The Impacts of an Undergraduate Research Program in the Geosciences for Minority STEM Students

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Abstract

The National Science Foundation Research Experiences for Undergraduates (NSF REU) Program at New York City College of Technology (City Tech) has supported undergraduate research from years 2013-2018. With the need to increase minority representation in the geosciences, City Tech's REU program focused on satellite and ground-based remote sensing research conducted at the NOAA Cooperative Remote Sensing Science and Technology Center. The program is opened to all City University of New York STEM students. This study examined the impact of a summer undergraduate research program on underrepresented minority students. Data from four student cohorts was collected via pre- and post-surveys. To evaluate the effectiveness of the program, participants were asked to measure their expectations, their perceptions about research, their self-efficacy in research skills and processes, and their desires to pursue graduate school and/or a research career. The 49 students participated in the program over a four-year period. Descriptive statistics, paired-sample t-tests, and independent sample t-tests were used to analyze the self-reported responses. Results showed that by the end of the summer, students self reported significant learning gains on their research confidence, experience, and overall exposure.

Introduction

- Employment of geoscientists projected to grow 14% from 2016 to 2026 (BLS, 2018)
- There is a need to address the significant underrepresentation of minorities in the geosciences.
- For this research, *underrepresented minorities* are defined as females, African Americans, and Hispanics and *first generation* are students who are first in their family to attend college.
- National Science Foundation Research Experiences for Undergraduates (REU) Program
  - Participants must be US citizens or permanent residents
  - Undergraduates participate in active research projects
  - Host institutions include City Tech and City College
  - Students are given stipends

Research Questions

- Are there statistically significant mean difference in research expectations, in research skills and confidence, and in graduate school plans before and after the summer research experience?
- Did specific groups (based on gender, ethnic background, and generational status of students) show significantly larger benefits than the comparison group?

Literature Review

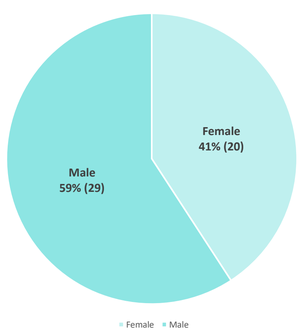
- 95% of the Arkansas Biomedical Science Institutional Development Award (IDeA) Networks of Biomedical Research Excellence (INBRE) program participants noted that the program influenced their choice of graduate school and the decision to attend. 60% of the respondents pursued graduate degrees after participating in the research program (Mcsweeney *et al.*, 2018).
- 78% of 139 participants, of which 134 were underrepresented minorities, conducting research in biomedical research in the Summer Health Disparities Research Program at Loma Linda University, enrolled in a graduate degree program (Salto *et al.*, 2014).
- 68% of students developed an interested in pursuing graduate school, with no previous graduate school intentions, during the course of their Program for Research Initiatives in Science and Math (PRISM) experience (Carpi *et al.*, 2016).
- Statistically significant increases in student's self-efficacy for four underrepresented, first-generation, low-income, and at-risk students in the Summer Undergraduate Nursing Research Immersion Experience (SUNRISE) (Patel *et al.*, 2017).

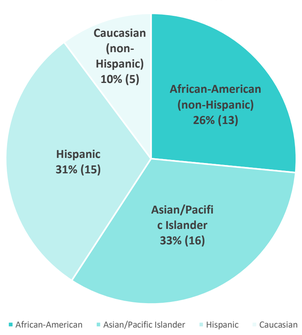
Methodology

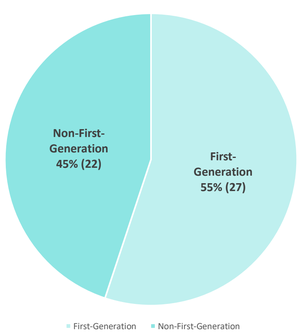
- A pre- and post-survey were given before and after the summer REU program, respectively
- 39-question survey on:
  - *Expectations*
  - *Experience, Knowledge, and Ability*
  - *Exposure to Research*
  - *Future Goals*
- 6-point Likert scale (1 indicating strong disagreement and 6 indicating strong agreement)

