Curriculum and Community Enterprise
for Restoration Science in New York Harbor

Integrating Environmental Restoration with Computer Science in New York Harbor with New York City Public Schools Phase III

December 2021

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I. Executive Summary

The Billion Oyster Project (BOP) Curriculum and Community Enterprise for Restoration Science (CCERS) in New York Harbor project aims to advance the efforts of the National Science Foundation (NSF) Innovative Technology Experiences for Students and Teachers (ITEST) program. The current CCERS ITEST project is in its third round of funding from NSF (Award # = 1759006) and is currently in its fourth and final year, which is a no-cost extension year (project awarded February 23, 2018 to February 28, 2022). The objectives of this CCERS ITEST project are to better understand and promote practices that increase student motivation and preparation to pursue careers in the fields of science, technology, engineering, or mathematics (STEM) by expanding and testing an innovative curriculum model that features locally relevant problem-based learning. This report provides an update on the progress of the research in understanding the influence of the ITEST program on students' motivation and preparation to pursue STEM careers. The report covers the activities implemented between January to December 11, 2021.

Research team activities, achievements, and highlights in year 4:

Research activity	Summary
Project management	• The research team **attended biweekly meetings** with the Principal Investigator (PI), evaluation team, BOP staff, and other key project staff to discuss progress toward activities, programming, instrument development and modification, data collection, and data analysis and dissemination.
Data collection	• The research team **worked with BOP staff and partners** to collect data from students engaged in BOP activities and activities with partners, as well as from students with low to no engagement in CCERS activities. • The research team worked with BOP staff and partners **to refine and improve the accessibility of survey items and design**. • BOP staff introduced the research to parents and students and provided survey links at various events, such as, near-peer mentoring, career panels, STEM Hub workshops, and BOP newsletters. • **A total of 356 students accessed** a student survey link. • The **research team matched 257 survey responses** with parental consent and student assent to use for data analysis. • The rate of **students accessing** the survey and completing all necessary steps **(i.e., parent consent, student assent, and completing survey questions) rose significantly from 22% in ITEST Phase 2 to 72% in the current phase**.
Data cleaning	• R statistical programming software was used to clean student survey data and develop a codebook and research dataset.
Data analysis	• The research team **conducted preliminary analyses** for two of the research questions using data gathered from the **student survey responses.**

	• Preliminary analyses were conducted by comparing ITEST (treatment) and comparison group (non-ITEST) respondents' motivation and preparation to pursue STEM careers.
Findings related to ITEST students'	• ITEST respondents, on average, had **higher scores of scientific identity (motivation) and higher levels of preparation to pursue STEM careers, with higher average scores of general engagement and engagement in scientific activities, than respondents in the comparison group**.
Findings related to URM ITEST students'	• Underrepresented minority (URM) ITEST respondents, on average, had higher reported levels of scientific identity (motivation) and engagement in scientific activities (preparation) than the comparison group.

Next steps

Researchers will work with the project PI, BOP staff, and other key partners to continue to identify student outreach events that that will increase the number of students reached. Since a challenge in collecting research data has been the difficulty in obtaining parental consent, researchers will also continue to discuss strategies with the project PI, BOP staff, and other key partners to engage parents and students to provide consent to complete the surveys. It should be noted that the number of students who complete the survey has significantly increased since the implementation of the modified survey, suggesting that refinement of the survey was successful in increasing response rates. In addition, the research team has been collaborating with the PI and BOP staff to create a paper version of the survey with the hopes of increasing the accessibility of the survey to both students and parents. Thus, the researchers will continue to identify and implement improvements to the data collection strategy to capture a larger number of participant responses.

I. Research Objectives

Project overview

The Billion Oyster Project (BOP) Curriculum and Community Enterprise for Restoration Science (BOP-CCERS) in New York Harbor project aims to advance the efforts of the National Science Foundation (NSF) Innovative Technology Experiences for Students and Teachers (ITEST) program. The objectives of this CCERS ITEST project are to better understand and promote practices that increase student motivation and preparation to pursue careers in the fields of science, technology, engineering, or mathematics (STEM) by expanding and testing an innovative curriculum model that features locally relevant problem-based learning. The current CCERS ITEST project is in its third round of funding from NSF (Award # = 1759006) and is currently in its fourth and final year, which is a no-cost extension year (project awarded February 23, 2018 to February 28, 2022).

The research team collaborated with the project PI and relevant stakeholders to identify the most feasible ways to embed data collection into the program activities and adapt to rapid changes in external circumstances. The CCERS curriculum model is organized around habitat restoration in New York harbor and engages students and teachers in a sequence of activities that span the middle and high school grades of the nation's largest urban school system. BOP has continued to run limited, socially distanced in-person activities during the COVID-19 pandemic and adapted activities for digital delivery. Students continue to conduct field research in support of restoring native oyster habitats with special emphasis on various science disciplines that include geology, biology, and environmental sciences to bridge the scientific knowledge gap of these particular subjects

The project has a broad partnership of institutions and community resources, including Pace University, the New York City Department of Education, the Columbia University Lamont-Doherty Earth Observatory, the New York Academy of Sciences, the New York Harbor Foundation, the New York Aquarium, and others. This project builds on and extends the BOP library of learning materials of the New York Harbor School. Below is a map that demonstrates the reach of the CCERS ITEST project.

