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RESEARCH AND THEORY

Breaking barriers: female and Hispanic undergraduate students experience gains in self-confidence and tolerance for obstacles during a sustainability-centered internship program in the USA

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Abstract

Previous research has shown that female and Hispanic students who are underrepresented in science, technology, engineering and mathematics (STEM) face more educational barriers than their non-Hispanic, male peers. However, little research has been conducted on the effects of intersectional identities in the STEM space. In an effort to bridge the gap in underrepresented students' experience, the PSEG Institute for Sustainability Studies organizes a paid, interdisciplinary, team-based, experiential learning and internship program called the Green Teams that occurs during 10 weeks of the summer. The Green Teams Program strives to provide undergraduate students from all backgrounds–academically, economically, and demographically–an opportunity to develop their abilities in STEM fields and prepare them to enter the professional world. Based upon a survey given post-internship, self-reported learning gains for all students were analyzed to determine if the program had a significantly greater impact on students who are from groups traditionally underrepresented in STEM in their STEM-related learning gains and their confidence in STEM disciplines. Through t-tests, a Principal Component Analysis (PCA), and a 2-way factorial Analysis of Variance (ANOVA), Hispanic and female participants were found to report significantly higher learning gains than their counterparts in multiple STEM areas from increased tolerance for obstacles to gains in self confidence. The results of the study suggest Hispanic and female students benefit from paid work experiences in STEM with diverse peers and intentional, supportive mentoring. This research on the Green Teams Program provides insight into how this approach positively impacts STEM education of individuals from traditionally underrepresented groups in STEM. The findings may help to further guide the development of the Green Teams Program and the adoption of paid, interdisciplinary, team-based, experiential learning and internship experiences in additional academic STEM settings.

Keywords Internship · Undergraduate · Underrepresented · Diversity · Environmental · Sustainability

Introduction

Science, technology, engineering, and mathematics (STEM) careers serve substantial segments of society and are in need of diversification (NCSES 2023). The number of STEM occupations constitutes a quarter of all United States (US) jobs and has been rapidly increasing, gaining six million positions from 2011 to 2021 (NCSES 2023). STEM employers value diversity, as diverse teams have been found to provide innovative solutions and raise a company's bottom line

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(Byars-Winston and Rogers 2019). Nonetheless, various minority groups are still vastly underrepresented within both the STEM workforce and academia. Women make up half of the entire bachelor-degree-holding workforce, yet a mere 29% of women work in science and engineering occupations (NCSES 2023). Hispanic individuals' share of science and engineering bachelor's degrees has consistently increased since 2011, approximately matching their 22% share in the overall college-aged population (NCSES 2023). Hispanic workers make up 17% of total employment across all occupations in the USA but only 8% of STEM workers (Fry et al. 2021). Internships in STEM fields, especially internships that furnish additional support to underrepresented groups (URGs) within STEM, can offer a significant stepping stone to graduation and STEM careers. URGs are individuals from groups whose identity is traditionally underrepresented in STEM, i.e., women and underrepresented minorities (URM). URGs include all types of people underrepresented in STEM, while URMs include people specifically with racial and/or ethnic identities whose representation in STEM employment and science and engineering education is smaller than their representation in the US population. This includes Blacks or African Americans, Hispanics or Latinos, and American Indians or Alaska Natives (NCSES 2023).

Sustainability and STEM are deeply intertwined, as almost every sustainability initiative has an impact on the STEM community and vice versa. The PSEG Institute for Sustainability Studies (PSEG ISS) at Montclair State University has been running a 10-week, paid internship program called the Green Teams since 2016 (Kay et al. 2018). The Green Teams consist of diverse groups of undergraduate students organized in teams of five, with each team serving a host organization to help address sustainability challenges. These host organizations consist of nonprofits, corporations, government agencies, and other organizations. Many of their goals are rooted in areas such as engineering, business, and community development. Throughout this full-time summer internship, PSEG ISS provides interns with training and workshops on sustainability topics, professional development, communication, and team building. The Green Teams' leadership addresses key barriers for underrepresented and minority students, providing an equitable work environment, striving to bridge the gaps that exist and build towards a just and equitable STEM workforce.

Informed by previous research on URGs within the STEM community and the barriers they face, this study strives to assess the effects of an internship experience on learning gains, looking into multiple URG identities, to assess whether Green Teams interns are gaining in skills that the program is designed to foster. Research on the Green Teams Program can also provide insights into whether the intentional program components break down unspoken barriers that students with URG identities perceive, particularly since such barriers are not always acknowledged by universities and employers. The research presented in this paper may help other programs identify tools and strategies that can help URGs transcend barriers, make the most of their undergraduate research experiences, and gain access to equal opportunities post-graduation.

Literature review

Underrepresentation in STEM has been the focus of recent research, and while there have been efforts to remedy this underrepresentation, few studies have focused on individuals with intersecting identities (Canning et al. 2019; Henkhaus et al. 2022; Kay et al. 2018; Maton et al. 2012). Intersectionality, defined as "the interconnected nature of social categorizations such as race, class, and gender as they apply to a given individual or group, regarded as creating overlapping and interdependent systems of discrimination or disadvantage," plays a significant role in how female-identifying minority students in STEM are able to access and excel in STEM careers (Oxford English Dictionary 2023; AWIS 2018). Research has shown that individuals belonging to multiple groups whose identities are not stereotype-congruent, such as Black women in STEM disciplines, face further isolation and lack a sense of belonging compared to single stereotype-incongruent groups (Charleston et al. 2014, pg. 283). When investigating the effects of stereotypes on the performance of STEM students with stereotype-congruent and stereotype-incongruent identities, it was found that the effect of stereotypes is "especially pernicious for those whose identities are both salient *and threatened* by the stereotypes." Black women who are impacted by both race and gender expressed that the culture in their respective STEM-related departments was "clearly unwelcoming to women, and even more ostracizing to African American women" (Charleston et al. 2014, pg. 282). This study also found that Black women in computing sciences faced unique harmful stereotypes in regard to their academic identity and intellectual capacity. Black women's experiences and perceptions of their role in the STEM field were distinctly different from those of Black men because Black women hold two underrepresented identities, each with their own unique stereotypes and expectations (Charleston et al. 2014; p.172). Black women's experiences in STEM academics are "noticeably different to those of their male colleagues where many of the commonly occurring barriers for women were simply non-issues for men" (O'Connell and McKinnon 2021, pg. 1). Additionally, these women reported feeling that they have to work harder to be in equal positions as their male counterparts (O'Connell and McKinnon 2021). In interviews with STEM students, it was found that White men were most likely to report a sense of belonging, whereas women of color were the least likely (Rainey et al. 2018).