Statistical Analyses Used
- Descriptive Statistics
- Paired sample t-test, Independent sample t-test

	Ethnicity					
	African American	Hispanic	Asian	Caucasian	Other	Total (%)
Male	9	10	9	1	0	29 (59%)
Female	4	5	7	4	0	20 (41%)
Minority	13	15	-	-	-	28 (57%)
Majority	-	-	16	5	0	21 (43 %)
First-Generation	10	6	10	1	0	27 (55 %)
Non-First-Generation	3	9	6	4	0	22 (45 %)



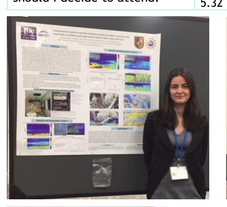


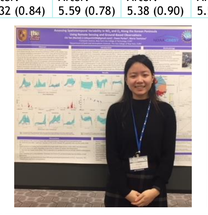


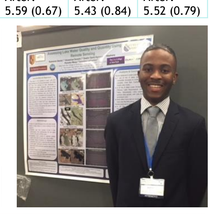
Results

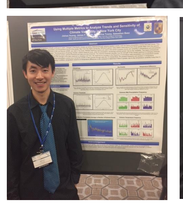
(Note: Shaded boxes indicate p<.05)	Females (n=20)	Males (n=29)	Minority (n=28)	Non-Minority (n=21)	First Generation (n=27)	Non-First Generation (n=22)
EXPECTATIONS: I EXPECT THE REU EXPERIENCE… (Shaded results indicate significant mean differences at p<.05)						
To be challenging.	Before: 5.76 (0.44) After: 5.46 (0.80)	Before: 5.21 (1.23) After: 5.55 (1.06)	Before: 5.21 (1.23) After: 5.66 (0.61)	Before: 5.76 (0.44) After: 5.32 (1.25)	Before: 5.56 (1.01) After: 5.57 (0.74)	Before: 5.32 (1.00) After: 5.44 (1.16)
To provide me with faculty mentorship.	Before: 5.95 (0.22) After: 5.41 (0.85)	Before: 5.63 (1.04) After: 5.66 (0.97)	Before: 5.67 (1.04) After: 5.62 (0.73)	Before: 5.91 (0.30) After: 5.46 (1.14)	Before: 5.70 (0.99) After: 5.50 (0.75)	Before: 5.86 (0.48) After: 5.61 (1.12)
To help me to better understand how to conduct research.	Before: 5.86 (0.48) After: 5.77 (0.61)	Before: 5.71 (1.01) After: 5.72 (0.96)	Before: 5.71 (1.01) After: 5.86 (0.44)	Before: 5.86 (0.48) After: 5.59 (1.14)	Before: 5.70 (1.03) After: 5.75 (0.59)	Before: 5.86 (0.47) After: 5.74 (1.05)
To encourage me to pursue my own academic interests.	Before: 5.76 (0.54) After: 5.68 (0.72)	Before: 5.71 (0.98) After: 5.62 (0.98)	Before: 5.71 (1.01) After: 5.83 (0.47)	Before: 5.76 (0.44) After: 5.41 (1.18)	Before: 5.59 (1.01) After: 5.68 (0.67)	Before: 5.91 (0.43) After: 5.61 (1.08)
To provide opportunities to interact with undergraduate and graduate students who have research interests similar to mine.	Before: 5.91 (0.30) After: 5.64 (1.09)	Before: 5.54 (1.04) After: 5.66 (1.01)	Before: 5.64 (1.03) After: 5.69 (1.00)	Before: 5.76 (0.44) After: 5.59 (1.10)	Before: 5.63 (1.01) After: 5.64 (1.03)	Before: 5.77 (0.53) After: 5.65 (1.07)
To provide opportunities to interact with research scientists.	Before: 5.81 (0.51) After: 5.68 (0.72)	Before: 5.57 (1.10) After: 5.62 (0.98)	Before: 5.64 (1.03) After: 5.79 (0.62)	Before: 5.71 (0.72) After: 5.46 (1.10)	Before: 5.59 (1.12) After: 5.82 (0.39)	Before: 5.77 (0.53) After: 5.44 (1.20)
