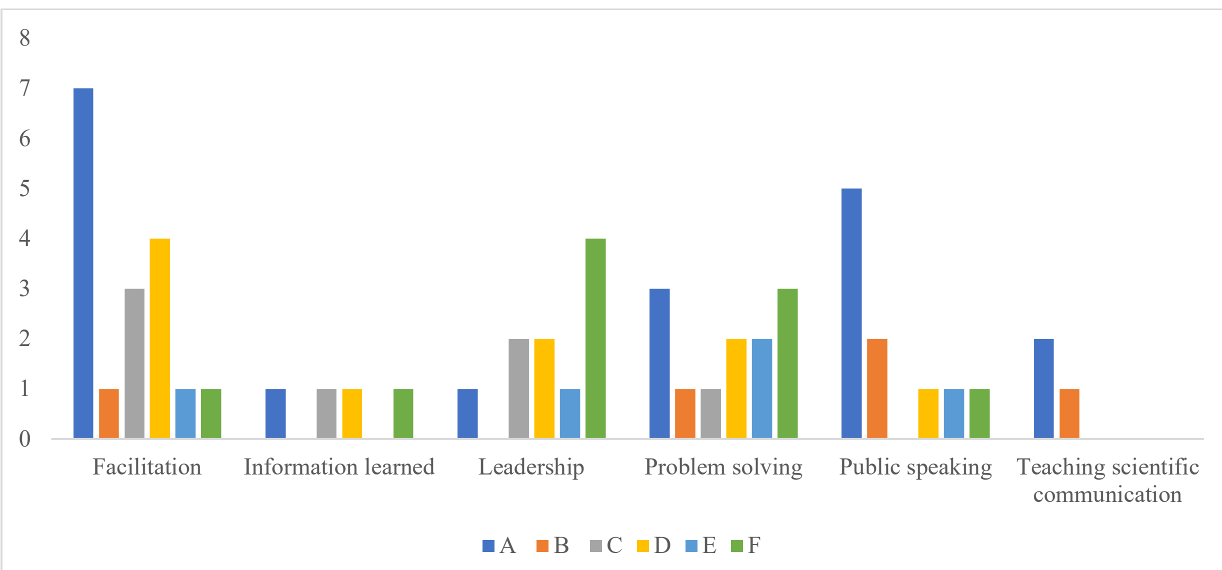

Figure 16: Counts of how many times the undergraduate respondents mentioned skills they gained from the program.

5 Discussion

The HackBio outreach program aims to educate underrepresented high school students to human-environment interactions and introduce them to pathways to STEM careers using experiential learning activities. Undergraduate students with experience in environmental science research serve as mentors to the high schoolers during the program. Based on the logic model developed for the program, I expected high schoolers to gain knowledge of environmental health challenges and pathways to STEM careers. Undergraduates who volunteered during the program were expected to gain leadership, problem-solving, and mentorship skills. Because of the global COVID-19 pandemic, we had to convert the program to a virtual format, so I also determined whether the virtual program provided participants with a similar experience as the in-person event.

5.1 High school surveys

5.1.1 Environmental health and human risk questions

For the in-person event, I found that participants increased their knowledge of environmental hazards in their community and were more confident in their knowledge of environmental hazards. This is consistent with research that shows experiential learning programs improve knowledge retention (Millenbah & Millspaugh, 2003). There was not a significant increase in participants' response scores for their perception of how much humans cause damage to the environment or how much human health is affected by the environment after the in-person event, but this was because the scores were already high on the scale used. This suggests that participants already understood how much harm is done to the environment but were not aware of that damage in their own community before the program.

The results from the open-ended questions confirmed that participants learned information about human-environment interactions. After the in-person event, all participants were able to identify ways their community and human health were affected by environmental hazards. Participants at the in-person event mentioned a new theme, "toxins or chemicals", as a way their community was affected, and they connected that theme to human health as well. This shows that participants are not only realizing toxins or chemicals are a threat to their community, but also connecting toxins to human health issues. This evidence supports our expected outcomes of increased knowledge in human-environment interactions.

For the virtual program, there was a significant increase in participants' scores about how strongly they felt their community was affected by environmental hazards, how much human health is affected by the environment, and how confident they were in their knowledge of environmental hazards. This suggests that the virtual program is effective at teaching high schoolers about environmental hazards in their community and how environmental hazards can affect human health. Furthermore, this suggests that a virtual experiential learning environment is just as effective as an in-person one. This could be because of an effort to increase engagement with individual participants to make up for not being with the class in person which would be consistent with research by Schoenfeld-Tacher et al. (2001) and Merritt et al. (2020) that says online students may perform better than their in-person peers because teachers initiated interactions more frequently with online students. There was not a significant increase in participants' response scores for their perception of how much humans cause damage to the environment at the virtual event. Similar to the in-person event results, participants' understanding of how much humans cause damage to the environment were already high before the event, so there was not room on the scale for scores to move much higher.