Feeling isolated and the pressure to work twice as hard as one's peers can have a catastrophic effect on one's confidence, creating further separation (Rodriguez and Blaney 2021). This gap of confidence also predicts the gender pay gap among STEM students (Sterling et al. 2020). For underrepresented individuals, confidence plays a major role in their perceived ability to pursue STEM education and apply their education in STEM-related fields (Hilts et al. 2018). This notable lack of confidence to pursue STEM careers boils down to lacking a *science identity,* which can start as early as kindergarten due to underfunded STEM programs and a lack of encouragement for STEM exploration in child education through high school (Stets et al. 2017; PCAST 2010). In a study exploring racial and ethnic differences in interest, preparation, identity, and influence pertaining to environmental-focused careers, there was strong evidence that students from URGs are interested in environmental careers despite data showing that the percentage of people of color currently employed in environmental organizations is low (Taylor 2017). Students often have difficulty, especially coming from backgrounds and support systems that lack STEM role models, knowing what exactly a science career entails and seeing themselves as scientists (Nealy and Orgill 2019).

Since Hispanic students experience differences in academic preparation, a lack of representation when it comes to role models, and subtle messages of discouragement within predominantly white institutions, Hispanic students need additional support to develop strong science identities (Frederick et al. 2021). Providing this support in a Hispanic student's undergraduate career is important because many Hispanic PhD and postdoctoral students are struggling with the Imposter Phenomenon, feeling undeserving and fraudulent of their research work in their respective STEM fields (Chakraverty 2022). In order to mitigate Hispanic students' feelings of self-doubt, research and support have to be provided earlier on in a student's educational career. Female Hispanic students often feel marginalized within their STEM environments, face self-doubt inflicted by their male peers, and experience feelings of isolation during college (Rodriguez and Blaney 2021). Just as a lack of representation contributes to decreased interest and opportunity in STEM fields, an increase in representation increases confidence in STEM. In Rainey's study, there were several factors that contributed to Hispanic students feeling a sense of belonging in STEM, and most of those revolved around the feeling that students and mentors resembled them and they received support from teachers and family members (Rainey et al. 2018). Most Hispanic students surveyed reported feeling self-motivated when it came to pursuing a career in STEM and demonstrated that small activities such as writing practice boosted their confidence levels (Bravo and Stephens 2023). In a study reviewing existing literature on academic access for STEM and non-STEM majors, it was found that significant predictors of higher graduation and retention involved reducing financial burden through loans, work-study, gifts, and aid (Whalen and Shelley 2010). The same study found that for women and/or URM students, being from out of state and beginning college enrolled in a STEM major contributed to lower retention and graduation rates (Whalen and Shelley 2010). Retention of URGs in STEM academic fields is vital to ensure the continuing growth of representation in STEM careers.

One of the things that makes this research novel and important is that sustainability is a relatively new field, and most existing research is about STEM internships, not sustainability-focused internships. STEM internships can be especially beneficial when they support various job types, including those outside of traditional STEM tracks. The collaboration of students with different skill sets and backgrounds allows for unique perspectives and innovative, holistic approaches to solving the world's most pressing issues (Henkhaus et al. 2022). Several studies on internships and educational experiences outside of a student's curriculum have found that there are specific measures that can be taken to ensure URG students are supported throughout their experience in order to meet their White male peers on an even playing field (Canning et al. 2019, VanMeter-Adams et al. 2014, Henkhaus et al. 2022, Madzima and MacIntosh 2021). Being intentional about how a program approaches inclusivity empowers minority students. Support and pay throughout internships can help URG students transcend economic barriers through advancement into higher-paying STEM careers. Research has shown that student involvement in faculty research and internships early on can be important for engagement, achievement, and retention of URG students in STEM (Freeman et al. 2014; Maton et al. 2012; Pender et al. 2010; Tsui 2007), and that this is particularly the case for students of color (Palmer et al. 2011; Tsui 2007). Predictors for persistence and academic success in STEM majors are based on a variety of factors such as gender, SAT Math scores, and first-semester college GPA, yet cultural characteristics and social capital are also important (Crisp et al. 2009). Using "reflective exercises provides us with defined targets for marginalized groups and the barriers that limit their participation to intentionally develop programmatic activities and systematic changes and increase equity" (Madzima and MacIntosh 2021).

Current study

The present study, which draws from previous research on the barriers faced by URGs within the STEM community, assesses the potential benefits of experiential team-based learning in the Green Teams sustainability-focused internship program.

We studied self-reported gains in skills the internship aims to help students achieve. It focuses particularly on the effects of a summer internship experience from the perspective of students with multiple underrepresented identities using the Survey for Undergraduate Research Experiences (SURE) survey. SURE is a survey used to evaluate summer student research experiences, and previously published data indicate that when comparing pre-experience and post-experience surveys, “participants began or continued to plan for postgraduate education in the sciences” (Lopatto 2007, pg. 297).

The framework for the Green Teams Program is guided by institutional experience, evidence-based best practices, and social capital theory, which contends that social relationships are resources that can build human capital and strongly impact individual well-being (Machalek and Martin 2015). Students who participate in the Green Teams Program gain social capital through their teamwork, training, and being a part of living-learning communities, which can later lead to the development and accumulation of human capital. For example, having an ongoing support network of like-minded young professionals and intentionally trained mentors can support career and postgraduate education aspirations, which is essential for students coming from underrepresented backgrounds (Mishra 2020). In this study, we hypothesized that learning gains would increase for all students, but that members of URGs would have higher learning gains than other populations due to the intentional structure of the program. We also hypothesized that through training, presentations, and professional development, students would experience learning gains in science communication skills during the Green Teams Program, which could further increase their sense of belonging and contribute to social capital. While we are not directly studying science identity, the gains being studied contribute to building a science identity.