EXPERIENCE, KNOWLEDGE, AND ABILITY (Shaded results indicate significant mean differences at p<.05)						
I am familiar with remote sensing.	Before: 3.43 (1.81) After: 5.00 (1.27)	Before: 3.25 (1.76) After: 5.00 (0.94)	Before: 3.21 (1.81) After: 4.90 (1.05)	Before: 3.48 (1.72) After: 5.14 (1.15)	Before: 3.22 (1.58) After: 4.89 (1.09)	Before: 3.46 (1.99) After: 5.13 (1.10)
I have experience using MATLAB.	Before: 3.24 (1.73) After: 5.14 (1.21)	Before: 3.46 (1.97) After: 4.93 (0.92)	Before: 3.14 (2.01) After: 4.83 (1.14)	Before: 3.67 (1.62) After: 5.27 (0.88)	Before: 3.11 (2.01) After: 5.00 (1.19)	Before: 3.68 (1.64) After: 5.04 (0.88)
I am familiar with Geographic Information Systems.	Before: 2.81 (1.86) After: 4.59 (1.14)	Before: 2.86 (1.56) After: 4.75 (1.04)	Before: 2.79 (1.75) After: 4.69 (1.11)	Before: 2.91 (1.61) After: 4.67 (1.07)	Before: 2.56 (1.60) After: 4.56 (1.01)	Before: 3.18 (1.74) After: 4.83 (1.15)
I know statistical concepts.	Before: 4.12 (1.73) After: 4.94 (0.75)	Before: 3.86 (1.52) After: 5.23 (0.92)	Before: 3.86 (1.62) After: 5.14 (0.96)	Before: 4.11 (1.61) After: 5.06 (0.73)	Before: 3.82 (1.81) After: 5.24 (0.75)	Before: 4.09 (1.45) After: 5.00 (0.93)
I have had experience working with others on a research team.	Before: 4.38 (2.04) After: 5.36 (1.05)	Before: 4.30 (1.96) After: 5.59 (0.83)	Before: 4.11 (2.06) After: 5.66 (0.48)	Before: 4.62 (1.86) After: 5.27 (1.28)	Before: 4.33 (1.94) After: 5.57 (0.69)	Before: 4.33 (2.06) After: 5.39 (1.16)
I understand factors that should be taken into account for successful teamwork.	Before: 5.48 (0.68) After: 5.68 (0.65)	Before: 5.64 (0.56) After: 5.62 (0.98)	Before: 5.71 (0.54) After: 5.76 (0.44)	Before: 5.83 (0.67) After: 5.50 (1.19)	Before: 5.63 (0.49) After: 5.68 (0.61)	Before: 5.50 (0.74) After: 5.61 (1.08)
FUTURE GOALS (Shaded results indicate significant mean differences at p<.05)						
I place a high value on the role of research in my future career.	Before: 5.48 (0.68) After: 5.50 (0.60)	Before: 5.36 (0.78) After: 5.57 (0.69)	Before: 5.43 (0.74) After: 5.52 (0.69)	Before: 5.38 (0.74) After: 5.57 (0.60)	Before: 5.33 (0.68) After: 5.48 (0.64)	Before: 5.50 (0.80) After: 5.61 (0.66)
I would be interested in enrolling in more courses related to research.	Before: 5.19 (1.03) After: 5.36 (1.05)	Before: 5.25 (0.80) After: 5.33 (0.88)	Before: 5.29 (0.76) After: 5.38 (0.82)	Before: 5.14 (1.06) After: 5.30 (1.13)	Before: 5.07 (1.00) After: 5.22 (1.01)	Before: 5.41 (0.73) After: 5.50 (0.86)