After the virtual program, fewer participants said they did not know how their community was affected by environmental hazards and more individuals mentioned air quality and toxins or chemicals as ways their community was affected. This shows that participants had an increase in knowledge of environmental hazards in their community. After the virtual program, more individuals connected human-environment interactions to health and illness. This demonstrates that students were able to make connections between what environmental hazards are present and how they affect human health.

5.1.2 College preparedness questions

There was not a significant increase in participants' interest in pursuing an education beyond high school or interest in pursuing a STEM career after both the in-person and virtual events. Research has shown that often, individuals know their chosen career field from early in their life (Feist, 2006: Bloom, 1985), so changing this may require a more intensive program over a longer period of time. This suggests that participants are strongly attached to their current plan for the future and HackBio was not long enough to be able to challenge that plan. However, there was a significant increase in participants' preparedness for the college application process and their understanding of STEM research in college at both events.

Before the in-person event, three participants indicated they were not interested in STEM careers and three participants said they did not know if they were interested in a STEM career. After the event, however, no participants said they were not interested in STEM careers and only one participant said they did not know. Along with this decrease in uncertainty about their interest in STEM, there was also an increase in participants' interest in science, marine biology, and research. This indicates that the in-person program solidified the careers in which they were interested and provided them with a new interest in research methods. More participants said they were unsure of which college they wanted to attend, and fewer participants wanted to attend out of state or other in-state colleges after the event. The participants' interest in Duke and UNC Chapel Hill, however, remained the same after the event. This signifies that the information participants received from the program could have solidified their interest in Duke. Overall, for the in-person event, there was a 41% decrease in participants who did not know anything about STEM research in college. Participants related STEM research to new themes such as fun and freedom, indicating that students not only learned information about STEM research, but were able to associate it with positive themes.

Both pre- and post-event surveys at the virtual event had a similar number of participants who said they did not know if they were interested in a STEM career or left the question blank which could indicate a disinterest in STEM careers or may have been because of the way the question was worded. The question wording, "If you are interested in a STEM career, which one and why do you want to enter that field?" could have suggested that students could leave the question blank if they weren't interested in STEM careers. After the virtual program, participants did name four more career types than they did before the event, which could also show that they learned of these different careers by participating in the program. Participants' interest in college was similar before and after the virtual event, but there was a decrease in their interest in out of state schools and in-state schools besides Duke and UNC Chapel Hill, which is similar to the results at the in-person event. Eight fewer participants said they did not know anything about doing STEM research after the virtual program, and participants mentioned new themes including that STEM research involves focus and study and that it can make a positive impact. This increase in positive attitudes toward science is consistent with research on inquiry-based programming (Gormally et al., 2009; Gibson & Chase, 2002; Sesen & Tarhan, 2013). This shows that the virtual program did help students understand more about STEM research.

5.1.3 Post-program questions

After the in-person program, most participants said they learned at least "a moderate amount" (70%) and most participants said at least "a moderate amount" of the information was new (69%). This demonstrates that high schoolers did learn new information from participating in the in-person program. After the virtual program, most participants indicated that they learned "a moderate" amount (79%) and that at least "a moderate" amount of the information was new to them (69%) showing that the virtual program had a positive impact on participants' learning. Seven participants at the virtual event said they enjoyed the scavenger hunt, but fourteen participants listed the scavenger hunt as their least favorite part of the virtual program. Two participants said the scavenger hunt was confusing and two participants said they did not feel as if they learned anything from it. Recommendations for changes to the scavenger hunt are below. Two participants at the virtual event said they did not like the presentation because they were worried about speaking and answering questions. This suggests that participants may have been uncomfortable with the presentation due to the uneasiness that comes from public speaking.

5.1.4 Pandemic questions

Most students said their classes had changed since the pandemic arrived. Some students mentioned positive change such as extra time and better grades, but most said class had become more difficult. However, nearly 50% of participants said they had the same amount of work and study the same amount as before the pandemic. This shows that while participants may have the same amount of work as before, they feel more burdened by the workload they have. Participants may also be struggling in class because they don't have social time or hands-on work. This is consistent with the phenomena of "Zoom Fatigue" which is the exhaustion that comes from overusing video conferencing platforms (Wiederhold, 2020). With this in mind, virtual programming must allow students time to interact socially with other participants and undergraduates as well as find creative ways for students to work away from their computers.

5.1.5 Comparison of events

While some elements of the in-person and virtual events were the same, some elements such as hands-on lab activities cannot be replaced in a virtual setting. These program elements cannot be compared across both events. However, the core of the HackBio program lies in the hack event and student presentations. Both programs showed similar results in the survey data, so despite some program elements being different, the programs did affect participants in similar ways and can be considered comparable.

5.2 Undergraduate interviews

All of the interviewees mentioned education or community outreach as a reason for participating in the program. This is consistent with the body of literature that says community building was a major motivation for undergraduates to volunteer (Dean, 2014; Holdsworth, 2010; Moore et al., 2014; Qian & Yarnal, 2010).