Our research questions were as follows: (1) Does the Green Teams Program participation coincide with increased undergraduate students’ sense of belonging, confidence, and social capital in STEM environments pre- vs. post-program? (2) Does participation in the Green Teams Program correspond to different magnitudes of learning gains for students whose identities are underrepresented in STEM compared to other students? and (3) Do students with intersecting underrepresented identities indicate different magnitudes of learning gains compared to those with a single underrepresented identity?

Methods

Green Teams Program

The Green Teams Program is set up as both a professional internship and an educational training program. Some projects include lab time, but others do not; instead, they require STEM-based skills with an environmental focus and research in the field. While traditional research settings tend to consist of a single student working with a single mentor, the Green Teams provide a team of peers supported by peer leaders (i.e., Assistant Project Managers and Project Managers), faculty mentors, and subject matter experts from diverse backgrounds to whom participants can reach out for assistance. This team feature enables the program’s strength. The diversity of its participants and the unique perspectives they bring from different backgrounds, both educationally and personally, create spaces for each participant to thrive. Furthermore, exposure to the many different types of STEM activities with which participants engage over the summer helps bridge the classroom-to-career gap that can present challenges in purely academic settings. Each day of the program is different, but many days consist of individual team working time, check-ins with Assistant Project Managers (APMs) and Project Managers (PMs), presentations from speakers actively working in STEM and sustainability, and various workshops on hard skills. Some examples of workshops and presentations provided are “Introduction to R,” “Green Accounting and Scope Emissions,” “Workshop in Geographic Information Systems (GIS),” “Workshop in Environmental Justice,” and “Diversity and Inclusion Training (Identity Signs).” Interns also enroll in the Art of Science Communication course from the American Society for Biochemistry and Molecular Biology (ASBMB 2024), which consists of a series of discussion and practice-based sessions facilitated by instructors. The course is designed to encourage students to think about who scientists are and what they do, how to identify audiences of different backgrounds, how to build a scientific presentation, and successfully deliver scientific information to various audiences. The ASBMB course brings together students from different teams, exposing interns to further diverse perspectives. The course helps students prepare for the public presentations each team gives at the end of the internship, but also pushes them to think about a variety of new STEM topics, and how to communicate them. To further improve communication skills and allow interns to become comfortable with presenting to an audience, each team gives a presentation at the end of every week to all other interns, updating everyone on the work that has been completed thus far toward their deliverables. These presentations become more detailed every week, culminating in a team final presentation given to company representatives and a public audience.

APMs and PMs are selected from previous Green Teams cohorts, so they have experience with the program and represent the student population of Green Teams interns. Hiring past Green Teams members also allows for further career readiness and professional experience, building on the APMs’ and PMs’ previous Green Teams experience. APMs and PMs meet regularly with the teams, tracking their progress and providing any type of support interns might require. Along with talks, courses, and workshops, interns are provided a multitude of resources on an as-needed basis in order to help the interns best participate in the program and complete projects. Participation support includes travel stipends, housing, and access to free professional attire, among other things. Project support includes access to subject matter experts, equipment, software, and training. PSEG ISS provides these things in order to ensure every intern can properly participate in the program, fully engaging themselves among their peers and team and within their projects, trainings, and workshops.

The Green Teams Program prioritizes equity over equality so that interns who are traditionally underrepresented in STEM have access to additional tools and training that allow them to excel in their project work and professional development. By the end of the internship, each student takes away valuable skills and knowledge that can be applied in STEM and non-STEM fields. The completion of a project with implemented deliverables and real impact on the companies and communities involved, coupled with the training and connections each student gains from completing the program, helps each intern enter into the workforce with valuable experience for their resume for prospective jobs later on. Although each student leaves the program with an impressive professional experience and vital STEM skills, students come into the program from vastly different backgrounds with varying levels of skill sets and needs. The aim of the program is to support each student as they progress through the internship by meeting them where they are and propelling them forward, ensuring an equitable experience. The 110 undergraduate students surveyed during this study participated in the Green Teams during the summers of 2021 and 2022 and represented 54 academic institutions, including two-year and four-year degree programs.

The demographic data collected was based on best practices and informed by Census guidelines, using only questions relevant to the research being conducted. The questions were aligned with Montclair State University's practices in collecting demographic information (Montclair State University 2023). As Table 1 below shows, the majority of interns were female (64.5%), and 33.6% identified as male. Two people identified as the other gender. Additionally, the majority of interns were White (64%), while 19% identified as Black, 11.5% Asian, and 2.9% American Indian and/or Alaska Native. Out of the students who identified their ethnicity, 32% self-identified as Hispanic or of Latin origin. Intentionally, interns represented many different majors, both in STEM and outside of STEM. The purpose of having academically diverse interns is to build a unified sense of belonging within the science community as well as have the teams approach challenges with multiple unique perspectives and skill sets. Most academic majors were involved in STEM (69.53%), and the remaining 30.47% were non-STEM degree majors. Majors were determined as STEM or non-STEM using the "DHS STEM Designated Degree Program List" from the US Department of Homeland Security (US DHS n.d.). Many respondents were either double majors or had minors (Table 2).

The summer 2021 and 2022 Green Teams cohorts resulted in a total of 22 completed projects serving a total of 19 hosting organizations (see Table 3 for examples). When interns presented their team's final presentation, designed to offer interns an opportunity to communicate their findings to a diverse, public audience and network, the audience was comprised of interns' family members, faculty, and staff at Montclair State University, as well as other institutions, professionals associated with hosting organizations, and other interested professionals from various fields.