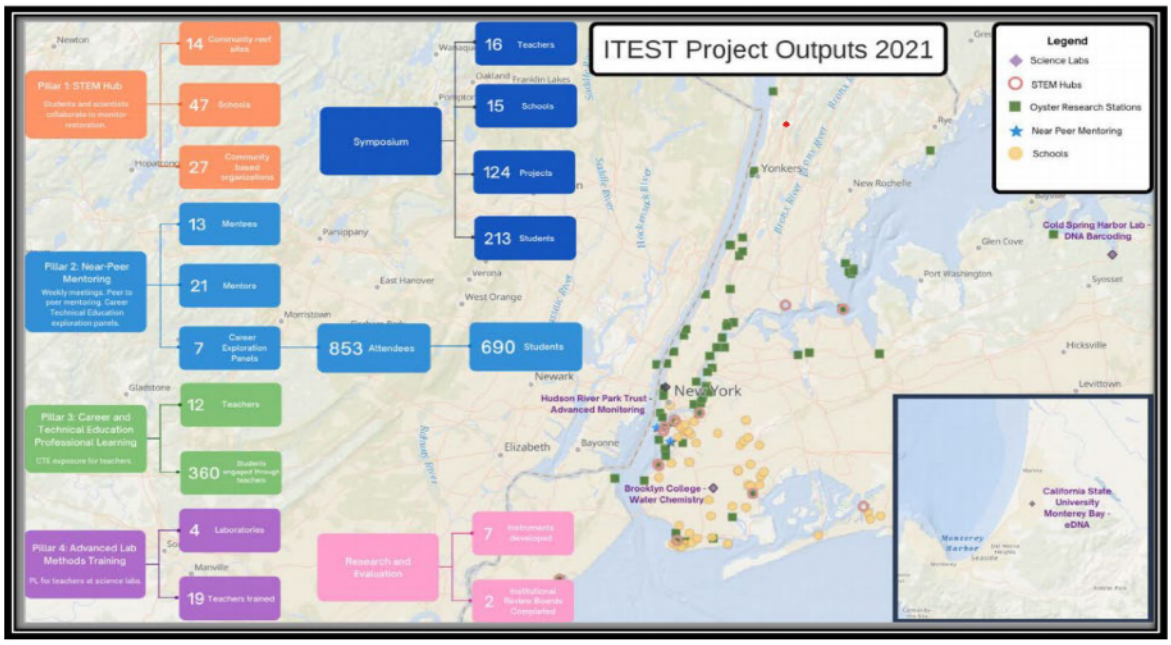


Figure 1. CCERS ITEST project output

Research Questions

As part of this project, the research team works with the evaluation team curriculum developers, digital platform administrators, BOP, and teachers to identify effective program implementation and assess the effectiveness of participation. For this report, the research team is exploring the following two research questions:

- **Research question 1**: Does participation in CCERS activities increase students' preparation and motivation to pursue STEM careers?
- **Research question 2:** Does participation in CCERS activities increase URM students' motivation and preparation to pursue STEM careers compared to non-project participating URG students?

II. Logic Model

The research team worked with the project team to create a logic model (shown below) that depicts how the activities connect to the intended outcomes as part of the research.

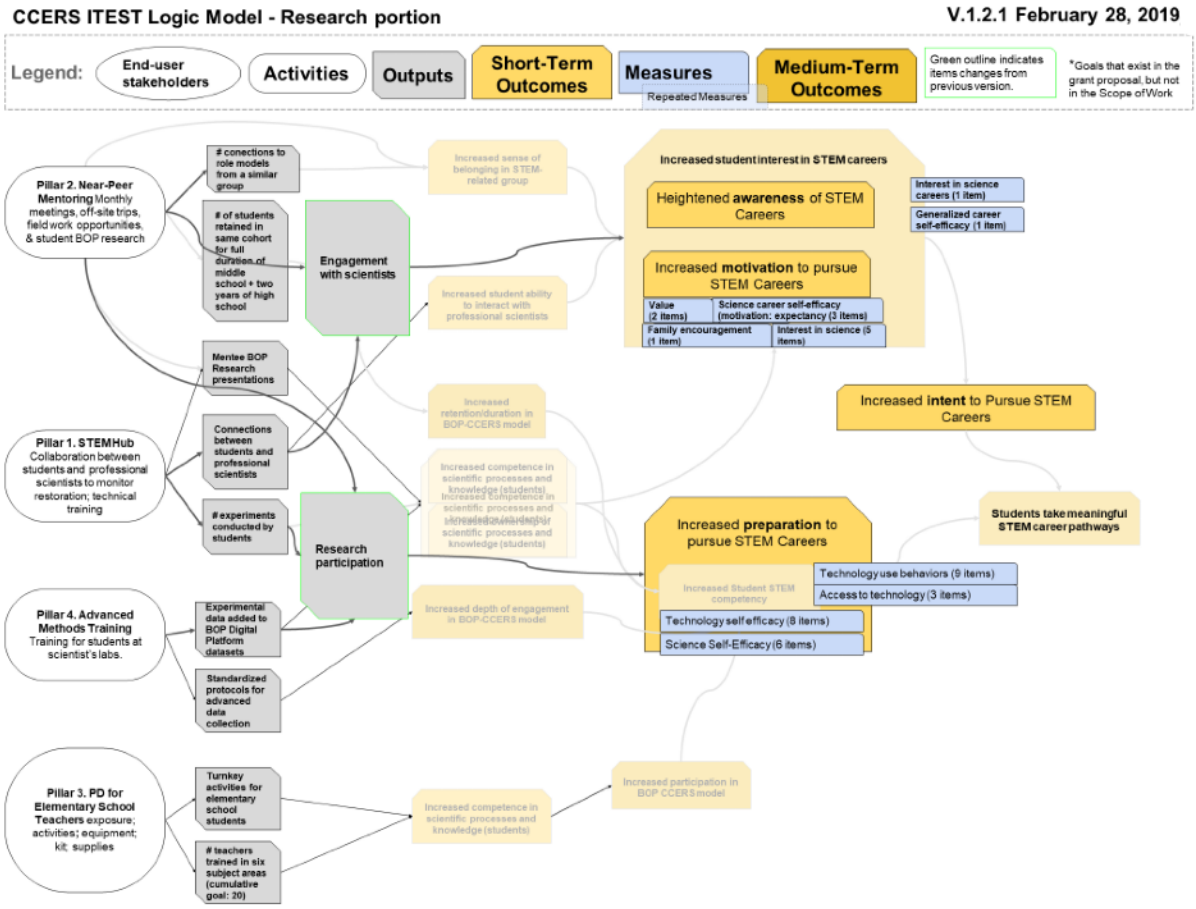


Figure 2. CCERS logic model for project research

III. Instrument Development and Research Design

The research team conducted literature reviews and worked with the project team to develop and refine metrics for data collection tools. The table below illustrates how instruments and data collection align to the research questions.