Based on the logic model developed for the program, I expected undergraduates to use or increase their skills in leadership, problem-solving, and mentoring, and the program did accomplish this goal to some degree. I found that interviewees mentioned facilitation, leadership, public speaking, problem-solving, and teaching scientific communication. We did not include facilitation and teaching scientific communication as skills that we anticipated undergraduates to use in the logic model; however, facilitation was mentioned more frequently than any other skill. They mentioned facilitation in relation to helping participants with the hack portion of the event. Facilitation should be added as an outcome on the program logic model. Teaching scientific communication was only mentioned by two interviewees. This was mentioned in relation to assisting participants with their presentations. Improvement in leadership and communication skills were also seen in college students who volunteered to work in pre-school classrooms (Trepanier-Street, 2007).

Undergraduates' attitudes of mentorship were more varied. While three undergraduates said they felt like they were mentors, the other three undergraduates had mixed feelings about their mentorship. Interviewee B did not feel like they were a mentor, because they did not have any one-on-one interactions with the participants. However, this individual did not participate in the hack portion of the event where undergraduates had more interpersonal interactions with the participants. Interviewee F also did not think they participated in the program long enough to act as a mentor, but they did mention they thought it was "good to be able to like kind of give mentorship back if you can even if it's in like a small way" (F, personal communication, March 30, 2020). This contradiction may either be a slip-up in wording or may come from an unclear definition of the word mentor. Interviewee A said that they did not feel like a mentor because a mentor supports a mentee in all elements of life not just academics. This may be alleviated by giving undergraduates more time with high schools to interact without facilitation from program staff.

5.3 Summary of program recommendations

5.3.1 Recommendations from the surveys

Based on the results from the survey responses, participants could benefit from more college preparation modules, because the program aims to provide high schoolers with a stronger preparedness for STEM careers and college. The directors could provide information on the college application process, help students find colleges in which they are interested, or provide assistance on college application essays. If the program was conducted over a longer period of time instead of only one week, the program could also provide more detailed advice from expert speakers to participants. This could give high school students more information on different pathways to STEM careers and give repeated feedback on college applications.

Participants said that they enjoyed the undergraduate Q&A panel and expressed an interest in getting to know the undergraduate students better. Because of this feedback, I would recommend adding in additional time that the participants could converse with the undergraduates more informally. This could be done during the lunch period of the in-person event or during a drop-in Zoom call during the virtual event.

Another recommendation would be to change how the program presents expert speakers to participants. The program could benefit from taking a student-driven approach, such as using a panel format where the guest experts give a short, ten-minute presentation of both their career pathway and research and then let participants ask questions. The program could also provide participants with a few pages of reading material from guest speakers and have them develop questions as homework, then have a panel the following day. Both of these options would allow high school participants to guide the conversation and make it a more interactive, personal, and relevant experience. A more personalized experience would be extremely beneficial to underrepresented groups, because it would enable them to see themselves in the role of the researcher (Gullatt and Jan, 2003; Long and Mejia, 2016). Guest experts should also be provided with information on participants' level of scientific knowledge to make sure their presentations are easy to understand.

For the virtual program, the scavenger hunt activity could have a section added to the beginning and the end of the activity to clarify the purpose of the activity. Participants mentioned that they were not sure what the purpose of the activity was or what knowledge they were supposed to get out of it. To alleviate this confusion, participants could be explicitly told about the learning expectations before the activity occurs. After the event, the program should have a reflection session to allow for participants to digest the information they discovered and make connections between the information they found and why it matters. This could be done by putting participants in breakout groups with undergraduate volunteers which will reduce the fear of public speaking and give them more time with the undergraduates.

Finally, for both in-person and virtual programs, the program directors should ensure that each day of the program has some hands-on activities. While front loading information on the beginning days of the event makes sense to provide students the information they need for the hack, participants said that they find it hard to concentrate when so much information is given at once. One way to alleviate this could be to provide participants with take-home work to allow them to have more interactive time in the live sessions.

5.3.2 Recommendations from the undergraduate interviews

Based on feedback from the undergraduate interviewees, I would recommend that the program organize a training session for undergraduates that is formally included as an element of the program. The training session should include a detailed overview of the program and its goals. Program directors can clearly set expectations for what undergraduates should do during the program and give undergraduates an understanding of what level of knowledge the participants will have. The session can also include information on best practices on facilitating high schoolers' learning, how to deal with group dynamics, and ways to facilitate a mentor relationship with high schoolers.

I would also suggest hosting the program on a sequence of days where undergraduates can participate for all days of the event so that they can receive a more immersive experience. If this is done, the program directors could assign undergraduates to groups of high schoolers that they could interact with throughout the program to allow them to develop more of a mentor relationship with the participants. This would allow undergraduates to develop a closer relationship with the high schoolers they assist and allow them to personalize the experience for the high schoolers. Furthermore, I would suggest encouraging undergraduates to mingle with participants unfacilitated during the program, perhaps during lunch, to allow them to have conversations with the high schoolers that are non-academic.