Learning assessment tools

The pre- and post-surveys included items from the Survey of Undergraduate Research Experiences (SURE) (Grinnell College 2018). Created by David Lopatto and Leslie Jaworski, the SURE survey is designed to evaluate the effects of undergraduate research programs on its participants by collecting quantitative data on these experiences (Grinnell

Table 1 Race and gender demographic information of the participants

Gender	*n*	%	Race	*n*	%	Ethnicity	*n*	%
Female	69	64%	American Indian or Alaska Native	3	3%	Hispanic, Latino/a/x, or other Spanish-speaking culture or origin	32	32%
Male	36	34%	Asian	12	12%	Non-Hispanic	68	68%
Other	2	2%	Black or African American	20	19%	**Total**	**100**	
Total	**107**		Native Hawaiian or other Pacific Islander	0	-			
			White	67	64%			
			Other	2	2%			
			Total	**104**				

Table 2 Academic majors of the Green Teams interns

Major	Participants (n)	% of participants
STEM majors		
Biology	5	4%
Chemistry	4	3%
Computer science/IT/cybersecurity/data science	6	5%
Earth/environmental sciences/studies	32	25%
Engineering	21	16%
Mathematics	3	2%
Psychology/sociology	3	2%
Sustainability sciences/studies	8	6%
Other: natural and physical sciences	7	5%
Non-STEM majors		
Art/Design	5	4%
Business (accounting/advertising/economics/finance/management/marketing)	10	8%
Communications/public relations/media	1	0%
Policy/justice/law/government	9	7%
Urban/community planning	5	4%
Other: humanities	4	3%
Other: pre-professional (exercise science, nutrition, public health, pre-law, pre-med)	1	0%
Other: social sciences	4	3%
Total	128	

Since some interns have minors or are double majors, the total major involvement is higher than the actual number of interns for both summers of 2021 and 2022

College 2018). The SURE has been used by researchers to assess retention and found that undergraduate research experiences increase interest in academic and research careers while also resulting in high levels of employment (Junge et al. 2017). Lopatto's previous work on the SURE investigated men's and women's differences in learning gains and plans to continue STEM education. They did not find any significant gender differences associated with traditional summer undergraduate research experiences (2017). The survey has also been used by Wei and Woodin to assess summer research experiences in comparison to apprenticeships, finding both experiences provide similar benefits (2017). Due to the survey's popularity and prominence in undergraduate STEM literature, the SURE was selected to address the research questions that guided this work.

The Green Teams pre-survey was administered before the start of the program and before any training occurred. The respondents were instructed to complete the survey through Qualtrics, an online survey distributor. The research team applied and was approved for an expedited study by the Institutional Review Board compliant with federal guidelines 45 CFR46 on collection of data and research, including all data and research in this article. Respondents were reminded before the survey that while their participation was appreciated, it was not required and respondents reserved the right to negate any answers they wished to keep private. They were required to sign a waiver acknowledging this information in Qualtrics before beginning the survey. The Green Teams post-survey was administered the day after final presentations, at the culmination of the Green Teams Program, and was administered in the same manner as the

Table 3 Previous Green Team hosting organizations and projects

Hosting organization	Projects/deliverables
AvalonBay communities	• Helped define embodied carbon goals based on competitors and industry organizations • Provided water consumption reduction opportunities • Completed competitor biodiversity and material health analysis • Helped map against Security and Exchange Commission and EU Taxonomy frameworks
City of Jersey City	• Placed > 100 heat sensors in Jersey City trees, assessing the heat island effect • Created an ArcGIS heatmap • Analyzed the relationship between heat and income and the impact of vegetation on temperature variability
Dr. O'Neil Lab	• Investigated and designed membrane-less electrolysis cells for producing clean hydrogen for energy storage applications • Market SWOT analysis was also conducted
Northern New Jersey Community Foundation	• Modeled estimated flood depths near the USGS gages at the New Jersey cities of New Milford, Oradell, and Hackensack • Created fact sheets for municipalities and residents to initiate action, particularly collaborative efforts • Generated a report containing data-driven recommendations for flood preparedness, including rain barrels and rain gardens
Weeks Marine, Inc	• Collected data and made a database of the company's current generator inventory • Used database to calculate the company's current carbon footprint • Researched and proposed other equipment and technology that can help reduce their carbon footprint

pre-survey. In the post-program survey, participants' self-identified learning gains and perceptions of program components were determined via a retrospective participant survey. The *SURE III* survey contains a list of 21 statements related to knowledge in the different aspects of the science field, from the *ability to integrate theory and practice* to *understanding of the research process in your field.* Participants were asked to reflect on their experience and rate their learning gains by choosing one out of five statements with which they identified. The five statements were *no gain or very small gain*, s*mall gain, moderate gain, large gain,* and *very large gain.* There was also a *not applicable* answer option. For the purposes of the study, we will only focus on one aspect of the SURE survey: self-identified learning gains.

Data analysis

For analysis, we followed the methods of a previous study from Lopatto (2007). The learning gains statements were translated to numbers, mimicking a Likert scale. *No gain* or *very small gain* represented a 1, while a *very large gain* represented a 5. If a respondent answered *not applicable*, then that answer was not included in the analysis. The participants' answers were grouped based on the respondent characteristics of interest (i.e., male/female, Hispanic/non-Hispanic). The scores translated from the answers were averaged by a specified group and compared to one another via a scatter-plot graph. The groups of interest are as follows: gender (male/female), underrepresented ethnicity (Hispanic/non-Hispanic), and underrepresented race status.

Means were calculated for each group of interest, and then Welch's t-tests were performed between groups for each learning gain item (i.e., survey question). The level of significance used in this study was $a = 0.05$. To address multiple comparisons, a Bonferroni correction was manually calculated and resulted in a suggested level of significance of $a = 0.002$. Both levels of significance were used for the analysis of results. To examine the distribution of variance for the learning gain responses, a principal component analysis (PCA) was conducted.

> "Principal component analysis is a versatile statistical method for reducing a cases-by-variables data table to its essential features, called principal components. Principal components are a few linear combinations of the original variables that maximally explain the variance of all the variables. In the process, the method provides an approximation of the original data table using only these few major components" (Greenacre et al. 2022, p. 1).

Using participant responses to each learning gain item (which investigates an independent area of STEM-related learning gains), and with a maximum of 110 participants giving a score for each learning gain, the PCA incorporates all responses into multiple dimensions and generates a new visualization of how the variance is distributed. Since there are 21 learning gains, the PCA contains 21 principal components. Each component had loadings for each learning gain that represented its contribution to the principal component. To assess learning gain differences between groups across all questions, t-tests were conducted using the first principal component (PC1) scores for underrepresented groups versus the PC1 scores for their counterparts to assess differences in learning gains. A two-way analysis of variance (ANOVA) was also conducted to assess similarities in learning gains between groups.