Instrument development and refinement

Researchers worked alongside the PI and other key staff to further refine the instrument used in the current phase of the project. The objective of the instrument refinement was to increase the response rate by reducing participant burden and length of time required to complete all necessary survey steps. Data collected from previous phases of the project was used to conduct item reduction analysis. The primary goal of this analysis was to obtain functional items (i.e., items that are correlated with each other, discriminate between individual cases, underscore single or multidimensional domains, and contribute significantly to the construct). This approach to instrument refinement allowed researchers to determine the effect of deleting a given item or set of items by examining the item information and standard error function for the item pool. Further, the refined instrument was evaluated by key project personnel for content relevance, representativeness, and technical quality.

Research design

Research Question	Hypothesis	Data Collection Tools and Methods	Sample
Research Question 1 (RQ1): Does participation in CCERS activities increase students' preparation and motivation to pursue STEM careers?	Hypothesis 1 (H1): Science research participation and engagement with scientists via CCERS ITEST positively influence motivation and preparation to pursue STEM careers compared to non-project participating students	▪ Student survey which contains the i) motivation to pursue STEM careers subscale, ii) preparation for STEM careers subscale, and iii) engagement with scientist subscale	Treatment group: students who participated in CCERS activities Comparison group: Students who have low to no engagement in CCERS activities (not exposed to BOP curriculum)
Research Question 2 (RQ2): Does participation in CCERS activities increase URG students' motivation and preparation to pursue STEM careers compared to non-project participating URG students?	Hypothesis 2 (H2): Science research participation and engagement with scientists via CCERS ITEST positively influence motivation and preparation to pursue STEM careers among underrepresented groups	▪ Same as those listed in RQ1 above ▪ Underrepresented groups were identified as those who self-identified as one of the following: a woman, person with disabilities, or as an underrepresented minority (Black, Hispanic, and American Indian or Alaska Native),	

Figure 3. Research design

Data collection

Data in this report was collected from January 2021 to December 11, 2021. Data was collected via an online survey (through the platform Alchemer, previously known as SurveyGizmo). The survey took the participants an average of 8 minutes to complete. The research team provided partners with a general survey link that anyone could access. Due to IRB restrictions, only middle school and high school students who provided parental consent were included in the sample. In addition, due to IRB and other restrictions, this report only examines the differences between students who participated in CCERS activities (treatment group) and students who did not participate in CCERS activities (comparison group).

Process for engaging with the online survey

Clicking on the survey link would start the respondent on a 6-step process:

- Step one: A landing page, which provided the introduction to the survey and included screening questions to ensure students met participation requirements (e.g., middle or high school student)
- Step two: Obtain parental consent for their child to participate in the research
- Step three: Obtain student assent, where the student provides their consent to participate in the research study
- Step four: An evaluation survey, that captured which activities the respondents engaged in and included questions developed by the evaluation team to collect feedback on the activities
- Step five: A research survey, which included questions specific to the research study
- Step six: Reward page, where the respondent received a certificate for completing the survey

A total of **356** students opened the survey through the general link and arrived at the landing page in Step 1. A total of **257** respondents completed all the necessary steps for the surveys (i.e., steps 2 & 3), including providing parental consent, an important IRB stipulation for responses to be included in the research analyses.

In phase 2 of the ITEST project, 503 students accessed the survey, with only 22% (111 respondents) of students completing all necessary steps to be included in the analysis. In phase 3, with the implementation of the refined instrument, 356 students accessed the survey, with 72% (257 respondents) of students completing all necessary steps (i.e., steps 2 & 3). This is a significant increase in data collection, suggesting that the refinement and item reduction of the survey was successful in increasing the participant response rate.

Survey response rate

The figure on the following page depicts the number of survey responses collected by month, with specific dates listed. Please note that not all participants provided date of survey completion.

Date	# of surveys
January	
1/5/2021	1
1/25/2021	9
1/29/2021	1
February	
2/9/2021	1
2/10/2021	1
2/15/2021	1
2/17/2021	1
2/22/2021	8
2/23/2021	8
2/24/2021	1
2/28/2021	1
March	
3/6/2021	1
3/8/2021	7
April	
4/19/2021	3
4/21/2021	12
November	
11/13/2021	8
11/17/2021	1
11/18/2021	1
11/19/2021	3
11/22/2021	8
11/24/2021	36
11/28/2021	1
11/29/2021	8
11/30/2021	7
December	
12/1/2021	73
12/3/2021	1
12/5/2021	1
12/8/2021	1
Unknown	52

Figure 4. Number of students who completed survey by month

Participant demographics

This report only includes responses from participants who provided both student assent and parental consent per the IRB requirements. A total of 257 students with parental consent and student assent completed the research and evaluation surveys. The respondent demographics can be seen in the table below.

Survey Respondents	Overall (n=257) (%)	Control (n=48) (%)	Treatment (n=209) (%)
Gender			
Male	101 (39%)	21 (44%)	80 (38%)
Female	93 (36%)	13 (27%)	80 (38%)
Do not wish to specify	13 (5%)	1 (2%)	12 (6%)
N/a	50 (19%)	13 (27%)	37 (18%)
Ethnicity			
American Indian or Alaska Native	2 (1%)	0 (0%)	2 (1%)
Asian	36 (14%)	2 (4%)	34 (16%)
Black or African American	33 (13%)	8 (17%)	25 (12%)
Hispanic/Latino	56 (22%)	11 (23%)	45 (22%)
White (non-Hispanic or Latino)	53 (21%)	12 (25%)	41 (20%)
Other	14 (5%)	2 (4%)	12 (6%)
Do not want to specify	15 (6%)	0 (0%)	15 (7%)
N/A	48 (19%)	13 (27%)	11 (5%)
First Generation			
Yes	55 (21%)	11 (23%)	44 (21%)
No	124 (48%)	17 (35%)	107 (52%)
Not sure	29 (11%)	7 (15%)	22 (11%)
N/a	49 (19%)	13 (27%)	36 (17%)
Grade			
6th	2 (1%)	2 (4%)	0 (0%)
7th	6 (2.3%)	0 (0%)	6 (3%)
8th	4 (1.6%)	0 (0%)	4 (2%)
9th	35 (14%)	19 (40%)	16 (8%)
10th	70 (27%)	3 (6%)	67 (32%)
11th	37 (14%)	6 (12%)	31 (15%)
12th	41 (16%)	5 (10%)	36 (17%)
Do not wish to specify	13 (5%)	0 (0%)	13 (6%)
N/a	49 (19%)	13 (27%)	36 (17%)

Figure 5. Demographics of respondents

In addition, researchers collected information on participants' use of technology.