If the program directors would like to expand the program, two interviewees suggested that the program could include other fields of science besides the theme of environment and health. If the program lasted longer, perhaps a month or a semester, more material could be covered from other fields of study and allow participants to do hack projects that use many different fields.

5.4 Limitations of the study

5.4.1 Survey

Additional questions in the high school survey would have been useful to determine the high school participants' public speaking and problem-solving skills before and after the program. A survey could also be distributed to a sample of participants who did not complete the HackBio program in order to have a control group with which I could compare results.

There were also limitations to survey analysis due to the small number of program participants. Additionally, a comparison of the virtual and in-person programs was difficult because of the disparity in the number of participants who attended. Furthermore, because the programs were conducted during different times of the semester, the in-person event was near the beginning of the semester and the virtual event was at the end of the semester, they had different levels of background biology knowledge which may have changed their responses to environmental knowledge questions. For the virtual program there may have been a non-response error because some participants did not complete the survey.

5.4.2 Interviews

One limitation of my interview methods was that I did not have time to conduct undergraduate interviews after the virtual program to compare to the in-person program. Additional interviews with those undergraduates that participated in the virtual program would help to determine if the benefits gained by the undergraduate mentors are different when the program is conducted virtually.

Because I am a member of the program staff, interviewees may have been reluctant to tell me what problems they had with the program because they did not want to reflect poorly on the program or their faculty mentors who run the event. In some interviews, when I asked students if they developed each skillset, some students said they did develop those skills, but I sensed some hesitancy. When these events occurred, I reassured the interviewee that it was okay to say no, and some students did switch their answer. However, some students may have still chosen not to tell me the truth anyway.

5.5 Further research

Further research could include expanding the program surveys, adding a control group to the evaluation design, and interviewing more undergraduates. Expanding the program survey to include questions regarding participants' problem-solving and public speaking skills will improve the program staff's ability to determine the effectiveness of the program in improving high schoolers' skills. The program could also include an experimental design where some participants participate in the program while others do not participate in order to determine if the program is the cause of any observed changes. Further research could also include interviewing undergraduates who participated in the virtual event to learn if undergraduate benefits from the virtual event differed from the in-person event. Finally, in order to gain a holistic view of the program, the high school teachers who were involved in the program could be interviewed to learn their perspective on what their students gained from participating.

6 Conclusion

The HackBio program introduces underrepresented students to STEM careers through experiential learning activities. The primary goal of this evaluation was to determine if HackBio provided those high school students with knowledge of environmental health hazards and pathways to STEM careers. HackBio, both in-person and in a virtual format, was successful in increasing participants' understanding of the environment and increasing their preparedness for college. The program also provided meaningful mentorship and skill building to undergraduate students who volunteered. Developing programs are a step in the right direction to the ultimate goal of bringing diversity to STEM fields, but there is room for improvement.

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8 References

Allen-Ramdial, S., & Campbell, A. G. (2014). Reimagining the Pipeline: Advancing STEM Diversity, Persistence, and Success. BioScience, 64(7), 612–618. https://doi.org/10.1093/biosci/biu076

Alper, J., & Gibbons, A. (1993). The pipeline is leaking women all the way along. Science, 260(5106), 409–412.

Aud, S., Fox, M. A., & KewalRamani, A. (2010). Status and trends in the education of racial and ethnic groups.

Bloom, B. S. (1985). Developing talent in young people. New York, NY: Ballantine.

Caldwell, L., Garcia, R., & Cagle, N. (2018). K-12 Diversity Pathway Programs in the E-STEM Fields: A Review of Existing Programs and Summary of Unmet Needs. Journal of STEM Education: Innovations and Research, 19(4), Article 4. https://www.jstem.org/jstem/index.php/JSTEM/article/view/2324

Dean, J. (2014). How structural factors promote instrumental motivations within youth volunteering: A qualitative analysis of volunteer brokerage. Voluntary Sector Review, 5(2), 231–247. https://doi.org/10.1332/204080514X14013591527611

Ejiwale, J. A. (2013). Barriers to Successful Implementation of STEM Education. Journal of Education and Learning, 7(2), 63–74. https://doi.org/10.11591/edulearn.v7i2.220

Estrada, M., Burnett, M., Campbell, A. G., Campbell, P. B., Denetclaw, W. F., Gutiérrez, C. G., Hurtado, S., John, G. H., Matsui, J., McGee, R., Okpodu, C. M., Robinson, T. J., Summers, M. F., Werner-Washburne, M., & Zavala, M. (2016). Improving Underrepresented Minority Student Persistence in STEM. *CBE—Life Sciences Education*, *15*(3), es5. https://doi.org/10.1187/cbe.16-01-0038

Feist, G. (2006). The development of scientific talent in Westinghouse finalists and members of the National Academy of Sciences. Journal of Adult Development, 13, 23-35.