Results

Moderate to very large gains were reported for overall groups on 20 out of 21 learning gain items. The results of the survey analysis showed large gains across all participants and found specifically large gains for participants who self-identified as being from groups who are traditionally underrepresented in STEM for gender and ethnicity, with less significant gains for individuals who self-identified as being from racial groups traditionally underrepresented in STEM. Table 4 shows the self-identified learning gain means that were retrospectively self-assessed by participants upon completion of the program across all participants, as well as means for specified groups along with the standard errors of each mean. The learning gains are pre-post retrospective scores that students self-assessed regarding their growth in a specific survey item. The highest mean score (4.04 ± 0.10) reported was s*kill in how to give an effective oral presentation*, and the lowest score was *learning laboratory techniques* (2.19 ± 0.14), which also had the highest standard error. The finding on oral presentation skills might be explained by the emphasis on and weekly delivery of presentations as well as the ASBMB Art of Science Communication Course. As the final presentations are the culminating program activity, the program places almost as much emphasis on the presentation of the findings as they do the project research. Laboratory techniques being the smallest gain with the highest standard error are not surprising, as many Green Teams projects do not require any laboratory work.

Underrepresented groups in STEM analysis

Gender and ethnicity in STEM

Female and Hispanic participants both reported higher learning gain averages than their counterparts in all categories. Graphs displaying learning gain averages between

Table 4 Learning gain means across all participants as well as each underrepresented group

Question	Overall mean ± SE	Female mean ± SE	Underrepresented ethnicity mean ± SE	Underrepresented race mean ± SE
SU_11_1: clarification of career path	3.61 ± 0.10	3.79 ± 0.12	4.00 ± 0.20	3.67 ± 0.20
SU_11_2: interpretation of results	3.57 ± 0.01	3.68 ± 0.12	3.80 ± 0.18	3.33 ± 0.23
SU_11_3: tolerance for obstacles faced	3.79 ± 0.01	4.03 ± 0.11	4.10 ± 0.15	3.81 ± 0.22
SU_11_4: readiness for more demanding research	3.79 ± 0.10	3.91 ± 0.11	3.87 ± 0.18	3.62 ± 0.20
SU_11_5: knowledge construction	3.48 ± 0.11	3.57 ± 0.14	3.86 ± 0.20	3.63 ± 0.24
SU_11_6: understanding of research process	3.42 ± 0.12	3.59 ± 0.15	3.77 ± 0.21	3.52 ± 0.24
SU_11_7: ability to integrate theory and practice	3.37 ± 0.11	3.55 ± 0.13	3.67 ± 0.19	3.55 ± 0.21
SU_11_8: how scientists work on real problems	3.57 ± 0.11	3.81 ± 0.13	3.69 ± 0.24	3.81 ± 0.25
SU_11_9: scientific assertions require supporting evidence	3.49 ± 0.10	3.69 ± 0.13	3.79 ± 0.18	3.80 ± 0.24
SU_11_10: ability to analyze data and other information	3.65 ± 0.11	3.80 ± 0.15	3.97 ± 0.19	3.67 ± 0.28
SU_11_11: understanding science	3.37 ± 0.12	3.61 ± 0.16	3.67 ± 0.21	3.45 ± 0.26
SU_11_12: ethical conduct	3.48 ± 0.12	3.64 ± 0.15	3.80 ± 0.18	3.60 ± 0.27
SU_11_13: lab techniques	2.19 ± 0.14	2.37 ± 0.21	2.48 ± 0.28	2.00 ± 0.32
SU_11_14: read and understand literature	3.03 ± 0.12	3.08 ± 0.15	3.21 ± 0.26	3.40 ± 0.28
SU_11_15: effective oral presentation	4.04 ± 0.10	4.26 ± 0.11	4.33 ± 0.16	4.05 ± 0.25
SU_11_16: science writing	3.38 ± 0.11	3.44 ± 0.15	3.60 ± 0.20	3.38 ± 0.20
SU_11_17: self-confidence	3.68 ± 0.01	3.88 ± 0.13	4.00 ± 0.18	3.48 ± 0.25
SU_11_18: how scientists think	3.19 ± 0.01	3.30 ± 0.15	3.31 ± 0.22	3.24 ± 0.23
SU_11_19: work independently	3.16 ± 0.01	3.26 ± 0.17	3.60 ± 0.22	3.05 ± 0.28
SU_11_20: learning community	3.76 ± 0.01	3.97 ± 0.14	4.10 ± 0.17	3.71 ± 0.26
SU_11_21: potential to be a teacher of science	3.17 ± 0.01	3.31 ± 0.16	3.43 ± 0.20	3.24 ± 0.22

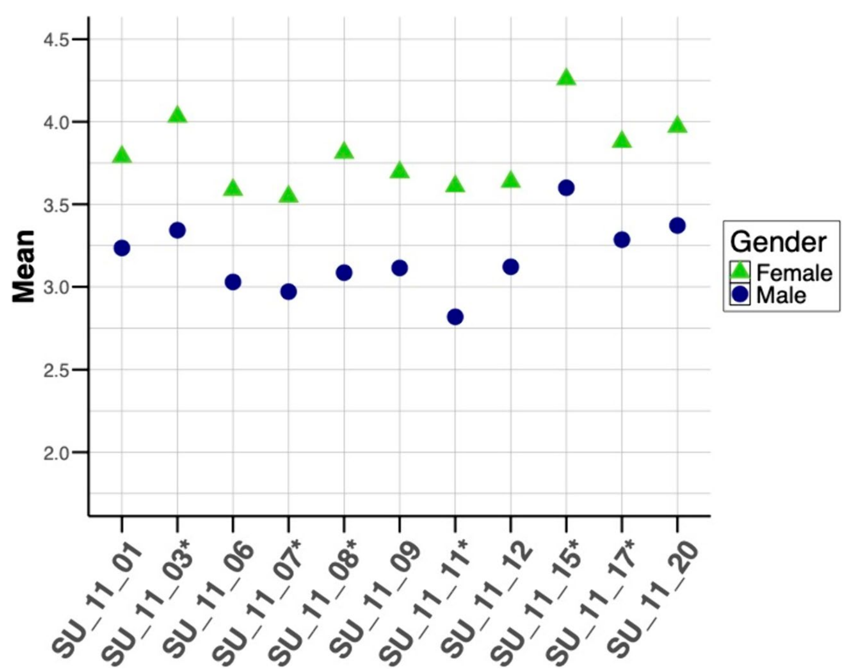

Fig. 1 Significant learning gains for females and males; significance can be assessed with $*p < 0.01$

females and males, as well as Hispanic and non-Hispanic participants, can be found below in Figs. 1 and 2. The largest differences between genders were *understanding science* (0.79) and *how scientists work on real problems* (0.72), and the biggest differences for ethnicity were *learning to work independently* (0.63) and *clarification of career path* (0.58). *Tolerance for obstacles faced* was especially high for Hispanic participants ($\bar{X} = 4.03 \pm 0.11$)