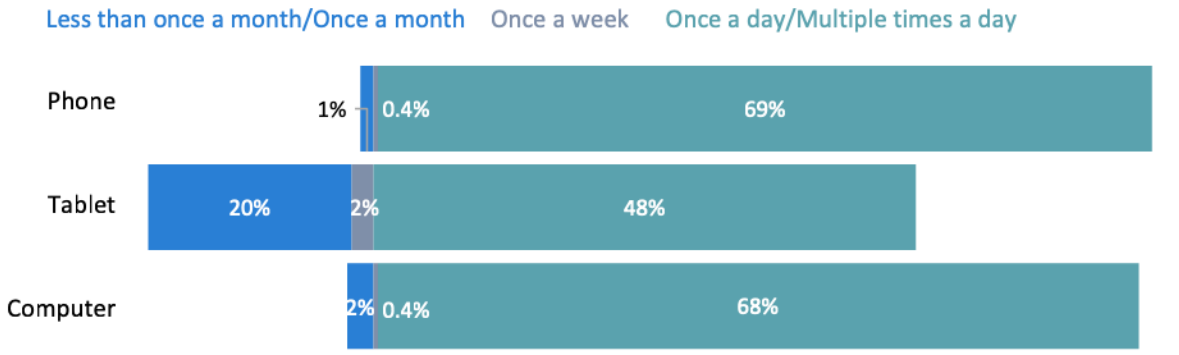


Figure 6. Phone, tablet, and computer usage. Note that about 30% of the participants did not respond to this question, thus only 179 respondents answered this question.

Data analysis

Researchers matched pre-survey responses with parental consent and survey response data. This report includes only responses from those who provided both student assent and parental consent per the IRB requirement, and completed the research and evaluation surveys (step 4 & step 5).

For Research Question 1, the sample was divided by ITEST respondents (treatment), defined by respondents who participated in CCERS activities; and a comparison group, defined as respondents who did not participate in CCERS activities. There was a total of 257 student respondents across both conditions, with 209 participants in the ITEST group and 48 in the comparison group. For Research Question 2, the sample included only respondents who identified as members of an underrepresented minority[1](URM). A total of 91 respondents across both conditions identified as part of an URM, with 72 URM respondents in the ITEST group and 19 URM respondents in the comparison group.

For each of the research questions, indices were created by averaging items on the survey's subscales (see Appendix A). Where appropriate, the research team calculated Cronbach's alpha to ensure internal consistency. In addition, researchers examined the data used for normality of distribution, as assessed by Shapiro-Wilk's test, extreme outliers in the data, as assessed by boxplot method, and equality of variance, as assessed by Levene's test. For continuous data that did not meet the assumptions of normality, the Mann-Whitney U test was used, and for categorical data, Fisher's exact test was used. The research team presented the means and standard deviations of the indices for each group identified. Please note that sample size may vary in different sections because not every respondent answered every question (or a "N/A" option was chosen).

[1] Per NSF definition, three racial and ethnic groups—Black, Hispanic, and American Indian or Alaska Natives are considered as members of an underrepresented minority in STEM.

IV. Summary of Findings

Research question 1: Does participation in CCERS activities increase students' motivation and preparation to pursue STEM careers?

In order to assess how CCERS participation impacts respondents' motivation and preparation to pursue STEM careers, researchers examined respondents' scientific identity (motivation) and STEM career interest (motivation), general engagement (preparation), and engagement in scientific activities (preparation). ITEST respondents, on average, had higher scores of scientific identity (motivation) and higher levels of preparation, with higher average scores of general engagement and engagement in scientific activities, than the comparison group respondents. Though non-significant, the comparison group had slightly higher average scores of career interest than the ITEST group. Results are presented below. Individual item response frequencies by the condition are provided in Appendix B through Appendix D.

Scientific identity (motivation)

Respondents answered four questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their scientific identity. Cronbach's alpha was run to examine internal validity (.80), and then items were averaged to compute an index, with higher average scores representing higher scientific identity. On average, the ITEST group expressed a higher sense of scientific identity (n= 209, M=3.94, SD=0.75 than the comparison group (n=48, M=3.82, SD= 1.23).

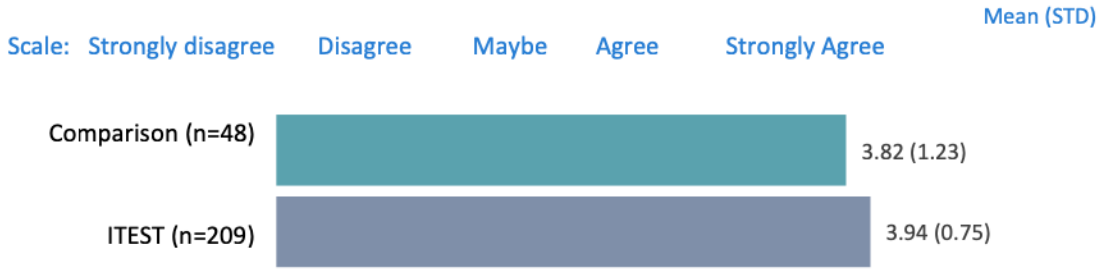


Figure 7. Average scientific identity of respondents from the ITEST and comparison groups

STEM career interest (motivation)

Respondents answered two questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their interest in pursuing careers related to STEM. Items were averaged to compute an index of career interest. Though non-significant, the comparison group expressed a slightly higher motivation in pursuing STEM careers (n=48 M= 3.92, SD= 0.78) than the ITEST group (n=209, M=3.79, SD= 0.90).