Fitzpatrick, B. R., Berends, M., Ferrare, J. J., & Waddington, R. J. (2020). Virtual Illusion: Comparing Student Achievement and Teacher and Classroom Characteristics in Online and Brick-and-Mortar Charter Schools. *Educational Researcher*, *49*(3), 161–175. https://doi.org/10.3102/0013189X20909814

Funk, C., & Parker, K. (2018). Diversity in the STEM workforce varies widely across jobs. Pew Research Center's Social & Demographic Trends Project. https://www.pewsocialtrends.org/2018/01/09/diversity-in-the-stem-workforce-varies-widely-across-jobs/

Ghee, M., Keels, M., Collins, D., Neal-Spence, C., & Baker, E. (2016). Fine-Tuning Summer Research Programs to Promote Underrepresented Students' Persistence in the STEM Pathway. CBE—Life Sciences Education, 15(3), ar28. https://doi.org/10.1187/cbe.16-01-0046

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. Science Education, 86(5), 693–705. https://doi.org/10.1002/sce.10039

Gormally, C., Brickman, P., Hallar, B., & Armstrong, N. (2009). Effects of Inquiry-based Learning on Students' Science Literacy Skills and Confidence. International Journal for the Scholarship of Teaching and Learning, 3(2). https://doi.org/10.20429/ijsotl.2009.030216

Gullatt, Y., & Jan, W. (2003). How do pre-collegiate academic outreach programs impact college-going among underrepresented students. Washington, DC: Pathways to College Network Clearinghouse.

Holdsworth, C. (2010). Why volunteer? Understanding motivations for student volunteering. British Journal of Educational Studies, 58(4), 421–437. https://doi.org/10.1080/00071005.2010.527666

Honey, M., Pearson, G., & Schweingruber, H. (n.d.). Committee on Integrated STEM Education. 181.

Hurlbut, A. R. (2018). Online vs. traditional learning in teacher education: A comparison of student progress. *American Journal of Distance Education*, *32*(4), 248–266. https://doi.org/10.1080/08923647.2018.1509265

Hutchison, L. F. (2012). Addressing the STEM Teacher Shortage in American Schools: Ways to Recruit and Retain Effective STEM Teachers. Action in Teacher Education, 34(5–6), 541–550. https://doi.org/10.1080/01626620.2012.729483

Long, L. L., & Mejia, J. A. (2016). Conversations about Diversity: Institutional Barriers for Underrepresented Engineering Students: Conversations about Diversity. Journal of Engineering Education, 105(2), 211–218. https://doi.org/10.1002/jee.20114

McDonald, J.H. (2014). Handbook of Biological Statistics (3rd ed.). Sparky House Publishing, Baltimore, Maryland. This web page contains the content of pages 29-39 in the printed version.

McGuire, T., Papke, L., & Reschovsky, A. (2008). Local funding of schools: The property tax and its alternatives. *Handbook of research in education finance and policy*, 357-372.

Merritt, E., Stern, M., Powell, R., & Frensley, T. (2020). Promising Principles to Enhance Distance Learning in Environmental Education. *Journal of the Association of Nature Center Administrators*.

Millenbah, K. F., & Millspaugh, J. J. (2003). Using Experiential Learning in Wildlife Courses to Improve Retention, Problem-solving, and Decision-Making. Wildlife Society Bulletin (1973-2006), 31(1), 127–137. JSTOR.

Moore, E., Warta, S., & Erichsen, K. (2014). College Students' Volunteering: Factors Related to Current Volunteering, Volunteer Settings, and Motives for Volunteering. *College Student Journal*, *48*(3), 386–396.

Noonan, R. (2017). STEM Jobs: 2017 Update. ESA Issue Brief #02-17. In US Department of Commerce. US Department of Commerce. https://eric.ed.gov/?id=ED594354

Qian, X. L., & Yarnal, C. (2010). Benefits of volunteering as campus tour guides: The rewards of serious leisure revisited. Leisure/Loisir, 34(2), 127–144. https://doi.org/10.1080/14927713.2010.481109

Schoenfeld-Tacher, R., McConnell, S., & Graham, M. (2001). Do No Harm—A Comparison of the Effects of On-Line vs. Traditional Delivery Media on a Science Course. *Journal of Science Education and Technology*, *10*(3), 257–265. https://doi.org/10.1023/A:1016690600795

Sesen, B., & Tarhan, L. (2013). Inquiry-Based Laboratory Activities in Electrochemistry: High School Students' Achievements and Attitudes. Research in Science Education, 43(1), 413–435. https://doi.org/10.1007/s11165-011-9275-9

Sommers, S. R. (n.d.). On Racial Diversity and Group Decision Making: Identifying Multiple Effects of Racial Composition on Jury Deliberations. 16.