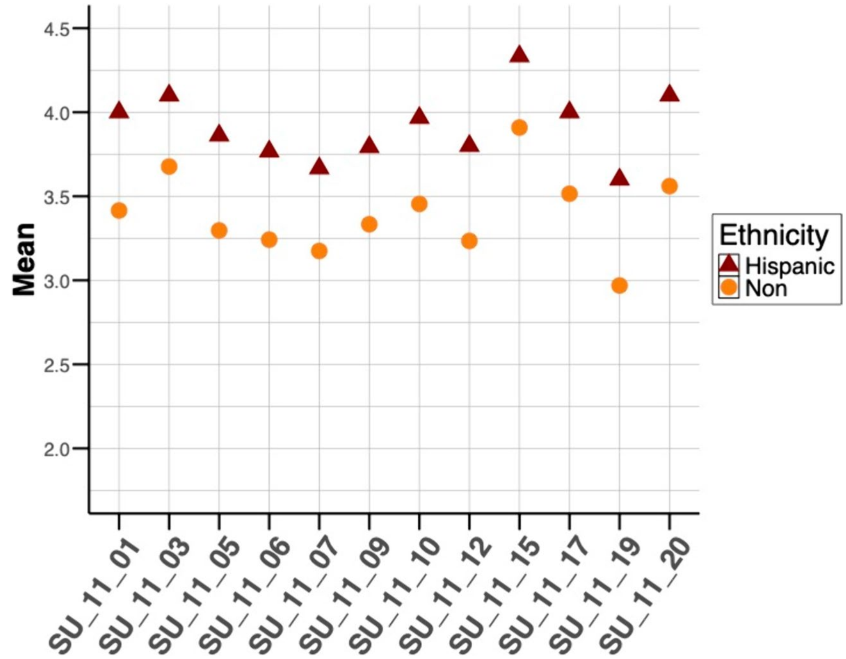

Fig. 2 Significant learning gains for Hispanic and non-Hispanic

Table 5 *t*-Test results for ethnicity and gender groupings

Question	Gender			Hispanic		
	t-test stat	*p*-value	*t*-test *n* (female/male)	*t*-test stat	*p*-value	*t*-test *n* (Hispanic/non-Hispanic
Clarification of career path	2.527	0.014*	66/34	2.506	0.015*	30/65
Tolerance for obstacles faced	2.982	0.004**	65/35	2.039	0.045*	30/65
Knowledge construction	1.467	0.147	63/35	2.291	0.026*	29/64
Understanding of research process	2.275	0.026*	63/34	2.042	0.046*	30/62
Ability to integrate theory and practice	2.666	0.010**	64/34	2.118	0.038*	30/63
How scientists work on real problems	3.480	0.001**	64/35	0.909	0.369	29/65
Scientific assertions require supporting evidence	2.516	0.014*	64/35	2.018	0.048*	29/63
Ability to analyze data and other information	1.638	0.106	66/35	2.061	0.043*	30/66
Understanding science	3.518	0.001**	64/33	1.859	0.069	30/63
Ethical Conduct	2.069	0.042*	66/33	2.384	0.02*	30/64
Effective oral presentation	3.143	0.003**	66/35	2.053	0.044*	30/66
Self-confidence	2.838	0.006**	66/35	2.158	0.035*	30/66
Work independently	1.341	0.184	65/35	2.273	0.027*	30/65
Learning community	2.569	0.012*	66/35	2.382	0.02*	30/66

Significance can be assessed with *$p<0.05$ and **$p<0.01$

and high for female participants ($\bar{X}=4.1\pm0.15$) compared to the overall group mean ($\bar{X}=3.79\pm0.10$). Welch's *t*-tests were performed for the two groups on each unique learning gain and resulted in various levels of significance. Welch's *t*-test results for the two groups can be found below in Table 5. Of all the gender-based learning gains *t*-tests, 11 had $a=0.05$ significant results ($p<0.05$), and six of those had results that met the threshold of $p<0.01$, while two met the Bonferroni corrected alpha of $a=0.002$. The smallest *p*-value was the *t*-test for *understanding science* ($p=0.001$). Females' highest average learning gain was *skill in giving an effective oral presentation* ($\bar{X}=4.26\pm0.11$), followed by *tolerance for obstacles faced* ($\bar{X}=4.03\pm0.11$). Twelve ethnicity-based learning gain t-tests had significant *p*-values ($p<0.05$). The highest average learning gain for Hispanic participants was *skill in*

Table 6 Eigenvalues and percent of variance for principal components 1–3 (PC1–PC3)

Principal component	Eigenvalue	Variance percent
PC1	11.58	55.16%
PC2	1.16	5.54%
PC3	1.03	4.93%

Table 7 PC1 loadings for a sample of variables (learning gains) from PC1

PC1 Loadings	
SU_11_1	−0.21
SU_11_4	−0.22
SU_11_5	−0.24
SU_11_18	−0.24
SU_11_19	−0.21
SU_11_20	−0.24

giving an effective oral presentation ($\bar{X} = 4.33 \pm 0.1$), followed by *tolerance for obstacles faced* ($\bar{X} = 4.1 \pm 0.15$) and *becoming part of a learning community* ($\bar{X} = 4.1 \pm 0.17$). The smallest p-value was the t-test for *clarification of career path* ($p = 0.015$).

Underrepresented race in STEM

As seen in Table 4, the URM race groups' highest learning gains were *skill in how to give an effective oral presentation* (4.05 ± 0.25, respectively). The URM race group had the smallest n of any group being researched and did not have any significant difference between any learning gains.