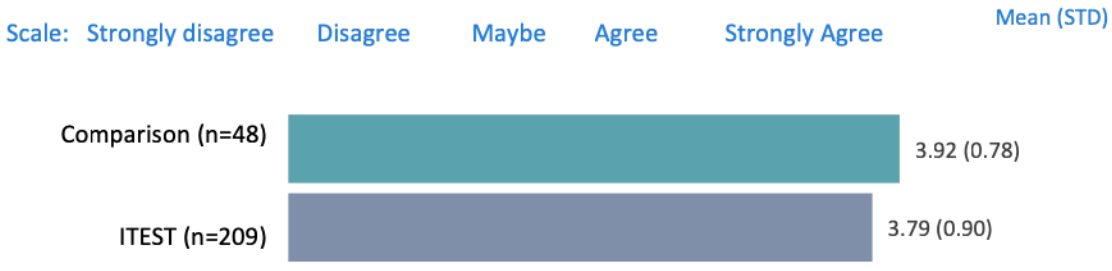


Figure 8. Average career interest of respondents from the ITEST and comparison groups

General engagement (preparation)

Respondents answered one question on a Likert scale with ratings from 1 = not at all engaged with a scientist to 5= extremely engaged with scientists regarding their general engagement with a scientist. On average, the ITEST group expressed a higher sense of general engagement with scientist (n= 209, M=3.08, SD=1.06) then the comparison group (n=48, M=2.82, SD= 1.21).

Figure 9. Average general engagement of respondents from the ITEST and comparison groups

Engagement in scientific activities (preparation)

Respondents answered five yes or no questions on whether they had participated in a variety of scientific activities in the past 12 months (e.g., attended scientist talks, read scientific articles, listened to a scientific podcast). Fisher's exact test revealed that respondents in the ITEST group were significantly more likely to say that they had received guidance on projects from a scientist (40%, $p<.01$) than respondents from the comparison group (13%). In addition, ITEST respondents reported a higher average number of scientific activities engaged in (n=61, M=1.60, SD=0.10) than the comparison group (n=30, M=1.20, SD=0.29).

Figure 10. Average engagement in scientific activities of respondents from the ITEST and comparison groups

Research question 2: Does participation in CCERS activities increase URM students' motivation and preparation to pursue STEM careers compared to non-project participating URM students?

To understand the impacts of CCERS participation on URM preparation and motivation to pursue STEM careers, researchers assessed participants' scientific identity (motivation), STEM career interest (motivation), general engagement (preparation), and engagement in scientific activities (preparation). URM ITEST respondents, on average, reported higher levels of scientific identity (motivation) and engagement in scientific activities (preparation). Though non-significant, the URM comparison group on average, had higher reported levels of career interest (motivation) and general engagement (preparation). Results are presented below. Individual item response frequencies by the condition are provided in Appendix E through Appendix G.

Scientific identity (motivation)

Respondents answered four questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their scientific identity. Cronbach's alpha was run to examine internal validity (.76), and then items were averaged to compute an index. On average, URM ITEST respondents (n= 72) expressed a higher sense of scientific identity (M=3.87, SD =0.71), than the URM comparison group respondents (n=19, M=3.64, SD=0.65).

Figure 11. Average scientific identity of respondents from the URM ITEST and URM comparison groups

STEM career interest (motivation)

Respondents answered two questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their interest in pursuing careers related to STEM. Items were averaged to compute an index of career interest. On average, URM respondents in the comparison group (n= 19) expressed a slightly higher STEM career interest (M=3.90 SD =0.70), than URM ITEST respondents (n= 72, M=3.73, SD=0.90).

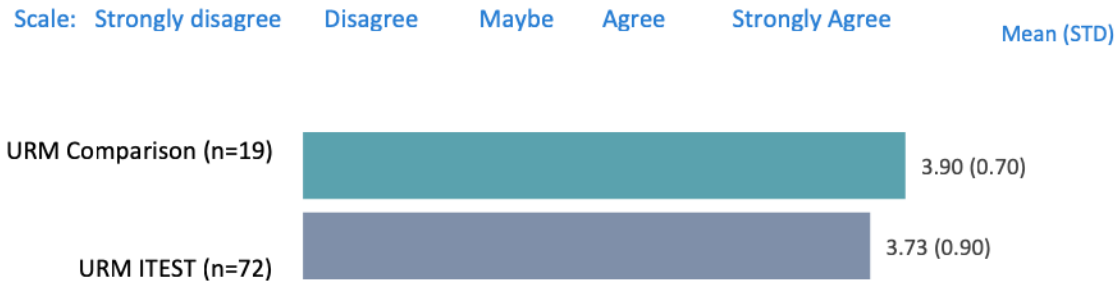


Figure 12. Average STEM career interest of respondents from the URM ITEST and URM comparison groups

General engagement (preparation)

Respondents answered one question on a Likert scale with ratings from 1 = not at all engaged with a scientist to 5= extremely engaged with scientists regarding their general engagement with a scientist. Though non-signigicant, on average, the URM comparison group respondents (n=19) expressed a slightly higher general engagement level with scientists (M=3.05, SD =1.20), than URM ITEST respondents (n= 72, M=2.96, SD=1.00).

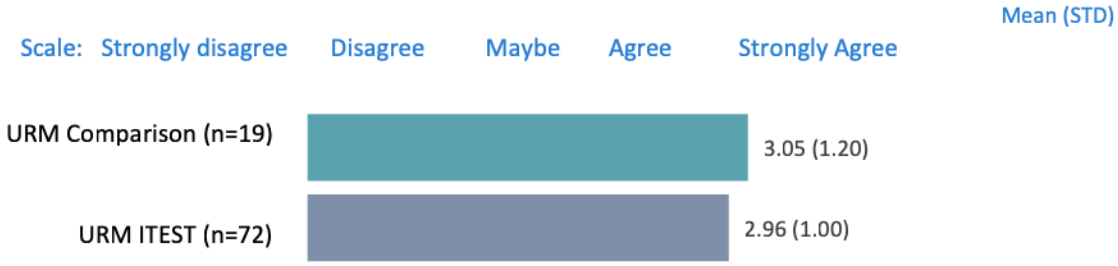


Figure 13. Average general engagement of respondents from the URM ITEST and URM comparison groups

Engagement in scientific activities (preparation)

Respondents answered five yes or no questions on whether they had participated in a variety of scientific activities in the past 12 months (e.g., attended scientist talks, read scientific articles, listened to a scientific podcast). On average, URM ITEST respondents (n=53) reported a higher average number of scientific activities engaged in (M=1.46, SD=0.28) than URM respondents in the comparison group (n=19, M=1.20, SD=0.29).