Trepanler-Street, M. (2007). Mentoring Young Children: Impact on College Students. Childhood Education, 84(1), 15–19. https://doi.org/10.1080/00094056.2007.10522962

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, Technology, Engineering, and Mathematics (STEM) Pathways: High School Science and Math Coursework and Postsecondary Degree Attainment. Journal of Education for Students Placed at Risk (JESPAR), 12(3), 243–270. https://doi.org/10.1080/10824660701601266

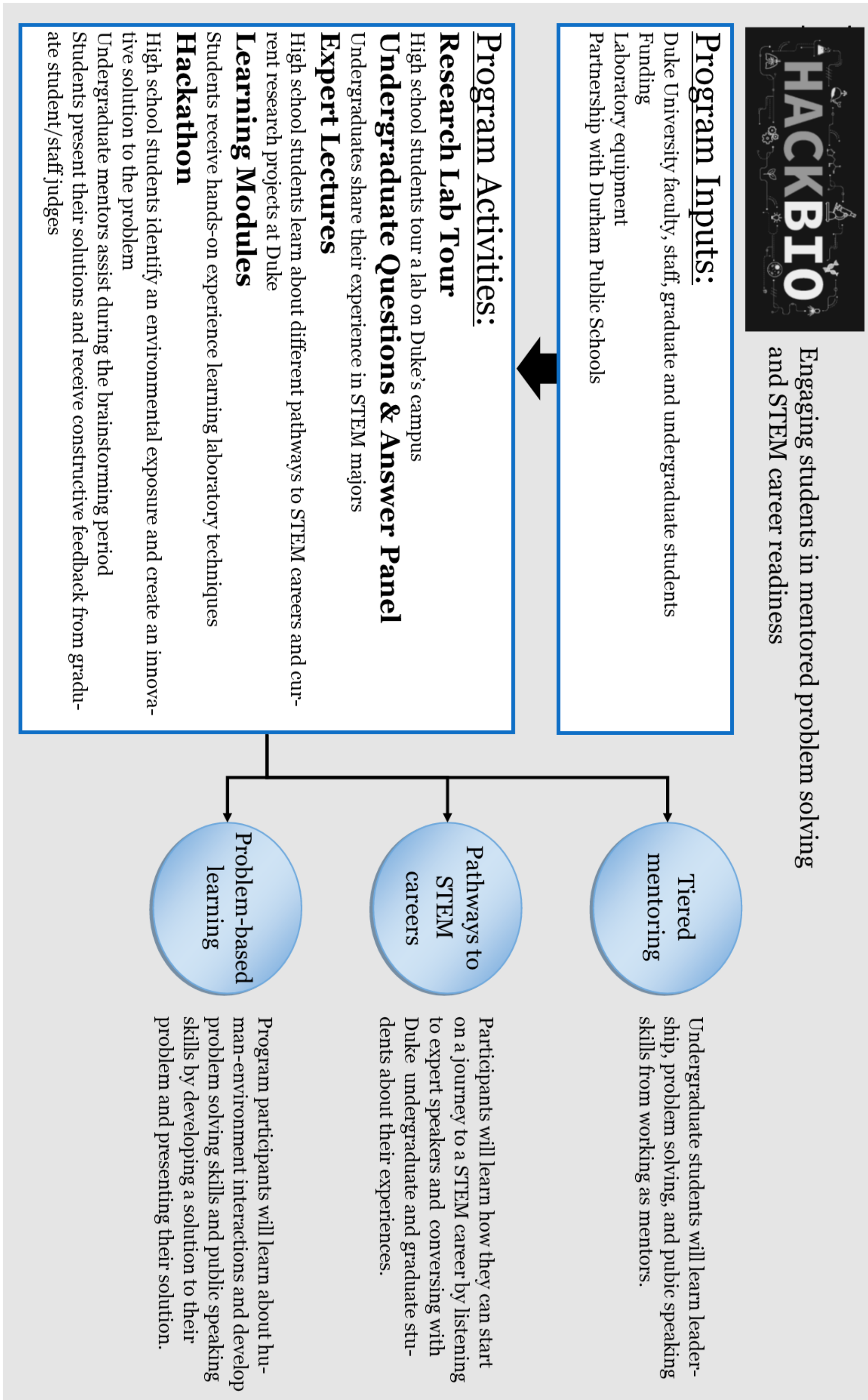
Wang, M.-T., & Degol, J. (2013). Motivational Pathways to STEM Career Choices: Using Expectancy-Value Perspective to Understand Individual and Gender Differences in STEM Fields. Developmental Review : DR, 33(4). https://doi.org/10.1016/j.dr.2013.08.001

Wiederhold, B. K. (2020). Connecting Through Technology During the Coronavirus Disease 2019 Pandemic: Avoiding "Zoom Fatigue." Cyberpsychology, Behavior, and Social Networking, 23(7), 437–438. https://doi.org/10.1089/cyber.2020.29188.bkw

U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey", 2018-19 v.1a; "Public Elementary/Secondary School Universe Survey Geographic Data (EDGE)", 2018-19 v.1a.