Principal component analysis

In the principal component analysis (PCA) conducted, each principal component (PC) accounts for a certain percentage of the variance of the 21 learning gain variables. The findings of the PCA show the first principal component 1 (PC1) represents over half (55.16%) of the variance (Table 6), while subsequent PCs account for below 6% of the variance. Table 6 shows the eigenvalue and percent of variance accounted for within the original learning gains data set for each principal component. An eigenvalue represents the variance accounted for by the component (Gauch 1982). Within each principal component, there are loadings for each variable (learning gain) that represent that variable's contribution to the variance of that principal component. The loadings for PC1 show each learning gain contributed roughly equally to the first principal component, as indicated in the narrow spread of the loadings. Table 7 shows PC1 loadings for a small sample of learning gains. As such, PC1 was utilized for further analysis as a measure of overall gain.

The research team then explored how specific groups (i.e., female, Hispanic) contributed to the first principal component. PC1 scores were utilized as an overall gain measure, and subsequent t-tests were performed by group to test for differences among overall gains by ethnicity and gender.

Welch's t-tests were conducted using PC1 scores for males versus PC1 scores for females to assess the significance of differences in learning gains from a comprehensive standpoint. The same analysis was conducted for each underrepresented group pairing. The PC1 scores for ethnicity had a t-value of 1.961 and a p-value close to the $a = 0.05$ level of significance ($p = 0.055$), indicating that learning gain responses varied to some extent by ethnicity across all learning gains. The PC1 scores for race t-test results showed no significant differences in their results. The PC1 scores for the gender t-test were the most significant finding, with a t-value of $t = 3.030$ and a p-value of $p = 0.003$, which meets the criteria of $a = 0.05$, confirming that responses by gender varied across for overall gain as well as within individual learning gains.

Intersectionality analysis

Individual's PC1 scores described above were used for the following two-way ANOVA. A table representing the demographic count breakdown of ethnicity by gender can be found in Supplementary Table S1. The ANOVA was conducted on the PC1 scores with ethnicity and gender as factors to address the overall learning gains' relationship within and between gender and ethnicity. The ANOVA can be seen in Supplementary Table S2. PC1 ethnicity (Hispanic vs. non-Hispanic) scores and gender (female vs. male) scores both showed significant differences $a = 0.05$ ($p = 0.046$ and $p = 0.004$ respectively), and there was no interaction effect between ethnicity and gender ($p = 0.123$). The ANOVA results support the findings of the t-tests, suggesting women and Hispanic students had higher learning gains than others and that these gains were independent of each other, rather than one group relying on another.

A Tukey Honestly Significant Difference test was administered using the PC1 scores, assessing differences between and within the gender and ethnicity groups, Hispanic/non-Hispanic, and female/male. A box plot visualization of the PC1 scores of the groups tested can be found below in Fig. 3. The results of the Tukey Honestly Significant Difference test, as indicated in Table 8, found significance in four pairings: male/female, Hispanic/non-Hispanic, Hispanic Females/Hispanic Males, and Hispanic Females/non-Hispanic males. The findings of male/female ($p = 0.004$) and Hispanic/non-Hispanic ($p = 0.046$) support the previous t-test findings discussed above. The low p-value for the difference between non-Hispanic Males and Hispanic Females ($p = 0.003$) shows a stark difference. The significant difference between

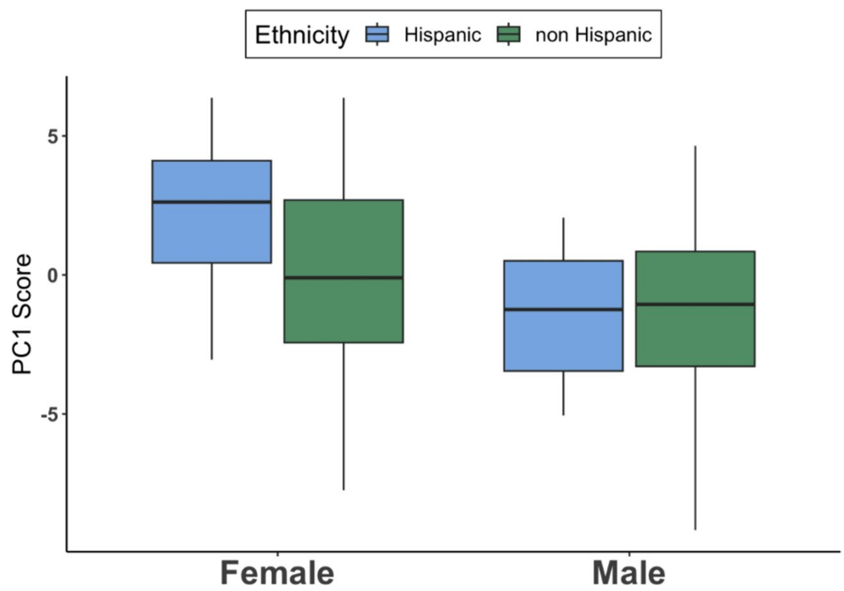

Fig. 3 PC1 scores' boxplots broken down by gender and ethnicity. Plots with different letters indicate significant differences between those groups, as indicated in Table 8

Table 8 Tukey's HSD test results

Demographics	Significance
Male/female	**
Hispanic/non-Hispanic	*
Hispanic female/non-Hispanic female	-
Hispanic female/Hispanic male	*
Hispanic female/non-Hispanic male	**
Hispanic male/non-Hispanic female	-
Hispanic male/non-Hispanic male	-
Non-Hispanic male/non-Hispanic female	-

Significance can be assessed with $*p<0.05$ and $**p<0.01$

Hispanic males/Hispanic females ($p=0.023$) supports the argument that those with two underrepresented identities are learning at a higher rate than those with a single underrepresented identity and suggests that the intersectionality of one's identity plays a significant role in how interns experience the Green Teams Program.

Implications and limitations

As with all research on human subjects, the data discussed throughout this study may be partially incomplete, not representing the full respondent population discussed above. Respondents may not have answered a certain question for various reasons, omitting themselves from certain analyses. Respondents are reminded before participation that they are allowed to stop at any point, and that the information given may be used for publication purposes. If a respondent did not answer a demographic question required for a certain analysis, they were omitted from that graph and subsequent analyses. For example, those who did not identify with a binary gender were not included in the gender analysis, as there were not enough participants to indicate significance. Since there is both a pre- and post-survey, this study only used data from participants who completed both surveys, which provided an *n* of 105. The results of the study can be strengthened through a larger sample size, possibly through assessing the experiences of more Green Teams cohorts in the future.