Developing research skills is an important part of my career goals.	Before: 5.62 (0.74) After: 5.46 (1.01)	Before: 5.50 (0.79) After: 5.66 (0.55)	Before: 5.64 (0.68) After: 5.55 (0.69)	Before: 5.43 (0.87) After: 5.59 (0.91)	Before: 5.41 (0.80) After: 5.46 (0.92)	Before: 5.73 (0.70) After: 5.70 (0.56)
I would be interested in doing research in an university setting.	Before: 5.62 (0.59) After: 5.64 (0.58)	Before: 5.61 (0.63) After: 5.54 (0.64)	Before: 5.64 (0.56) After: 5.48 (0.57)	Before: 5.57 (0.68) After: 5.71 (0.64)	Before: 5.52 (0.64) After: 5.52 (0.64)	Before: 5.73 (0.55) After: 5.65 (0.57)
I would like to obtain a Master's degree in a science field.	Before: 5.60 (0.68) After: 5.75 (0.44)	Before: 5.69 (0.62) After: 5.75 (0.65)	Before: 5.63 (0.63) After: 5.71 (0.66)	Before: 5.68 (0.67) After: 5.80 (0.41)	Before: 5.56 (0.70) After: 5.78 (0.42)	Before: 5.79 (0.54) After: 5.71 (0.72)
I would like to obtain a Ph.D. degree in a science field.	Before: 5.16 (1.02) After: 5.35 (0.81)	Before: 5.08 (1.29) After: 5.25 (1.14)	Before: 5.14 (1.27) After: 5.25 (1.11)	Before: 5.06 (1.03) After: 5.35 (0.88)	Before: 5.04 (1.00) After: 5.33 (0.92)	Before: 5.21 (1.40) After: 5.24 (1.14)
I would like to attend graduate school majoring the geosciences.	Before: 4.39 (1.50) After: 4.40 (1.67)	Before: 4.17 (1.20) After: 4.32 (1.28)	Before: 4.12 (1.42) After: 4.40 (1.53)	Before: 4.47 (1.18) After: 4.28 (1.36)	Before: 4.04 (1.15) After: 4.40 (1.44)	Before: 4.53 (1.50) After: 4.30 (1.49)
I would like to attend graduate school in another field.	Before: 3.62 (1.91) After: 4.05 (1.66)	Before: 4.62 (1.17) After: 4.63 (1.64)	Before: 4.43 (1.35) After: 4.33 (1.66)	Before: 3.79 (1.90) After: 4.43 (1.69)	Before: 4.42 (1.47) After: 4.50 (1.61)	Before: 3.86 (1.74) After: 4.23 (1.74)
I would like to work before going to graduate school.	Before: 4.05 (1.43) After: 3.55 (1.74)	Before: 4.35 (1.60) After: 4.36 (1.45)	Before: 4.41 (1.42) After: 4.03 (1.45)	Before: 3.95 (1.65) After: 3.95 (1.86)	Before: 4.15 (1.56) After: 4.25 (1.40)	Before: 4.32 (1.49) After: 3.61 (1.84)
I am not interested in graduate school.	Before: 1.17 (0.51) After: 1.23 (0.43)	Before: 1.82 (1.47) After: 1.72 (1.44)	Before: 1.60 (1.44) After: 1.45 (1.12)	Before: 1.50 (0.89) After: 1.59 (1.18)	Before: 1.62 (1.20) After: 1.36 (0.62)	Before: 1.47 (1.26) After: 1.70 (1.55)