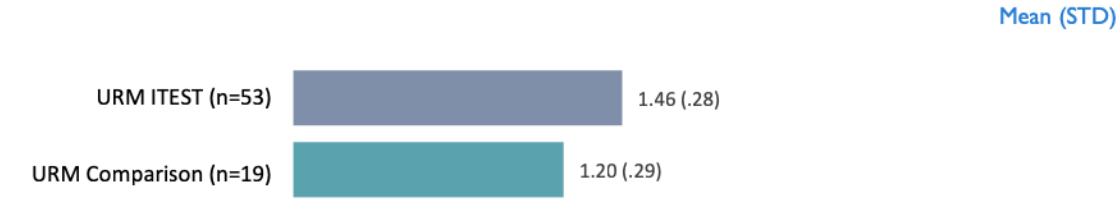


Figure 14: Average scientific activities engaged in by URM ITEST respondents and the URM comparison groups

Conclusion

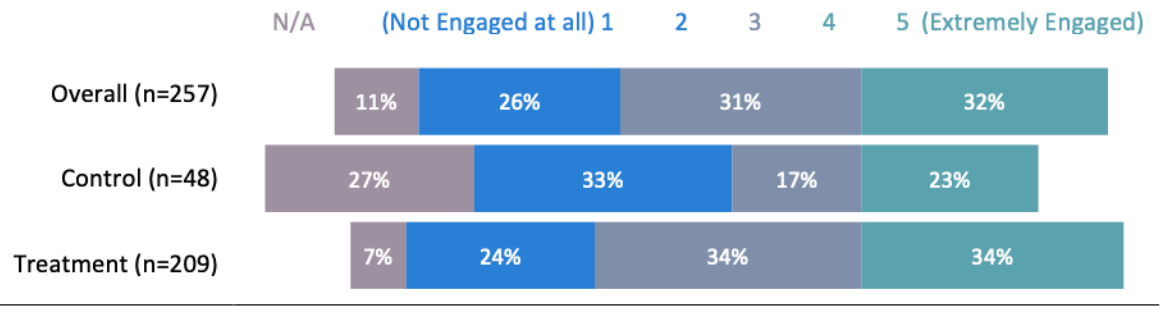
Analysis results indicate that ITEST respondents, on average, have higher engagement than those from the comparison group, which is expected given they are provided more opportunities to learn about STEM through participating in CCERS activities, engaging with scientists, and receiving

guidance from mentors than the comparison group students. In addition, though not statistically significant, the comparison group reported a slightly higher average in their motivation to pursue STEM careers; thus, researchers will continue to work with key project staff to identify avenues of programmatic improvement and continue to collect participant data, such as participation intensity, the timing of the survey, dosage effects, and STEM interest prior to participating in activities, to better understand the findings.

Appendix A: ITEST Survey Questions

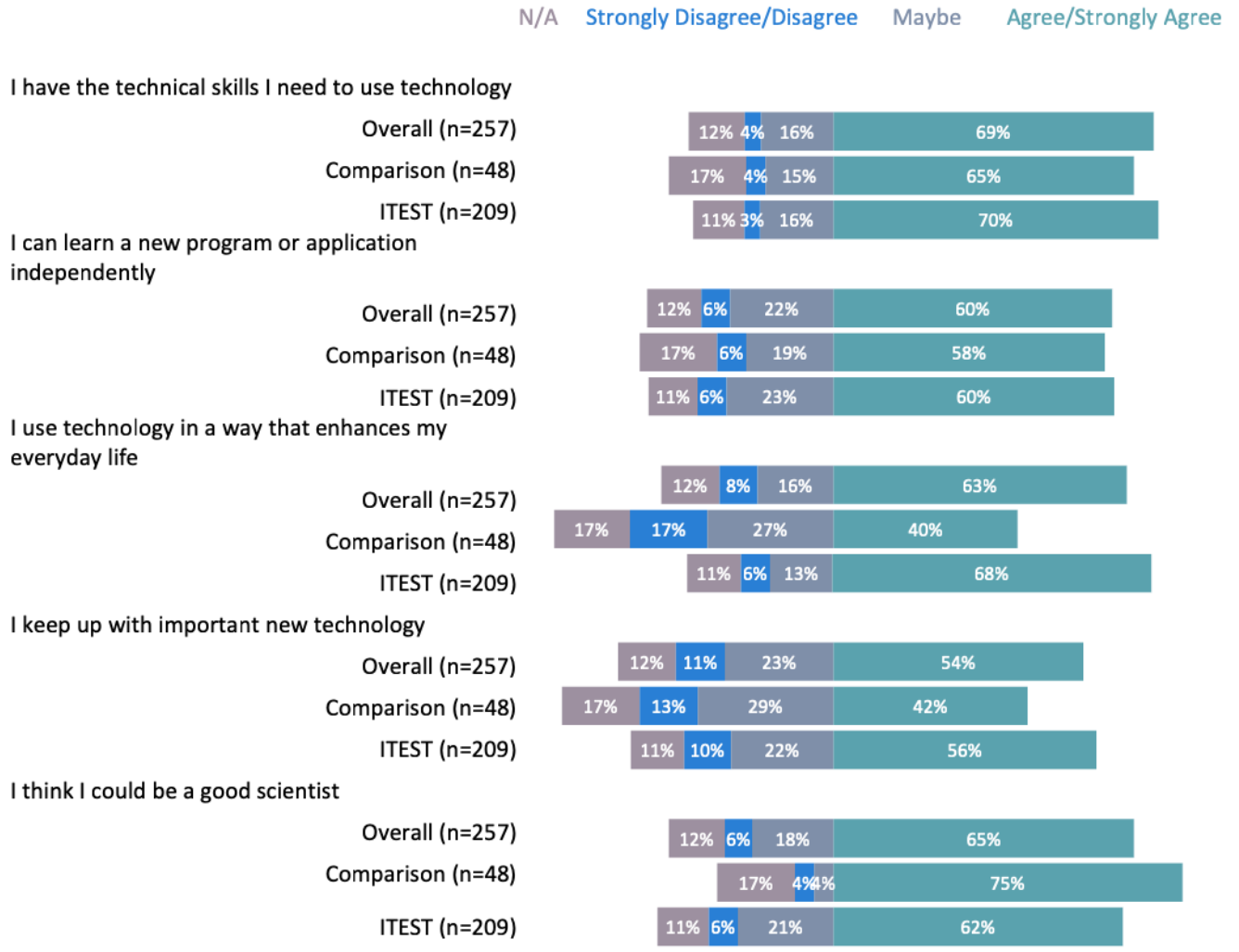
Scientific identity		
	I have the technical skills I need to use technology	1 = strongly disagree to 5= strongly agree
	I like learning a new program or application (app) independently	1 = strongly disagree to 5= strongly agree
	I use technology in a way that enhances my everyday life	1 = strongly disagree to 5= strongly agree
	Keeping up with new technologies is important to me	1 = strongly disagree to 5= strongly agree
Career interest		
	How interested are you in jobs related to science?	1 = strongly disagree to 5= strongly agree
	How interested are you in jobs relate to technology?	1 = strongly disagree to 5= strongly agree
General engagement		
	How would you rate your level of engagement with a scientist in general?	1 = not at all engaged to 5= extremely engaged
Engagement in scientific activities		
	Have you participated in the last 12 months: Received direct guidance on projects from a scientist	Yes/No
	Have you participated in the last 12 months: Watched videos made by scientist	Yes/No
	Have you participated in the last 12 months: Attended any talks where a scientist spoke	Yes/No
	Have you participated in the last 12 months: Read articles written by scientist	Yes/No
	Have you participated in the last 12 months: Listened to podcast by scientist	Yes/No