Discussion

The Green Teams internship provides a diverse and interdisciplinary experience for students, bringing together STEM and non-STEM individuals and their skills in order to resolve a sustainability or environmental challenge faced by a hosting organization. Fostering a learning environment among interns by bringing in faculty and subject matter experts to lead workshops and mentor projects while requiring professional-level work with demanding deadlines provides interns with a clearer sense of the working world and prepares them for success. Because inequity persists in STEM, the Green Teams Program works to diminish the sense of isolation many people from URGs have reported feeling in STEM. The results of this study suggest that the program encourages confidence in our interns. Previously published work has demonstrated the important role confidence plays in cultivating a successful science identity (Charleston et al. 2014; Hilts et al. 2018; Sterling et al. 2020). Lopatto's (2017) research on the SURE program revealed no significant gender differences in learning gains or intentions to continue STEM education from traditional summer undergraduate research experiences. In contrast, the findings from this study indicate that the Green Teams Program offers a distinctive team-based experience that helps mitigate gender disparities in the STEM field. The scarcity of prior research on intersectionality within STEM internships and internships focused on sustainability, in general, highlights the foundational nature of these findings in these emerging areas of study.

The results of this study show that the structure of the Green Teams Program fosters an environment where interns can collaborate, utilize personal specialties, and innovate, leading to a multitude of positive outcomes — in particular, significantly higher self-confidence, sense of belonging within a scientific community, and improved science communication skills. Previous findings show that confidence in STEM plays a major part in one's ability to pursue an STEM education and participate in the STEM workforce, and that diversity within a STEM space helps to build confidence among URGS in STEM (Hilts et al. 2018; Taylor 2017; Rainey et al. 2018). Interns experienced gains in confidence, indicating that the program is expanding students' outlook on educational STEM topics and introducing students to new career paths that integrate both their original academic discipline and introduce additional STEM skills. Charleston et al. (2014) and O'Connell and McKinnon (2021) found that the intersecting underrepresented identities of Black women create unique barriers and struggles in addition to those already associated with the individual underrepresented identities. This study found that those with intersecting underrepresented identities, specifically Hispanic women, have benefitted from higher overall self-reported learning gains than their non-intersecting counterparts, Hispanic men and non-Hispanic women.

Hispanic and female participants reported that the program improved their understanding of science, enhanced their ability to present scientific information, and helped them clarify a career path in STEM. This is vital, as these two groups are currently underrepresented in STEM (NCSES 2023). The larger self-reported gains of Hispanic and female participants compared to their majority counterparts suggest the Green Teams supports and encourages students from these URGs, thus contributing towards an equitable and diverse future of the STEM community. Anecdotally, aspects that may have contributed to the high self-reported learning gains of women and Hispanic students may include that interns work in academically and demographically diverse teams of five students, receive extensive DEI training, benefit from a diverse and supportive leadership team, and take advantage of student supports. Utilizing holistic approaches with individuals who come from unique backgrounds has been found to lead to effective educational experiences, and the Green Teams Program results align with this finding (Henkhaus et al. 2022). Additionally, the program has added microaggression training for both students and staff and will continue to build on the current curriculum to ensure increased gains for all.

In addition to project work and training, interns gain knowledge and experience through their peers' perspectives and experiences. The Green Teams Program primarily works to increase access and reduce barriers for URGs to participate in STEM internships through stipends, on-campus housing, training, travel grants, and access to resources. The research results from this study can help to inform future changes in the Green Teams Program, provide a framework for other programs and institutions to utilize and build upon, and inform future research.

Future research

The findings of this study confirm the difference in experiences between underrepresented individuals and their counterpart majority peers, reflected in the higher self-reported learning gains of women and Hispanic students. Further research on the Green Teams Program will reveal which aspects of the program are most important in fostering these differences. As more data are collected throughout the coming years of the program, further research into the program will identify other elements vital in supporting a sense of belonging for URGs in the STEM work field and STEM classrooms. To increase the support provided and further bolster their teamwork, the Green Teams Program piloted a psychoeducational group counseling effort in 2022 that puts teams of interns in a professional group counseling setting for one hour per week, focusing on identifying and communicating struggles, increasing interns' sense of belonging, and improving cultural awareness. Future studies will also look into the effects of participating in weekly group counseling. Additionally, the program has added microaggression training for both students and staff and will continue to build on the current curriculum to ensure increased gains for all. The results of future studies can be strengthened through a larger sample size, utilizing data collected from future Green Teams cohorts and adding it to the overall database. Intersectional identities are still largely under-researched, so the current findings can serve as a start to understand intersectional identities and looking into how the interaction of multiple underrepresented identities affects individuals in STEM.

The findings on the Green Teams Program may provide inspiration for others to investigate replicating these support structures and training in other STEM-focused internship experiences and explore the effects of intersectionality on student success. With further research and implementation of models like the Green Teams, underrepresented students can feel increasingly confident about engaging with STEM in the future, whether through education, within the STEM workforce, or through utilizing STEM skills outside of traditional STEM spaces. As science communication was a significant growth area for participants of the Green Teams

Program, aspects of the program that contribute toward this growth should receive further attention and research and should be implemented into other programs looking to emulate similar results. The ASBMB Art of Science Communication course, weekly presentations, and general gain in self-confidence could all be contributing factors.

Conclusion

The Green Teams internship program demonstrates that a team-oriented, inclusive, and supportive environment can significantly enhance confidence, sense of belonging, and communication skills among interns, particularly those from underrepresented groups. The findings from this study highlight the importance of interdisciplinary approaches, comprehensive support structures, and intentional interventions in fostering an equitable and diverse STEM community. Future research should explore replicating these models in other contexts and further investigate the impact of such programs on long-term career outcomes for URGs in STEM. Continuing to document and disseminate the best practices for supporting individuals from these groups will help to communicate to educators and employers how best to design inclusive and supportive work experiences that will build toward a more diverse and equitable STEM workforce.

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Data availability The dataset used for this study is available upon request to the corresponding author.

Declarations

Conflict of interest The authors declare no competing interests.

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