U.S. Congress Joint Economic Committee (2012). STEM education: Preparing for the jobs of the future. http://www.jec.senate.gov/public/index.cfm?a=Files.Serve&File_id=6aaa7e1f-9586-47be-82e7-326f47658320.

9 Appendix


HACKBIO
Engaging students in mentored problem solving and STEM career readiness
Program Inputs:
Duke University faculty, staff, graduate and undergraduate students
Funding
Laboratory equipment
Partnership with Durham Public Schools
Program Activities:
Research Lab Tour
High school students tour a lab on Duke's campus
Undergraduate Questions & Answer Panel
Undergraduates share their experience in STEM majors
Expert Lectures
High school students learn about different pathways to STEM careers and current research projects at Duke
Learning Modules
Students receive hands-on experience learning laboratory techniques
Hackathon
High school students identify an environmental exposure and create an innovative solution to the problem
Undergraduate mentors assist during the brainstorming period
Students present their solutions and receive constructive feedback from graduate student/staff judges
Tiered mentoring
Undergraduate students will learn leadership, problem solving, and pubic speaking skills from working as mentors.
Pathways to STEM careers
Participants will learn how they can start on a journey to a STEM career by listening to expert speakers and conversing with Duke undergraduate and graduate students about their experiences.
Problem-based learning
Program participants will learn about human-environment interactions and develop problem solving skills and public speaking skills by developing a solution to their problem and presenting their solution.

High school survey questions
Pre-event questions
Please write your first name and last initial.
What gender do you identify as?
What is your ethnicity? Circle all that apply.
Please list the science courses you have taken.
What grade are you in?
Do you know anyone who works in a STEM or environmental field?
Environmental questions
To what extent do humans cause damage to our environment?
To what extent do you feel your community is affected by environmental hazards?
To what extent do you feel that human health is affected by the environment you live in?
What kinds of environmental health hazards are present in your community?
On a scale of 1-5, how confident do you feel about your knowledge of environmental hazards?
How is your community affected by environmental hazards?
How is human health affected by the environment you live in?
College preparedness questions
Rate your interest in pursuing an education beyond high school.
Rate your interest in going into a STEM career.
If you are interested in a STEM career, which one and why do you want to enter that field?
Do you believe you are prepared for the college application process?
What colleges are you interested in attending?
To what extent do you understand the process of doing STEM research in college?
What do you know about doing STEM research in college?
Post-program questions
How much did you learn from the HackBio program?
How much of the information was new to you?
What do you consider the highlights of HackBio?
In what ways could HackBio be improved?
What was your least favorite part of HackBio?
Pandemic questions (virtual program only)
Has the pandemic made you think more about science? Why or why not?
Has the way that your classes are run changed since the pandemic arrived in March? If yes, what changes occurred?
How has your class workload changed since the pandemic arrived in March?
How have your study habits changed since moving to online classes?
Name 3 ways you feel attending classes online has affected your education, either for the better or for the worse.

Codebook for high school survey open-ended questions analysis	
Themes	**Definition**
Environmental questions	
Don't know	Student expressed they did not know what the answer was or was unsure of their answer
Not affected	Student did not think the subject in question was affected by environmental hazards
Water quality	Student mentions detrimental effects to water quality
Air quality	Student mentions detrimental effects to air quality
Pollution	Student mentions contaminants in the environment
Human health/illness	Student mentions detrimental effects on human health
Toxin or chemicals	Student mentions toxic substances or chemicals
Animal death	Students mentions animals being harmed by environmental hazards
Climate	Student mentions detrimental effects to earth's climate
Flooding	Students mention flooding
Social factors	Student mentions socioeconomic factors like lack of resources that lead to poor health and exposure to environmental toxins
College preparedness questions	
Don't know	Student expressed they did not know what the answer was or was unsure of their answer
Not interested	Student was not interested in pursuing a STEM career
Careers Science Marine biology Medicine Biology Microbiology Chemistry Research Programmer Environment Engineering	Students expressed an interested in pursuing one of the listed subjects
Colleges	
Duke	Students expressed an interest in attending Duke
UNC Chapel Hill	Students expressed an interest in attending UNC Chapel Hill
Other in-state	Students expressed an interest in attending another in-state university
Out of state	Students expressed an interest in attending an out of state university
Program elements	
Chapel climb	Part of the event where students participated in an ice breaker activity climbing the Duke Chapel tower
Admissions talk	Part of the event where a Duke Admissions Officer presented information to the students