Appendix B: Overall level of engagement item response frequencies by condition



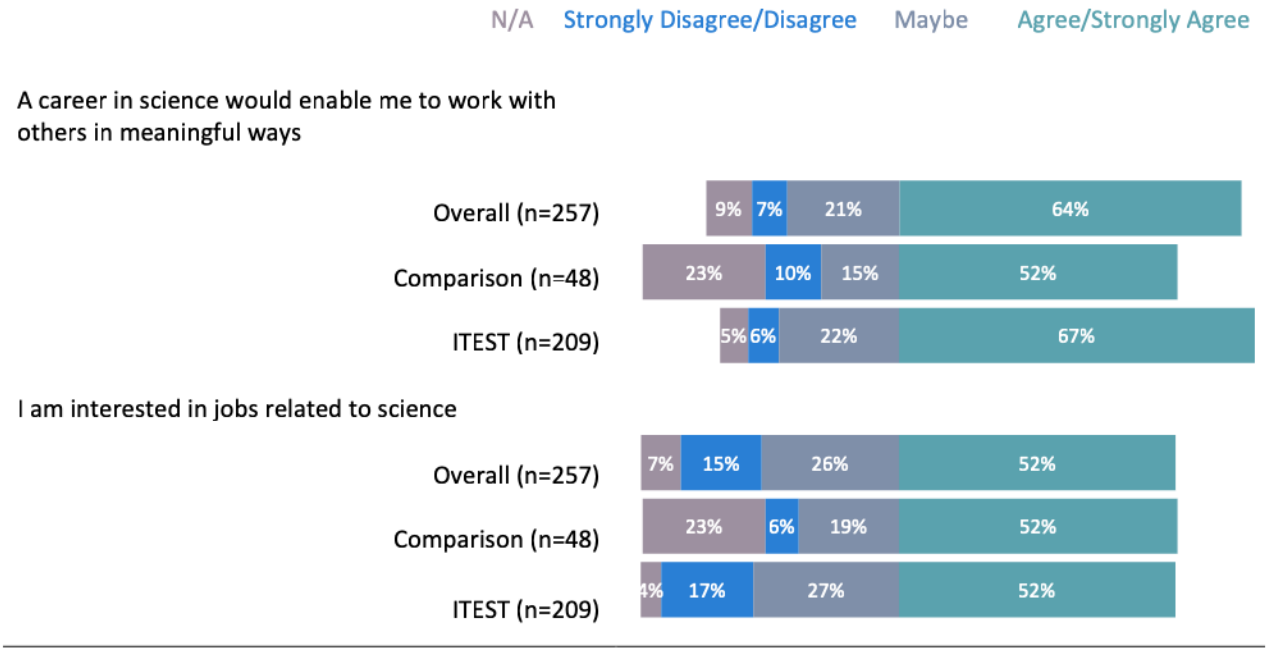
Overall level of engagement with scientists

Appendix C: Scientific identity individual item response frequencies by condition