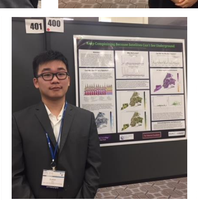
EXPOSURE TO RESEARCH (Shaded results indicate significant mean differences at p<.05)						
I had completed a remote sensing course.	Before: 2.00 (1.75) After: 4.27 (2.16)	Before: 1.48 (1.39) After: 5.24 (1.43)	Before: 1.56 (1.39) After: 4.86 (1.77)	Before: 1.89 (1.78) After: 4.77 (1.95)	Before: 1.17 (0.39) After: 4.64 (1.93)	Before: 2.30 (2.11) After: 5.04 (1.72)
I have been involved in a research project.	Before: 4.60 (1.98) After: 5.50 (1.23)	Before: 4.67 (1.98) After: 5.79 (0.68)	Before: 4.50 (2.06) After: 5.59 (1.12)	Before: 4.84 (1.83) After: 5.77 (0.69)	Before: 4.72 (1.86) After: 5.57 (1.14)	Before: 4.55 (2.11) After: 5.78 (0.67)
I have been required to make presentations.	Before: 5.50 (1.19) After: 5.68 (0.84)	Before: 5.61 (0.63) After: 5.93 (0.26)	Before: 5.44 (1.12) After: 5.79 (0.73)	Before: 5.71 (0.46) After: 5.86 (0.35)	Before: 5.48 (1.05) After: 5.82 (0.67)	Before: 5.67 (0.66) After: 5.83 (0.49)
I have attended a professional science/mathematics conference.	Before: 3.33 (2.40) After: 4.80 (1.85)	Before: 4.31 (2.17) After: 4.81 (1.88)	Before: 3.82 (2.37) After: 5.04 (1.71)	Before: 4.06 (2.22) After: 4.50 (2.01)	Before: 3.80 (2.22) After: 4.85 (1.81)	Before: 4.05 (2.44) After: 4.74 (1.94)
I am confident in my knowledge of research methods.	Before: 4.08 (1.47) After: 5.46 (0.74)	Before: 4.46 (1.26) After: 5.19 (0.96)	Before: 4.21 (1.37) After: 5.36 (0.83)	Before: 4.38 (1.36) After: 5.24 (0.94)	Before: 4.15 (1.46) After: 5.48 (0.75)	Before: 4.46 (1.22) After: 5.09 (0.97)
I am confident in my ability to develop research questions.	Before: 4.20 (1.80) After: 5.23 (0.87)	Before: 4.50 (1.14) After: 5.29 (0.71)	Before: 4.21 (1.48) After: 5.35 (0.81)	Before: 4.6 (1.39) After: 5.14 (0.73)	Before: 4.27 (1.51) After: 5.44 (0.64)	Before: 4.50 (1.37) After: 5.04 (0.88)
I am confident in my ability to discuss research findings.	Before: 4.19 (1.78) After: 5.36 (0.85)	Before: 5.07 (0.77) After: 5.14 (0.97)	Before: 4.61 (1.40) After: 5.41 (0.78)	Before: 4.81 (1.33) After: 5.00 (1.05)	Before: 4.56 (1.55) After: 5.33 (0.78)	Before: 4.86 (1.08) After: 5.13 (1.06)
I am confident in my ability to conduct a literature review.	Before: 3.90 (1.71) After: 4.86 (0.94)	Before: 4.50 (1.07) After: 5.18 (0.72)	Before: 4.19 (1.44) After: 5.24 (0.74)	Before: 4.33 (1.35) After: 4.76 (0.89)	Before: 4.07 (1.57) After: 5.11 (0.80)	Before: 4.48 (1.12) After: 4.96 (0.88)
I am confident in my ability to present research findings.	Before: 4.38 (1.56) After: 5.27 (0.88)	Before: 4.93 (0.77) After: 5.17 (0.81)	Before: 4.71 (1.08) After: 5.38 (0.82)	Before: 4.67 (1.35) After: 5.00 (0.82)	Before: 4.48 (1.42) After: 5.25 (0.80)	Before: 4.96 (0.79) After: 5.17 (0.89)
I am confident in my ability to evaluate the quality of a research study.	Before: 4.57 (1.63) After: 4.91 (0.68)	Before: 4.50 (0.92) After: 5.14 (0.92)	Before: 4.46 (1.20) After: 5.21 (0.82)	Before: 4.62 (1.36) After: 4.82 (0.80)	Before: 4.44 (1.42) After: 5.07 (0.77)	Before: 4.64 (1.05) After: 5.00 (0.91)