Guest speaker	Part of the event where a guest expert presented their career path and research topic to students
Hack	The hackathon portion of the event
Presentation	Part of the hack where the students create a presentation and present their idea to the group
Lab tour	Part of the event where the students are lead through a tour of a research laboratory at Duke
Walking	Students mentioned walking between different places on campus
Scavenger hunt	Part of the event where students participated in a scavenger hunt to identify elements outside and connect them to environmental and human health
Undergrad Q&A panel	Part of the event where undergrads are asked questions by the high schoolers as a part of a panel
TRI (Toxic Release Inventory)	Part of the event where students learn to use the EPA's Toxic Release Inventory as a tool for learning about environmental health exposures
Suggestions	
Nothing, already good	Students indicated that the program did not need any improvement
Fewer speakers	Students suggested that the program use less guest speakers
More diverse speakers	Students suggested that the program have speakers of different backgrounds
Better speakers	Students suggested that the program use better speakers or that speakers use less complicated language
More interactive	Students suggested that the program include more interactive activities
More undergraduates	Students suggested that the program use more undergraduate volunteers
In person	Students suggested the program would be better if it was presented in person instead of virtually
Not during lunch	Students suggested the program occur during another time rather than their lunch period
More college prep	Students suggested the program include more information about the college application process
Shorter	Students suggested that the duration of the program be shortened
Increased knowledge	Students mentioned learning information from the program
Too long	Students mentioned that the program lasted longer than they thought it should
Pandemic questions (virtual program only)	
Not affected	Students said their education was not affected by the pandemic
Accomplish more	Students said they are able to finish more work
Better grades	Students mentioned their grades improving
Better organization	Students mentioned that their learning environment is more organized
Bored	Students mentioned that they get bored
Distractions	Students mentioned they have distractions
Ease of communication	Students mentioned that being online allows for easier communication

Instability	Students mentioned that their grades are rising and falling
Less competition	Students mention they feel they are not being compared to peers or judged as much
Less focused	Students mentioned that they had trouble focusing on their schoolwork
Less hands on	Students mentioned having no experiments and no hands-on instruction
Less incentive	Students mentioned having less motivation and incentive to perform well in school
Less understanding	Students mentioned it was more difficult to understand their lessons
Limited social interaction	Students mentioned having fewer opportunities to interact with others
More independent	Students mentioned having more independent work
More focused	Students mentioned being able to focus better on their classwork
More motivated	Students mentioned being more motivated to succeed
Work harder	Students mentioned having to work harder to succeed
More resources	Students mentioned they have more resources to use
More time outside class	Students mentioned spending less time in organized instruction periods and having more free time
More work	Students mentioned having a larger workload and learning more information
Eye strain	Students said they exhibit symptoms of eye strain due to being online
Stress	Students said the changes in their classes made them more stressed
Tired	Students said fatigue was a consequence of the changes in their classes due to the pandemic
Less work	Students said their workload was lighter
Virtual learning	Students mentioned that their classes have moved to an online format

Codebook for undergraduate interview analysis	
Category	**Description**
Actors: Program directors High schoolers Volunteers	The interviewee directly references individuals or groups of people who took part in the event
Demographics	Demographic details about the interviewees such as year in school, major, and times participated in HackBio
Education	Interviewee mentions an interest in teaching students
Environment	Interviewee mentions environment, natural world, impacts of human activity on land or water
Mentor	Interviewee mentions making one on one connections with students, sharing personal information/life advice or references the act of mentoring
Community outreach	Interviewee mentions an interest in educating and supporting local students in their community
Preparedness	Interviewee discusses their level of preparation to engage in assisting students

Negative	General criticism or weaknesses of the program
Positive	Compliments or strengths of the program
Skills gained	Interviewee mentions personal skills they learned or improved as a result of volunteering in the program
Leadership	Ability to oversee others, steer students in a positive direction
Problem-solving	Ability to identify problems and generate solutions
Public speaking/ communication	Ability to share ideas and communicate effectively to others
Information learned	Interviewee mentions specific information or facts that they learned by participating in the event
Facilitation	Ability to guide students to work together
Teaching sci comm	Guiding students in communicating their findings in a cohesive way
Suggestions	Giving ideas to improve the program
Smaller groups	Suggesting that students be separated into smaller groups of individuals
Assigned groups	Suggesting that volunteers should be assigned to groups to assist them
Diversity	Suggesting that the program have a variety of people and STEM fields represented at the event
Training session	Suggesting that the program hosts a session to teach volunteers about the program and set expectations before the event, and learn tips for interactions with students
Sample Presentation	Suggesting that volunteers should model how to conduct a presentation to the high schoolers
Serve food	Suggesting that the program should serve food during the panel
Zoom Q&A	Suggesting that during a virtual event the program could use the Zoom Q&A function
Program elements:	Parts of a program
Hack event	The hackathon portion of the event
Brainstorming	Part of the hack where students generate ideas
Presentation	Part of the hack where the students create a presentation and present their idea to the group
Undergrad Q&A panel	Part of the event where undergrads are asked questions by the high schoolers as a part of a panel
Lab activity	Part of the event where students learn methods of lab science
TRI activity	Part of the event where students learn to use the EPA’s Toxic Release Inventory as a tool for learning about environmental health exposures