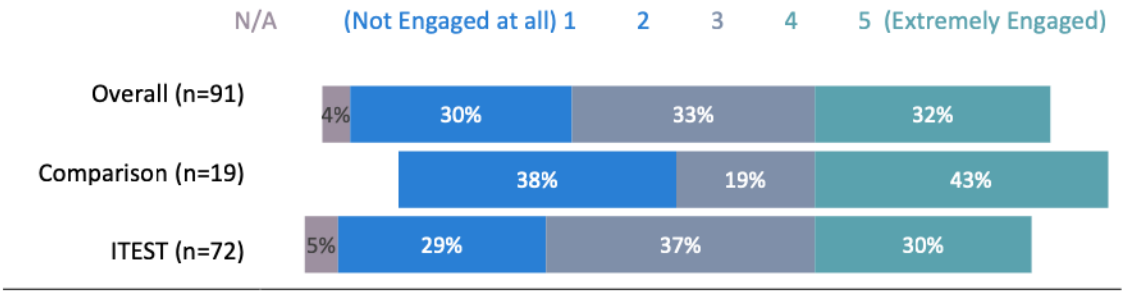
Scientific identity

Appendix D: Career interest individual item response frequencies by condition



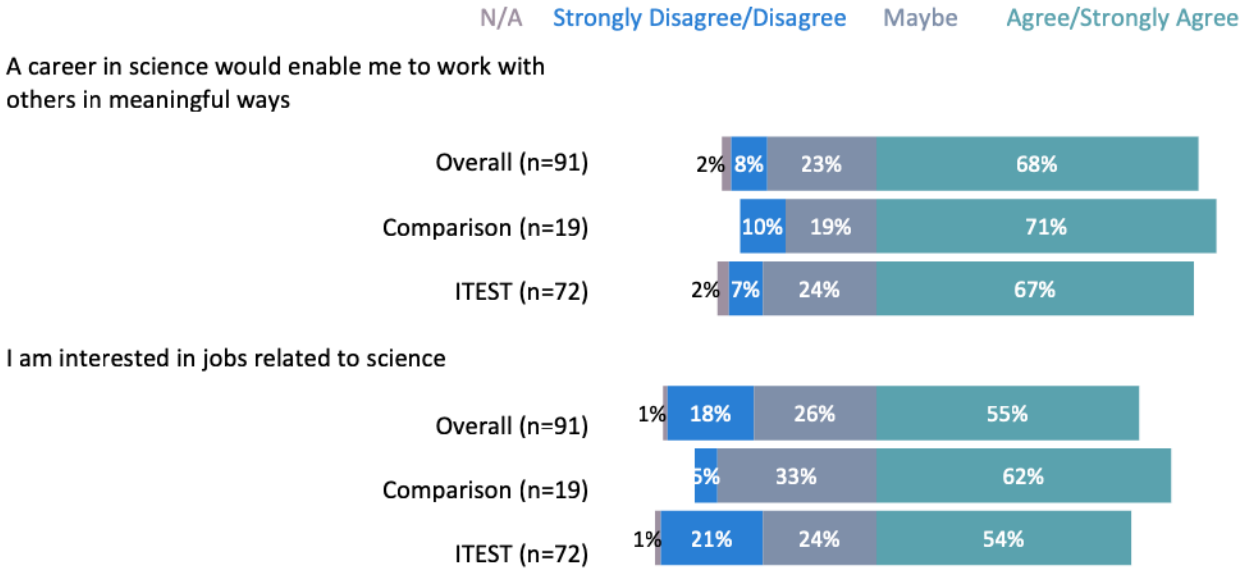
Career interest

Appendix E: URM overall level of engagement item response frequencies by condition



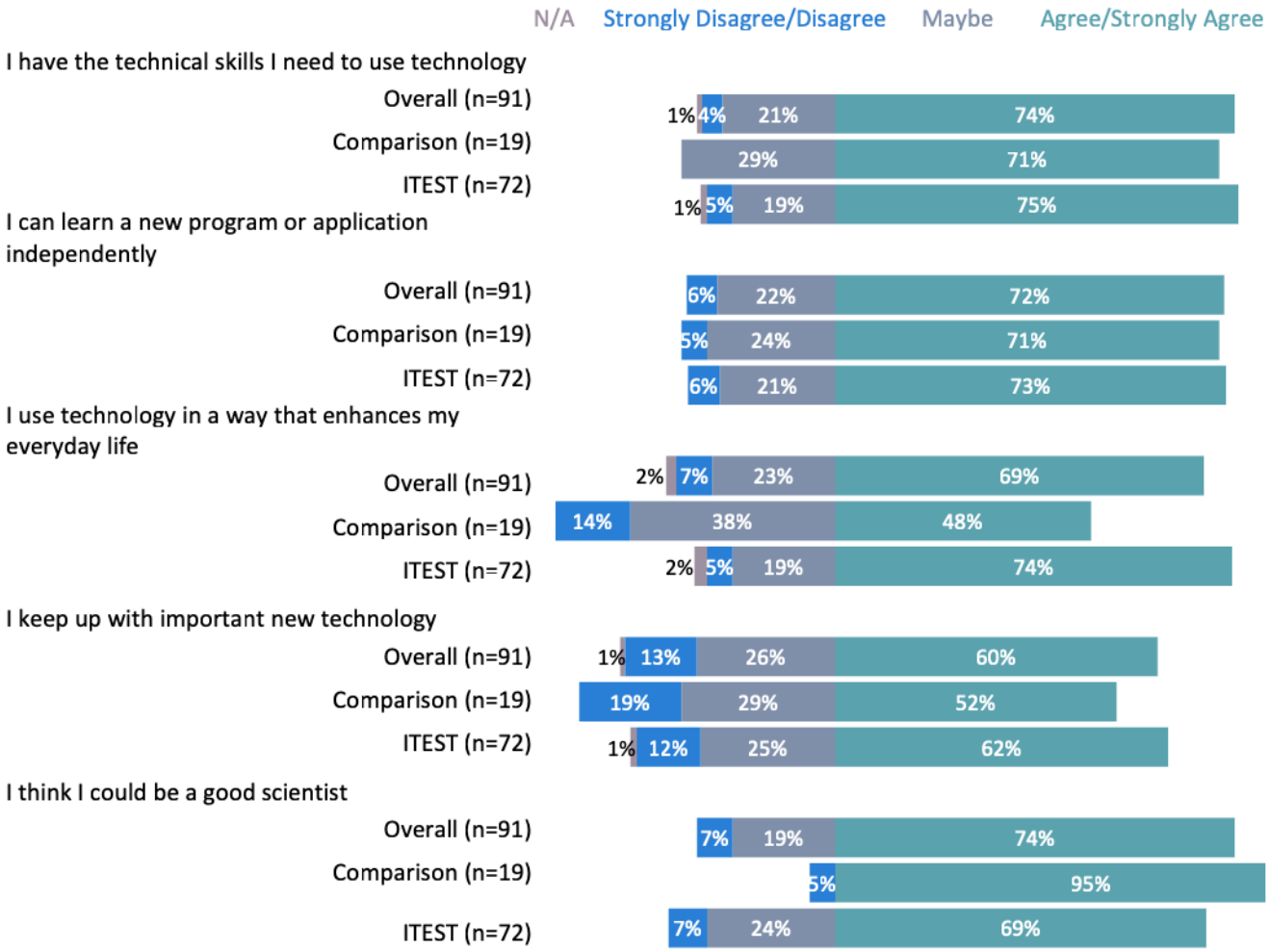
URM overall level of engagement with scientists

Appendix F: URM career interest individual item response frequencies by condition



URM Career interest

Appendix G: URM scientific identity individual item response frequencies by condition



URM scientific identity