I am confident in my ability to write up research for publication in a scientific journal.	Before: 3.62 (1.96) After: 4.67 (0.86)	Before: 4.11 (1.42) After: 4.82 (0.98)	Before: 3.71 (1.78) After: 4.79 (1.01)	Before: 4.14 (1.53) After: 4.70 (0.80)	Before: 3.89 (1.60) After: 4.78 (1.01)	Before: 3.91 (1.80) After: 4.73 (0.83)
Learning to do research is enjoyable.	Before: 5.43 (0.81) After: 5.59 (0.73)	Before: 5.54 (0.76) After: 5.59 (0.73)	Before: 5.56 (0.70) After: 5.69 (0.54)	Before: 5.40 (0.88) After: 5.46 (0.91)	Before: 5.32 (0.80) After: 5.64 (0.62)	Before: 5.68 (0.72) After: 5.52 (0.85)
I find research to be challenging.	Before: 5.19 (0.75) After: 5.14 (0.89)	Before: 4.85 (1.32) After: 5.62 (0.62)	Before: 4.78 (1.31) After: 5.41 (0.78)	Before: 5.29 (0.72) After: 5.41 (0.80)	Before: 4.96 (1.11) After: 5.46 (0.79)	Before: 5.05 (1.13) After: 5.35 (0.78)
I am confident in my ability to design a research poster.	Before: 4.86 (1.49) After: 5.59 (0.50)	Before: 4.96 (1.04) After: 5.25 (0.97)	Before: 4.75 (1.48) After: 5.48 (0.69)	Before: 5.14 (0.79) After: 5.29 (0.96)	Before: 4.78 (1.37) After: 5.48 (0.64)	Before: 5.09 (1.07) After: 5.30 (0.97)
I am confident in my understanding of ethics in science.	Before: 4.91 (1.04) After: 5.32 (0.72)	Before: 5.14 (1.08) After: 5.39 (0.74)	Before: 5.00 (1.09) After: 5.28 (0.80)	Before: 5.10 (1.04) After: 5.48 (0.60)	Before: 4.85 (0.86) After: 5.30 (0.72)	Before: 5.27 (1.24) After: 5.44 (0.73)
I am confident in my ability to prepare an application to graduate school.	Before: 4.50 (1.40) After: 4.86 (1.28)	Before: 4.50 (1.42) After: 4.93 (0.96)	Before: 4.12 (1.58) After: 4.66 (1.20)	Before: 5.00 (0.92) After: 5.23 (0.87)	Before: 4.35 (1.44) After: 4.96 (1.17)	Before: 4.70 (1.34) After: 4.83 (1.03)
I am confident in my ability to succeed in graduate school should I decide to attend.	Before: 5.63 (0.60) After: 5.32 (0.84)	Before: 5.32 (0.86) After: 5.59 (0.78)	Before: 5.48 (0.75) After: 5.38 (0.90)	Before: 5.40 (0.82) After: 5.59 (0.67)	Before: 5.31 (0.79) After: 5.43 (0.84)	Before: 5.62 (0.74) After: 5.52 (0.79)

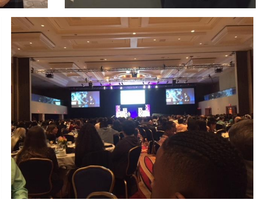












Conclusions

- Statistically significant increases in research skills, processes, and exposure were observed at the end of the summer research experience.
- CREST REU program offers underrepresented minority and first-generation students opportunities to improve their research skills and to build their confidence.
- Participation in the CREST REU program has impacted student growth in self-efficacy, research skills, exposure to the research community, and provided higher competencies in communicating effectively and thinking critically.

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